GEOSS Platform Plus

Enhanced GEOSS Platform v3 with 3rd Set of Applications

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Abstract:

This document describes the evolved GEOSS Platform and its technical implementation in view of the GPP proposed vision of evolving GEOSS towards a Digital Ecosystem. It describes the GEOSS Portal, Yellow Pages, GEO DAB and other middleware enhancements as resulting from GPP Task T3.4 (*GEOSS Platform Integration and Deployment*), as well as the applications output of GPP Task T3.5 (*Application Design, Development and Deployment*) during the second and third project cycles. This technical note provides an overview of the identified applications and the evolutions clarifying which services/applications/functionalities are integrated and which data is made accessible.

Document Log

Date	Author	Changes	Version	Status
29/11/2024	GPP Team	See section 1.3	1.0	Issued

Executive Summary

This document (*D3.7, Enhanced GEOSS Platform v3 with 3rd Set of Applications*) provides an architectural overview of the GEOSS Platform and describes the enhancements derived from the analyses of applications identified in the third GEOSS Platform Plus (GPP) project cycle and recognised (documented as requirements) in the context of WP2, *Use Cases Definition and User Requirements Specification v3*[RD-10].

The identified Scenarios (which are based on applications) aim at demonstrating how communities can benefit from the use of the GEOSS Platform ecosystem and how they can contribute to the evolution of GEOSS, and in particular how the wider GEOSS infrastructure contributes with actionable information derived by the use of the applications.

Applications are the bridge between data available in GEOSS and their usage. The adopted community driven approach drives the new architecture proposal of the GEOSS infrastructure at large and in particular of the GEOSS Platform capabilities by identifying the main evolutions within the GEOSS Ecosystems.

For this reason, the GEOSS Platform Plus project is focused on the application needs coming from the GEO Communities. The applications highlight what the Global Earth Observation System of Systems (GEOSS) should address and how the GEOSS Platform can evolve as means of implementation of GEOSS and thus how it should evolve to fulfil communities' needs and enforce data usage for generating actionable information. In the first cycle, applications were based on Use Cases reported in [RD-1] and the related enhancements specification are reported in [RD-2]; for the second cycle analysis the use cases and functional analyses are described in [RD-6] and [RD-7]; finally in the third cycle the use cases and functional analyses are described in [RD-10] and [RD-11] to identify a set of implementations that address both the GEOSS infrastructure, GEOSS Platform and middleware components. This document is the evolution of the previous [RD-3] and [RD-8] and contains all the enhancements.

Three kinds of enhancements can be identified, according to their main focus. The related implementations are listed below:

- Components-based Enhancements:
  - The GEO Discovery and Access Broker (GEO DAB)
  - Community Portal Self Creation
  - Eiffel Discovery Cognitive Search
  - The GEOSS Yellow Pages 2.0
  - AI (Artificial Intelligence) Based Search
- Community-driven Enhancement:
  - SDG 15.3.1 for Land Degradation
  - AfriGEO Community Portal Customisation
  - Custom Dashboard
  - SDG11.7 for Accessibility to Urban Green Area
  - All Atlantic
  - Nutrient Pollution in European Inland and Coastal Waters
  - Above-Ground Biomass (AGB) Estimation using Machine Learning Techniques
  - New Life 4 Dry Lands
  - Climate Change impact on Norovirus Pandemic rRsk
  - AGAME Project
  - Maps4GPP Project
  - GEOSS Portal Landing Page

- Re-usability, Re-producibility, Replicability Enhancements:
    - The Virtual Earth Laboratory (VLab)
    - OpenEO

Table of Contents

1. Introduction

1.1 Purpose and Scope

This document (*D3.7 - Enhanced GEOSS Platform with 3rd set of applications*) has been generated in the context of WP3 - GEOSS Evolution design, development, integration and deployment within the GPP (short for GEOSS Platform Plus) project, Grant Agreement no. 101039118.

The current document provides a technical description of the implemented enhancements in the first, second and third cycles of the GPP Project, in support of the applications requirements grouped within the high-level scenarios listed in Table 1.

Scenarios ID	Scenarios
S1	Resources discovery and access with linked information
S2	Service Use
S3	Resources Registration
S4	Promotion and collaboration.
S5	Data providers (registration)
S6	Exploiting discovery and access capabilities
S7	Discovering experiment results
S8	Reproducing an experiment
S9	Replicating an experiment
S10	Reusing an experiment

Table 1 Scenarios identified based on applications analysis.

The scenarios identified in the context of WP2 (documented in [RD-11] D2.6 Functional and non-functional enhancements specification v3.0) highlight the need to improve the usability of the GEOSS data. The use of data is a key driver for the future of GEOSS. To better identify how to use those data, a user-centric approach has been adopted in GPP involving the GEO communities and identifying communities' driven applications to non-specialists in the domain of adaptation to extreme climatic events and to changes in climatic conditions.

Another important aspect of the project is to enable the generation of actionable information and to fully exploit the GEOSS infrastructure and its components to the benefit of the users, to enable the connections with the data providers (including in-situ), which are relevant for the achievement of use cases, and to provide a user-friendly, up-to-date and therefore familiar environment, by making sure that the current trends in information technology are considered and exploited at maximum extent. All these concepts are reported in the [RD-12], providing a high-level vision for the future GEO Infrastructure (formerly GEOSS).

1.2 Document Organisation

The document is organised as it follows:

- Section 1: Introduction. It describes the purpose and scope of the document and its organization.
- Section 2: Rationale and Context. It contextualizes the content of this document by providing background information and details on the operational landscape encompassing the GEOSS

Platform. It also describes the general architecture of the system and the GEOSS Vision of a Digital Ecosystem.

- Section 3: The Enhancements. It is the core of the document where all the enhancements are described divided by the Project strategic lines.
- Section 4: Requirements traceability. It traces the WP2 User Requirements (functional and non-functional) to the implementation tasks.
- Annex A. References. List the references used in the document.
- Annex B. Figures and Tables. It provides links to figures and tables in the document.
- Annex C: The GEO DAB Standards
- Annex D: Terminology. It explains the meaning of the acronyms and definitions used in the document.

The document collects contributions from all the partners involved in the GEOSS Platform Plus (GPP) project. The authors are listed below, along with their affiliation:

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1.3 Changes to the previous version, enhancements

During the third application cycle, compared to the previous document GPP-WP3-DEL-D3.4-v1.0 D3.4 Enhanced GEOSS Platform v2 with 2nd set of applications, the following sections have been updated:

Section	Descriptions
2.2	The section "Architecture" has been moved in the "Rationale and Context" section
3.1.1	DAB Section has been updated
3.1.2	Community Portal Self Creation Section has been updated
3.1.4	The paragraphs "Yellow Pages setup" and "Yellow Pages 2.0: development, testing and deployment in pre-production (UAT)" has been merged and updated. The second paragraph title has been maintained.
3.2.1	The paragraphs "SDG 15.3.1 End-to-End solution" and "SDG 15.3.1 Land Degradation" have been merged and updated
3.2.3	Custom Dashboard feature Section has been updated
3.2.4	The paragraph "*SDG11.7: preparatory work for the use case*" has been updated and the title has been modified in "SDG11.7: Accessibility to urban green areas"
3.2.9	Above-Ground Biomass (AGB) estimation using Machine Learning Techniques Section has been updated
3.2.11	Climate Change impact on Norovirus pandemic risk Section has been updated
4.1	Updated the User requirement traceability list
4.2	Updated the list of Scenarios vs System requirement capabilities
4.3	Updated the list of System requirement vs User requirements

The following sections have been added:

Section	Descriptions
2.2.3	Towards a GEOSS Digital Ecosystem
3.1.5	AI Based Search
3.2.6	All-Atlantic – Phase II
3.2.7	All-Atlantic – Phase III
3.2.10	NewLife4DryLands Use Case
3.2.12	AGAME Project
3.2.13	Maps4GPP
3.2.14	GEOSS Portal Landing Page
3.3.2	OpenEO interoperability

2. Rationale and Context

2.1 Background and operational context

A central part of GEO's Mission is to build the Global Earth Observation System of Systems (GEOSS). GEOSS is a social and software ecosystem sharing independent and open Earth observation (EO) information and processing services. It connects and coordinates a large array of observing systems, data systems and processing services to strengthen monitoring of the state of the Earth. It facilitates the sharing of environmental data and information collected by countries and organizations within GEO. GEOSS ensures that these data are accessible, of identified quality and provenance, and interoperable to support the development of tools and the delivery of information services. Thus, GEOSS increases our understanding of Earth processes and enhances predictive capabilities that underpin sound decision-making: it provides access to data, information and knowledge to a wide variety of users.

The GEOSS Platform has been created to provide the technological tool to implement GEOSS. The story of the Platform began in 2008, as Clearinghouse catalogue; in 2012 the platform evolved into a Brokering infrastructure with the inclusion of the GEO Discovery and Access Broker (GEO DAB). The first user interface, the GEOSS Portal was initially created in 2010 and in 2016 has seen great enhancements in terms of user experience and enhanced discovery, access and visualization functionalities. In 2017 the platform has evolved into the currently known GEOSS Platform (see Figure 1).

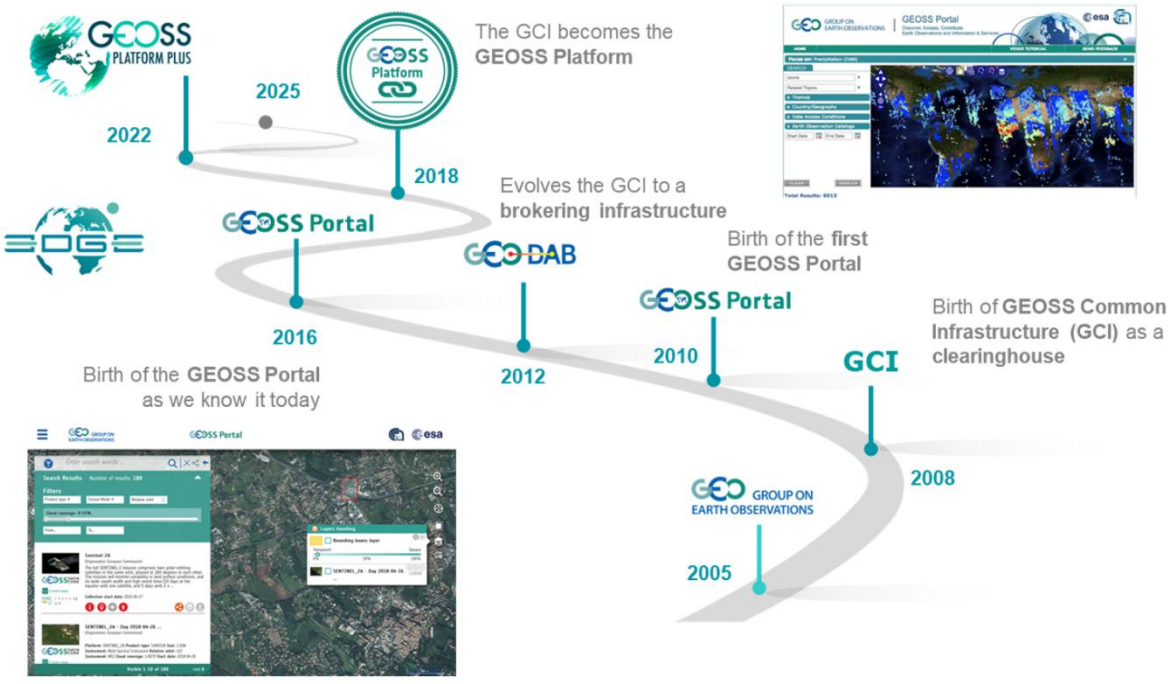


Figure 1 - The GEOSS Platform Journey

A first effort in demonstrating several proofs of concepts experimenting service execution with selection of public cloud-based analytical platforms (e.g. DIASs, AWS), navigation through linked (context) information and dedicated customisation of community portals features have been

implemented and experimented within a development platform in the framework of the EDGE (European Direction in GEOSS Common Infrastructure Enhancements) Project (for more details see [WR-1]).

Another EU effort in contributing to GEO is the GEOSS Platform Plus (GPP) Project with the aim to respond to the new challenges focused on the European Green Deal, implementation of the EU Strategy on adaptation to climate change and the outcomes of the Mid-Term Review frameworks (see Figure 3) by developing new tools and functionalities to better address the user needs adopting an user-centric approach by engaging User communities, GEO Work Programme (GWP) activities, initiatives and flagships and including European efforts in the Climate Change (CC) and green deal frameworks (see Figure 2 and Figure 3).

Figure 2 - GEOSS Platform Components

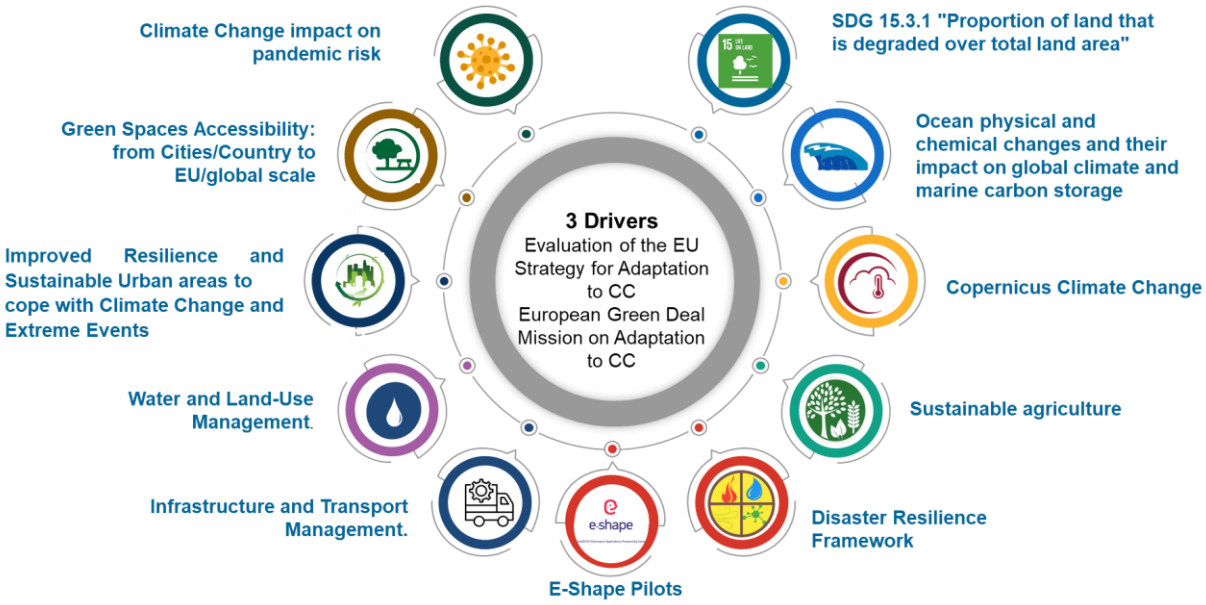


Figure 3 - The GPP Drivers and focus domains

Another objective of the GPP Project is to make the GEOSS Platform usable for a wide variety of users within the GEO communities and beyond, that covers users coming from scientific communities to non-experts and decision makers. Figure 4 provides a representation of the type of users involved and the functionalities they are interested in when using the GEOSS Platform.

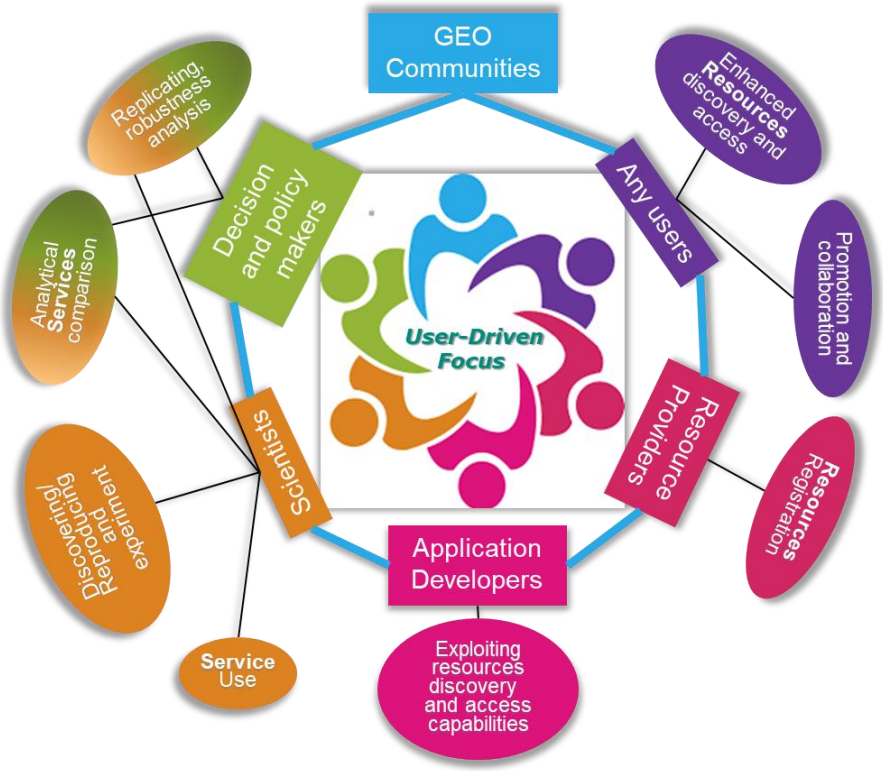


Figure 4 GPP User types and functionalities

2.2 Architecture

2.2.1 Architectural background and challenges for GEOSS

GEOSS has started evolving from a multi-functional system to a Web-based Ecosystem, where several (Web-based) components and technologies co-operate to deliver the services and products required by the GEO Community.

The GEOSS Platform is moving from a data to a knowledge platform providing users besides with the possibility to discover, inspect and access data as well with functionality to use data to derive actionable information and knowledge. Activities are on-going as well to discover, inspect, access and use information and knowledge via the Platform. Such developments are implemented via Platform Tools (or instruments), e.g. via specific Views and can be 'used' via APIs (directly interfacing on a Machine-to-Machine level with the GEO-DAB), via Widgets, or reuse components that are under development and can be integrated into community portals (GEOSS Like or external) in case of set-up for the relevant community(ies) and/or GEO Priority Area (e.g. for a specific Societal Benefit Area (SBA), Copernicus-service, ESA Thematic Exploitation Platform (TEP) community, Sustainable Development Goal (SDG), Paris Agreement Target, Sendai Framework, etc.).

Along this line, the next evolution should consider the inclusion in such an ecosystem of new components and/or instruments and/or applications (i.e. at infrastructures, platforms, middleware and applications layers) to enable communities to contribute to the evolution of the GEOSS ecosystem and to benefit users and communities using GEOSS by making the new enhancements discoverable, accessible and usable.

During the project, a set of challenges were analysed along with possible solutions, including:

- From discovery and access of data only to discovery and access of data, services, information, knowledge, tools, models and algorithms.
- Retrace the journey of experiments leading to results through resources links to enable reproducibility, replicability, reusability and robustness analysis.
- Community portals customisation freedom by developing an instrument that enable self-creation of community portals and views to foster a broader engagement of new communities and active contribution to the GEOSS ecosystem.
- From an obsolete discovery-download process to leveraging cloud technologies supporting **multi-Cloud approach** for actionable information generation.

Figure 5 shows the current relations and the main service components (i.e. infrastructures and platforms) to be considered as part of the GEO/GEOSS landscape.

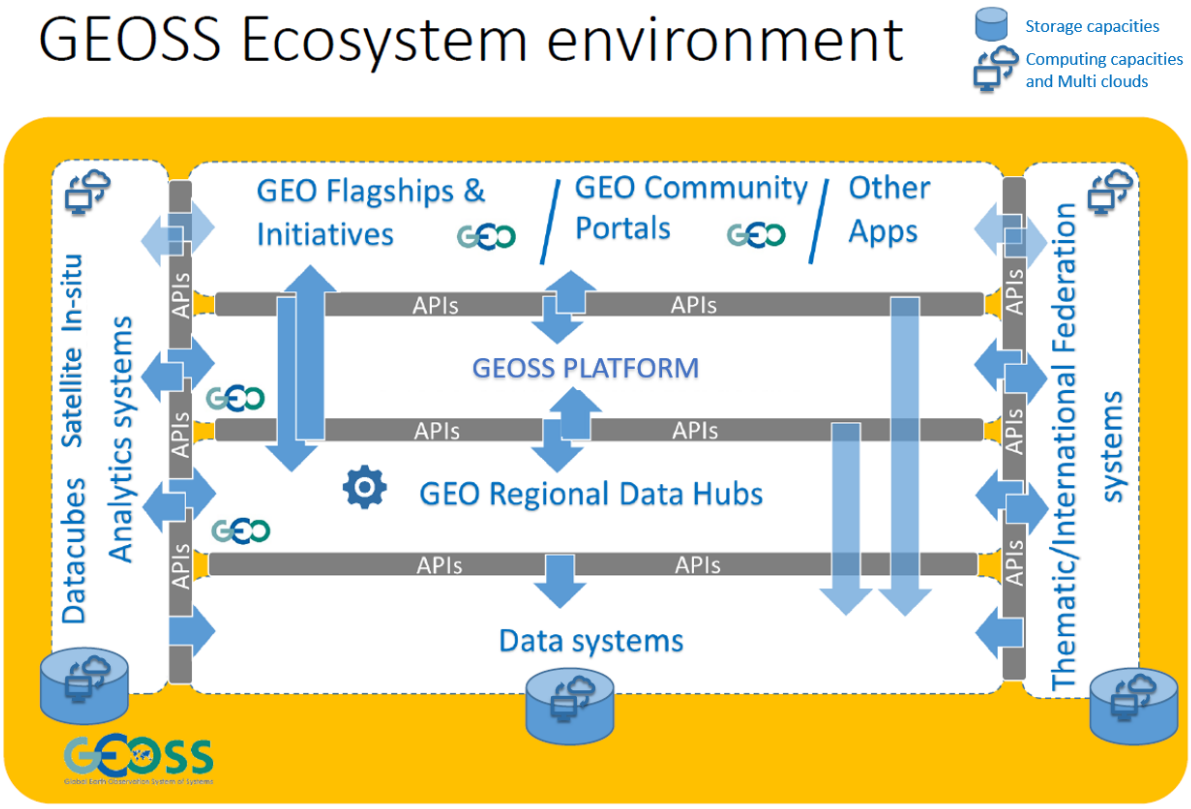


Figure 5 – Current GEOSS landscape for infrastructures and platforms to be considered.

2.2.2 The GEOSS Portal and GEO DAB architecture

Looking at the Figure 5, due to the multiple APIs and various knowledge perspectives, each component has to be based on a layered architecture. The GEOSS Portal internal architecture of the main component - which is a Single Page Application search part - has been furtherly decoupled to support interoperability even better. The main extracted components of the search are:

- Search Presentation layers – targeted search with various perspectives and various concept models:
  - GEOSS common search – opensearch based resource discovery/download /access;
  - thematic search – supported with internal domain model search in the thematically predefined subdomains;
  - Wikipedia search;
  - Knowledge producer search – supported with GEO-DAB ontology model search of resources and services registered on the DAB;
  - Geo-spatial data visualisation with WMS integration. OGC WMSes are presented based on DAB or Data Providers services.
- Catalogue discovery:
  - DAB opensearch client + CSW metadata explorer;
  - http(s) portal client for Wikipedia;
  - CKAN catalog browser – under development.

- Domain browser (ontology browser) - intermediate layer that translates the knowledge concept on the resources level like:
    - Core search to opensearch or CKAN or SciHub or other catalogues;
    - SDG concept to DAB view concept;
    - Core search to Wikipedia resources.

The front-end side is supported with Liferay based content management with user workspace functionalities for registered users.

The GEO DAB transparently connects GEOSS Portal to the resources shared by the GEOSS Data provider. The main goal is to facilitate cross and multi-disciplinary discovery and access of disparate data and information interconnecting several hundreds of autonomous and heterogeneous Supply Systems. The GEO DAB applies the broker pattern, which separates users of services (GEOSS Client Applications) from providers of services (GEOSS Supply Systems). When a client needs a service, it queries a broker via a service interface. The broker then forwards the client's service request to a server, which processes the request. The GEO DAB presently provides broker components for discovery, access and semantics-enabled search.

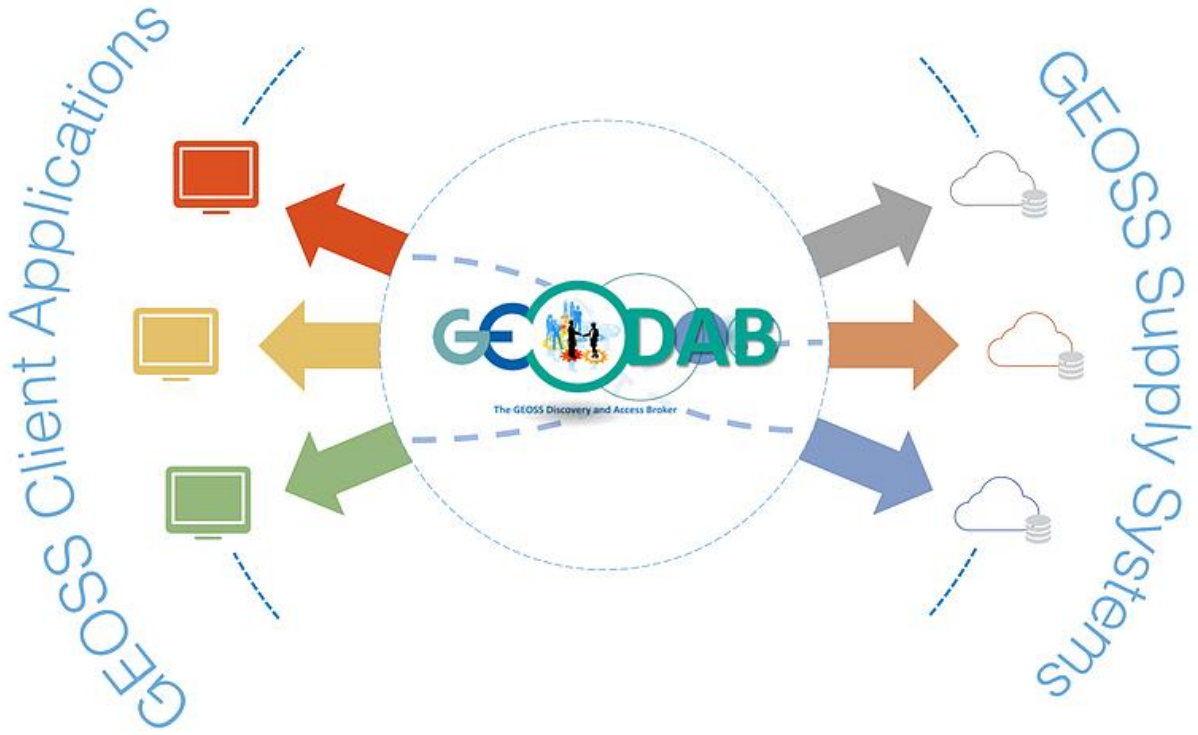


Figure 6 - GEOSS Portal and GEO-DAB interfaces

The main components of the layered architecture are:

- **Data Harmonization**: this layer provides harmonized discovery and access to heterogeneous data systems. The heterogeneity of data sources is hidden, resources appear as a single data source.
- **Data Access**: this layer provides data discovery and access functionalities to heterogeneous data systems.

- **Data Processing**: this layer enriches discovery and access with processing and semantics services.

2.2.3 Towards a GEOSS Digital Ecosystem

The GPP Vision for GEOSS Evolution [RD-12] provides a high-level vision for the future GEO Infrastructure (formerly GEOSS) and, also, a proposal for possible GPP contributions. The document outlines the GPP vision for the evolution of the Global Earth Observation System of Systems (GEOSS) into a Digital Ecosystem (DE) to better address the needs of decision-makers and other stakeholders. The envisioned GEOSS Digital Ecosystem is a forward-looking approach that aims to create a flexible, adaptive environment for knowledge generation and sharing, supported by a robust governance framework and technological integration.

The GEOSS Platform currently represents the midstream layer that enables access and exploitation of EO and non-EO data and other resources (upstream) made available by the providers, in a form that is easily exploitable by (downstream) applications, which are then utilized by the final users.

The GEOSS Platform Plus (GPP) project, in close collaboration with the GEO partners, evolved the European GEOSS Platform components, i.e., the GEOSS Portal, the GEO Discovery and Access Broker and the GEOSS Yellow Pages. Looking at the Core Digital Ecosystem Enablers initially identified in D3.6, it is easy to recognize that these are covered, at least partially, by the current GEOSS Platform components.

Besides, through the development of its use cases, GPP provided a significant contribution in assessing the proposed vision of the GEOSS Digital Ecosystem. In fact, use cases build on top of existing European GEOSS Platform components (which, as observed in previous section, can be considered as first implementations of GEOSS Ecosystem Enablers) and, when needed, develop prototypes of the missing middleware components. Thus, on one hand, GPP use cases can be used to validate the use of European GEOSS Platform components as early implementations of Core Digital Ecosystem Enablers; on the other hand, GPP use cases can be used to prototype new components with the aim of demonstrating how the GEOSS digital ecosystem can be enriched by third-party actors (i.e., intermediate users) and how they could interface and interoperate with the Digital Ecosystem.

In D3.6, we analyze how the developments of GPP use cases contribute to demonstrate the GPP Vision of a GEOSS Digital Ecosystem and its way forward, allowing different actors to contribute to the GEOSS Digital Ecosystem, by providing new tools, services, applications, middleware and other third-party components which exploit and enrich the GEOSS DE.

2.3 Links with other project activities

GPP identifies five work packages as follows:

- WP1: Project management
- WP2: Use cases definition and user requirements specification
- WP3: GEOSS Evolution design, development, integration and deployment
- WP4: User validation and assessment
- WP5: Dissemination, training, exploitation and GEOSS Contribution

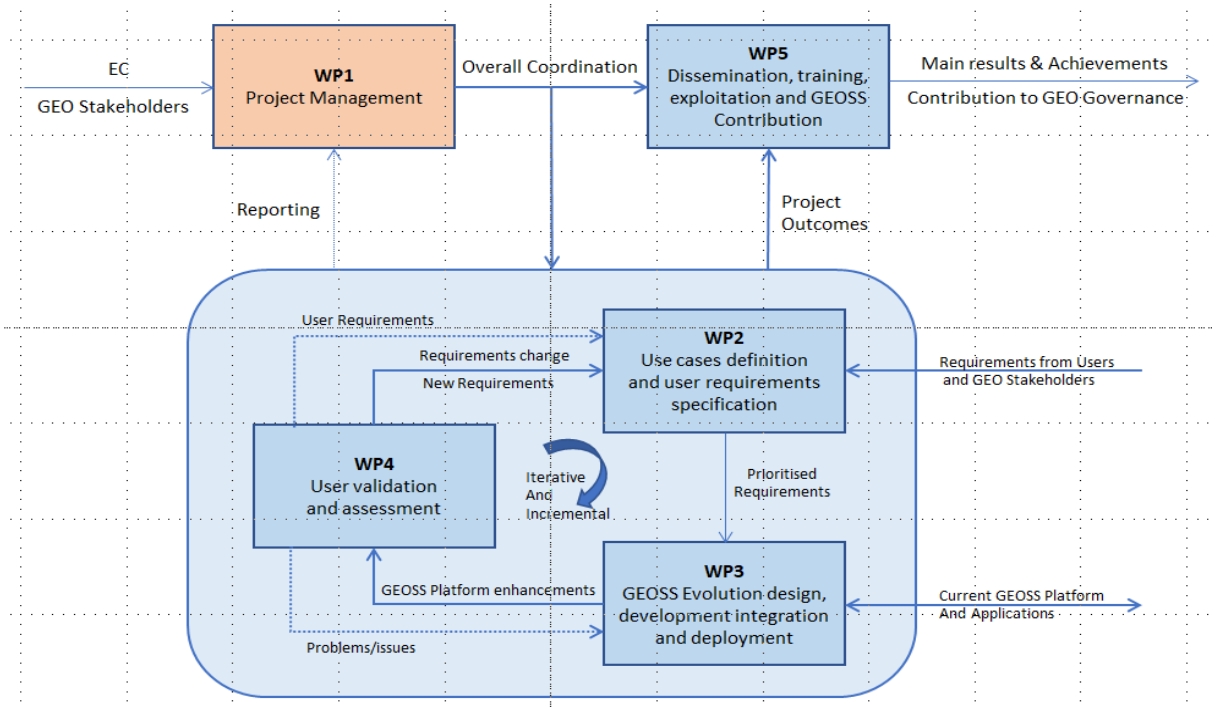


Figure 7 - GPP Work-packages and their relationships

WP3 builds on prioritized GEOSS Platform requirements as input to the identification of enhancements, their implementation and definition of an integration and verification strategy. The output of WP3 is an enhanced GEOSS Platform. On top of the requirements resulting from WP2, current workpackage considers as well requirements and other inputs resulting from other (external activities).

3. The Enhancements

Strategic Actions lines are the high-level areas for which enhancements have been investigated. The following strategic action lines have been identified within GPP:

- Components-based: APIs, Views, Widgets, Customised GEOSS Portal, Middleware, GEOSS Infrastructure, GEOSS Platform components
- Community-driven: GEO Activities, Initiatives, Flagships and communities' portals, EU Projects, communities' applications
- Reusability, Reproducibility, Replicability: knowledge sharing, experiments replicability, reproducibility and reusability, actionable information generation.

Components-based enhancements refer to all those enhancements to components and/or tools (APIs, Views, Widgets etc) that are made necessary to address the applications needs and are being implemented to fulfil GEO users' requirements and use cases.

Community-driven enhancements refer to all those enhancements coming from the GEO communities (Activities, Initiatives, Flagships) and EU projects (EIFFEL, e-Shape) requirements that drive new evolutions of GEOSS, GEOSS Platform, applications and services and middleware components to support community's needs.

Reusability, Reproducibility and Replicability enhancements refer to all those enhancements that will drive GEOSS evolution in support the scientific paradigm for replicate, reproduce and reuse experiments and enable knowledge sharing capabilities within the GEOSS Platform and GEO Communities and to trigger the generation of actionable information.

In particular, for the first and second evolution cycles the following enhancements have been identified and implemented in GPP:

- Components-based
    - DAB enhancements: harvesting of new catalogues and resources, and the creation of a dedicated view for the AfriGEO Community Portal implementation.
    - Community Portal Self Creation tool
    - Custom Dashboard
    - Yellow Pages 2.0
- Community-driven
    - SDG 15.3.1 Land Degradation enhancements related to the possibility to exploit customisable AOI over Africa for the three mandatory resources: Land cover, Productivity and Soil carbon maps over 3 specified regions Rwanda, Ghana, Uganda, Lesotho, Switzerland and Italy
    - AfriGEO - custom community Portal that allowed the AfriGEO community to get access to the customized community Portal package to be installed on their own premises. Customisation is related to DEA (Digital Earth Africa) data registration, View generation, Logo of the portal and whished thematic.
    - All Atlantic
    - Eiffel Discovery Cognitive Search
    - SDG 11.7
    - Water Cycle Pollution
    - Biomass
    - Norovirus

    - AGAME project
    - Maps4GPP
    - GEOSS Platform Landing Page
- Reusability, Reproducibility and Replicability
    - Virtual Earth laboratory component enhancements to allow the generation of additional knowledge from the SDG 15.3.1 algorithm with statistics and to enable the possibility to select different cloud resources providers to better satisfy users computing resources needs and familiarity.

3.1 Components-based Enhancements: APIs, Views, Widgets, Customised GEOSS Portal, Middleware, GEOSS Infrastructure, GEOSS Platform components

3.1.1 DAB

DAB is the main data provider of the portal. It serves with high content resource entries and datasets with filters, catalogues, and views. It also provides a registry of other Data Providers.

The latest data sources which were brokered and/or updated by the DAB are:

- DIONE Catalogue
- Digital Earth Africa (DEA)
- Water Quality Emergency Monitoring Service (WQeMS) Platform
- PRISMA (PRecursore IperSpettrale della Missione Applicativa)
- SEA scieNtific Open data Edition (SEANOE)
- European Marine Observation and Data Network (EMODnet)
- Webservice Energy Catalog
- TWIGA (in-situ data)
- Data Integration and Analysis System (DIAS) - Japan
- Federated EO Gateway (FedEO) – CEOS
- CEOS WGISS Integrated Catalog (CWIC)
- South African Environmental Observation Network (SAEON)
- PANGAEA
- China GEOSS
- AGAME
- ICOS
- Agrostac
- WorldCereal
- Harmonia

In addition, specific enhancements were developed to support the All-Atlantic use case:

- Fine-tuning the metadata coming from catalogues which are part of the All-Atlantic View (keywords, organizations, etc.)
- Creating advanced filters to allow the search for All-Atlantic sister projects (iAtlantic, Atlas, AtlantOS, TRIATLAS, MEESO, SUMMER, Mission Atlantic, AquaVitae, SO-CHIC)

- Brokering of new data sources (e.g. SEANOE)

As far as enhancing the support for in-situ data, GPP is collaborating with EEA to enhance the brokering of EEA data source with the following developments:

- Fine-tuning of metadata harvesting from GEO DAB
- Increasing the visualization feature using the Web Map Service (WMS) or the ArcGIS REST APIs
- Focusing on the discovery of in-situ data and the possibility to tag/categorize them - ongoing tests with EEA
- Enhancing the access feature to allow direct download of EEA products from the GEOSS Portal - ongoing tests with EEA.

Besides, a specific view for the AfriGEO Community Portal was created based on AfriGEO community requests.

In addition, GEO DAB was enhanced to support the new use cases developed in GPP dealing with in-situ data. In particular, the internal GEO DAB data model was extended to accommodate new metadata fields specifically utilized by the Agrostac and WorldCereal data sources. On top of this, the GEO DAB APIs were extended to provide additional harmonized filtering capabilities based on such metadata fields (e.g., crop type). These extensions were utilized by the GEOSS portal implementation of the "Harmonized agronomy in-situ data" view. In addition to these additional filtering capabilities, GEO DAB was enhanced to support the download of data from these in-situ repositories, allowing users to download only the data which matched their filtering criteria.

Finally, GEO DAB was extended to support a specific filtering capability to filter out non in-situ data, based on data providers' information. This feature was experimented with Agrostac, WorldCereal and EEA data sources. This capability is still under test and will be enhanced in future iterations with the availability of data providers sharing this type of information with GEO DAB (i.e., tagging their metadata as "in-situ").

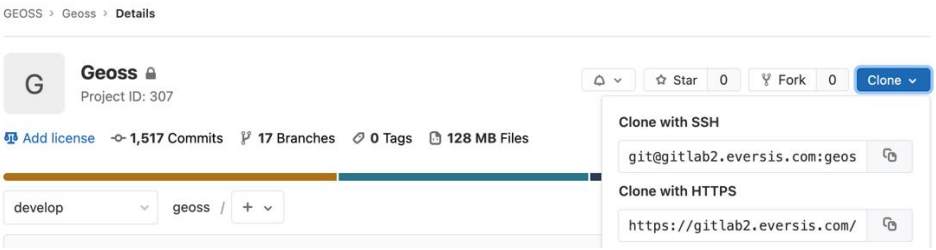
3.1.2 Community Portal Self Creation

The third phase of implementation of the Community Portal Self Creation tool resulted into the possibility to replicate all of the operational environment of the GEOSS Portal features, along with the options available only in terms of Proof of Concepts. With dedicated tool called "Creator", creating your own instance of Geoportal is as simple as possible.

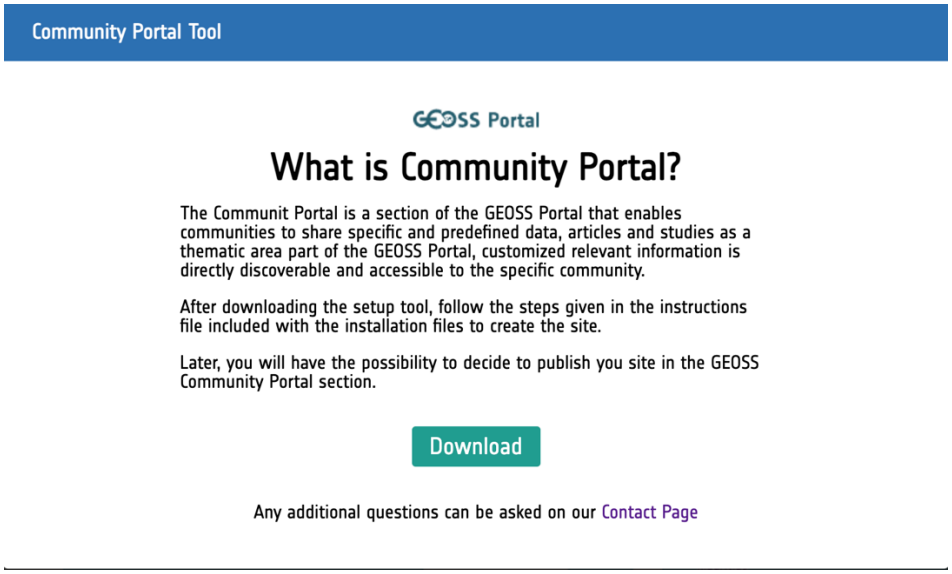
There are two ways of creating a community portal:

1. Clone or fork public repository
2. Download Docker images (packages) and install it on user's premises
3. Request creating a new community portal on current instance of a Geoportal

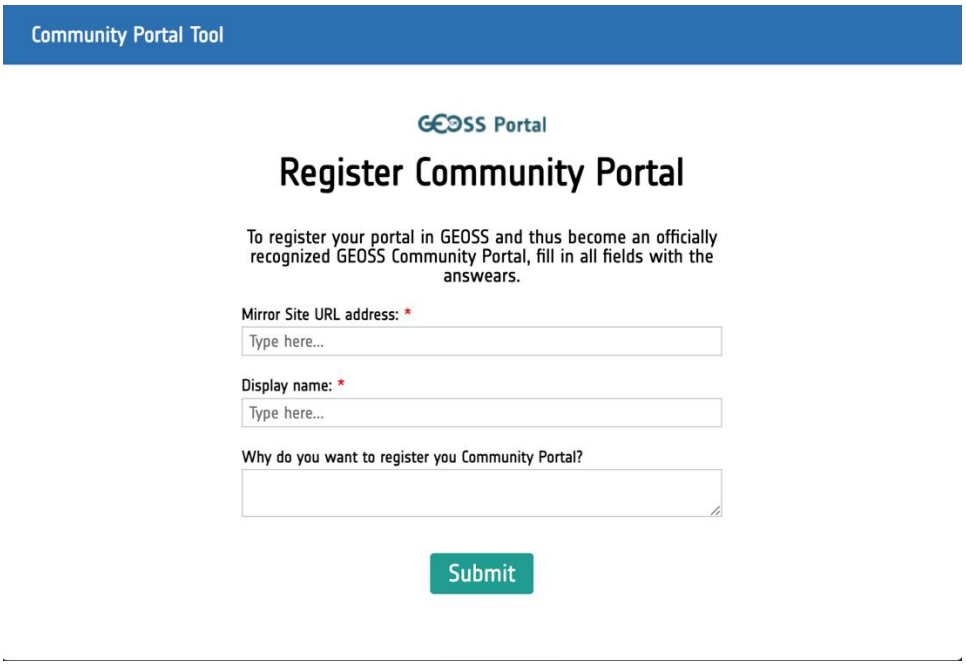
In the first approach (clone repository), registered user can download necessary packages and install them on one's premises, using his own hosting machines and infrastructure. Following steps in the technical instructions given with the packages, process is simple and complete. As an administrator of new instance, one has a full access to the system features along with the code modifications.



In the second approach (download Docker images), user has all of the necessary code packages already built and ready to deploy. Following the instructions, user can run them directly from Docker environment. Again, administrator access gives user the possibility to use all portal features, but this time, without codebase changes.



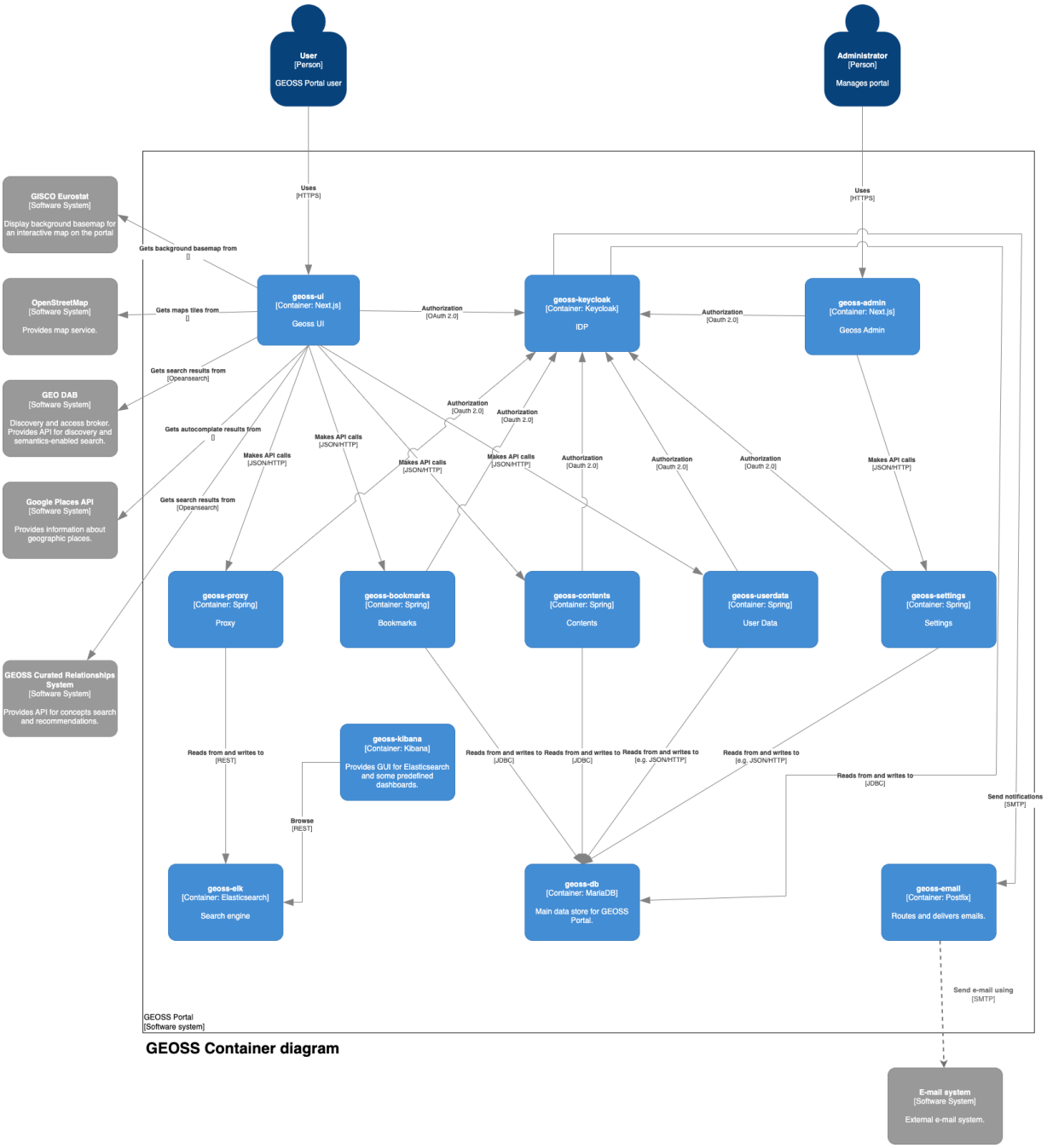
In the third approach, user can request creating a new community portal within already existing Geoportal instance. In this case, request is sent to the instance administrator and through the creator tool, he can easily create new community portal. User requesting for new community portal has limited impact of changes, restricted only to content management.



3.1.2.1 Microservice architecture

To achieve this flexibility, codebase of a Geoportal itself had to be rebuild, from outdated and insecure Liferay 6.2 monolith to modern microservice architecture.

The diagram below briefly visualizes the component and internal structure of the new applications architecture.



GEOSS Container diagram

3.1.2.2 Technical Specifications

Following list contains the description of all components, categorized by new architecture components:

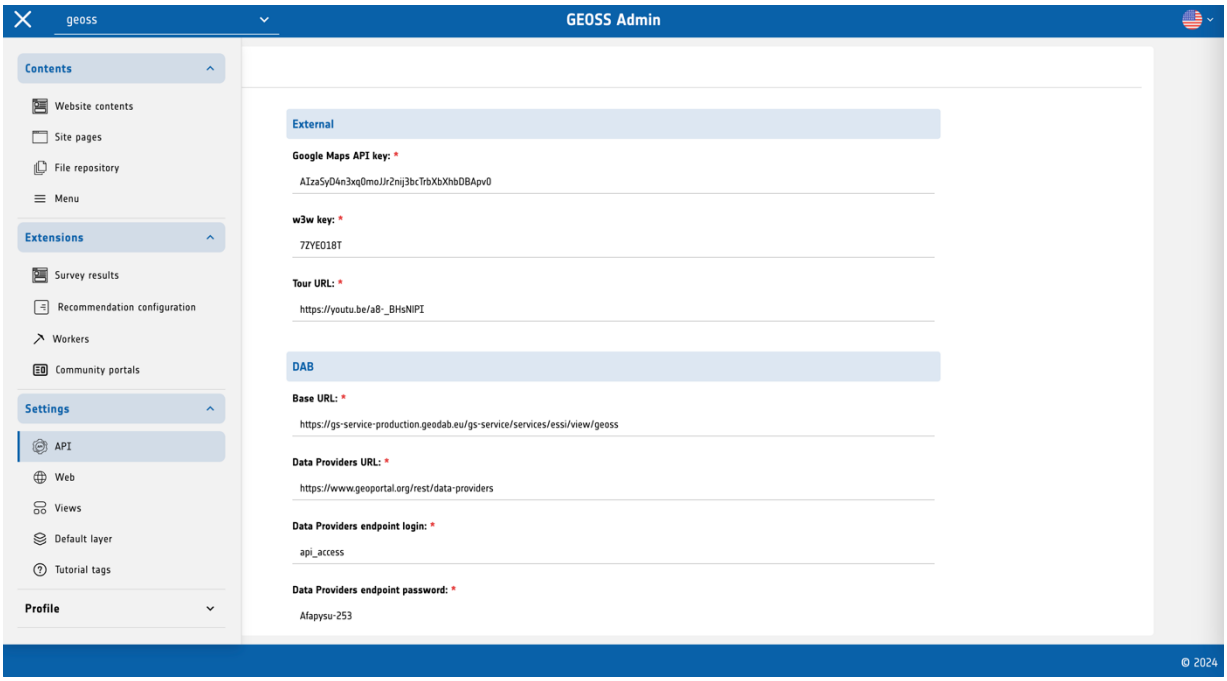
- GEOSS-ADMIN Component
- GEOSS-COMMON Component
- GEOSS-CONTENTS Component
- GEOSS-CURATED Component
- GEOSS-DB Component
- GEOSS-ELS Component

- GEOSS-KEYCLOAK Component
- GEOSS-KIBANA Component
- GEOSS-LANDINGPAGE Component
- GEOSS-LOGSTASH Component
- GEOSS-MATOMO Component
- GEOSS-NGNIX Component
- GEOSS-PERSONALDATA Component
- GEOSS-PROXY Component
- GEOSS-SEARCH Component
- GEOSS-SETTINGS Component
- GEOSS-UI Component
- GEOSS-WORKER Component

3.1.2.2.1 GEOSS-ADMIN Component

The fronted part of system for administrators. It let's administrators to manage all of the contents and settings for given Geoportal instance, with structured menu panel on the left side:

1. Contents
    a. Website contents
    b. Site pages
    c. File repository
    d. Menu
2. Extensions
    a. Survey results
    b. Recommendation configuration
    c. Workers
    d. Community Portals
3. Settings
    a. API
    b. Web
    c. Views
    d. Default layer
    e. Tutorial tags
4. Profile
    a. My profile
    b. Console
    c. Logout



3.1.2.2.2 GEOSS-COMMON Component

The backend part of system containing common technical features, methods and tools required to build and run the applications.

3.1.2.2.3 GEOSS-CONTENTS Component

The backend component related to system contents. This is a set of REST APIs used for following scope:

1. Contents
2. Documents
3. Folders
4. Menus
5. Pages
6. Profile-controller
7. Sites

Documentation can be found here:
https://admin.geoportal.app/contents/swagger-ui/index.html

3.1.2.2.4 GEOSS-CURATED Component

The backend component related to system curated resources. This is a set of REST APIs used for following scope:

1. Access policy
2. Bookmarked
3. Data-sources
4. Elasticsearch

5. Endpoint
6. Extensions
7. Organisation
8. Protocol
9. Rating
10. Recommendations
11. Relations
12. Resources
13. Source
14. Stats
15. Transfer option
16. Transfer option extension
17. Type
18. User dashboards
19. User extensions
20. User relations
21. User resources
22. Workflow

Documentation can be found here:
https://admin.geoportal.app/curated/swagger-ui/index.html

3.1.2.2.5 GEOSS-DB Component

The backend component related to system database managements. It includes database configurations and initial states.

3.1.2.2.6 GEOSS-ELS Component

The backend component related to internal system data storage and search. It includes all of the configuration for Elastic Search client.

3.1.2.2.7 GEOSS-KEYCLOAK Component

The backend component related to system authorization. This application, as standard IDP client, provides all of the methods, roles, permissions, etc. to identify and authorize the user within the Geoportal instance.

3.1.2.2.8 GEOSS-KIBANA Component

The backend component related to internal system data dashboard for administrators.

3.1.2.2.9 GEOSS-LANDINGPAGE Component

The frontend component related to separate Landing Page application.

3.1.2.2.10 GEOSS-LOGSTASH Component

The backend component related to internal event logging system.

3.1.2.2.11 GEOSS-MATOMO Component

The backed component related to behavioural data collecting.

3.1.2.2.12 GEOSS-NGINX Component

The backend (server) component related to internal infrastructure hosting and request handling.

3.1.2.2.13 GEOSS-PERSONALDATA Component

The backed component responsible for user data management. It is a set of REST APIs used for following scope:

1. Comments
2. Feedbacks
3. Highlighted-searches
4. Profile-controller
5. Saved-runs
6. Saved-searches
7. Settings
8. Surveys

Documentation can be found here:
https://admin.geoportal.app/personaldata/swagger-ui/index.html

3.1.2.2.14 GEOSS-PROXY Component

The backend component related to request handing.

3.1.2.2.15 GEOSS-SEARCH Component

The backend component related to GEOSS Curated Resources search and support. It is a set of REST APIs used for following scope:

1. Concepts
2. Extensions
3. Opensearch
4. Recommendations

Documentation can be found here:
https://admin.geoportal.app/search/swagger-ui/index.html

3.1.2.2.16 GEOSS-SETTINGS Component

The backend component related to system settings. It is a set of REST APIs used for following scope:

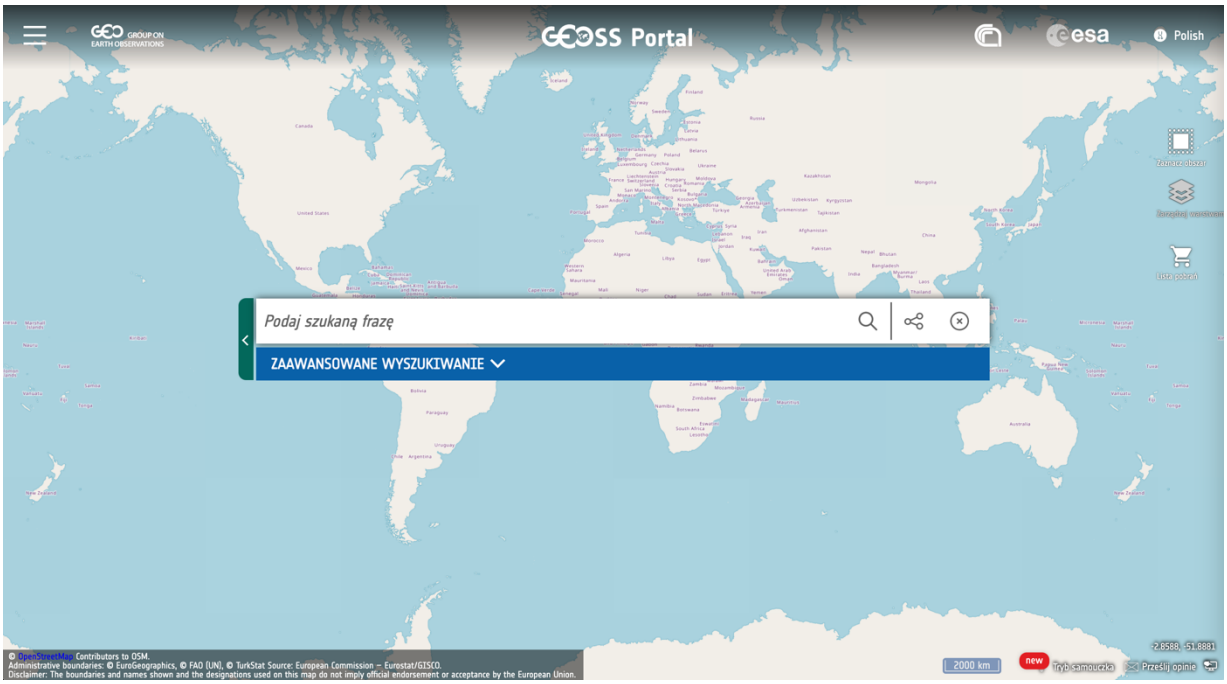
1. Api-settings
2. Catalogs
3. Dabs
4. Default-layers
5. Profile-controller
6. Regional-settings
7. Site
8. Tutorial-tags
9. Views

10. Web-settings

Documentation can be found here:
https://admin.geoportal.app/settings/swagger-ui/index.html

3.1.2.2.17 GEOSS-UI Component

The front-end part of the system for external users, with header, search box and basemap background.



3.1.2.2.18 GEOSS-WORKER Component

The backend part of system that runs the necessary data gathering workers triggered by administrator.

3.1.3 Eiffel Discovery Cognitive Search

In collaboration with EIFFEL project, GPP developed a proof of concept for the integration of EIFFEL cognitive search functionalities in GEOSS Platform.

The EIFFEL project developed a system that comprises an AI language model optimized for Clima Change-related text and queries[1]. To do this, GPP provided EIFFEL with a subset of the GEOSS Platform metadata, that was utilized for training the AI language model.

In order to exploit this capability in the GEOSS Platform environment, GPP and EIFFEL projects collaborated to implement a set of specific APIs which enable the discovery of GEOSS content not only with traditional text-based searches, but also taking advantage of the EIFFEL cognitive search. In particular, two integration approaches were implemented:

[1] https://meetingorganizer.copernicus.org/EGU23/EGU23-16662.html

- Cognitive Search
- Cognitive Sorting

From the technical point of view, the two approaches differ in how user's queries are fullfilled. The following provides the high level steps which are executed.

Cognitive Search:

a) DAB sends query to EIFFEL API, including paging information
b) EIFFEL API returns a sorted list of record ids
c) DAB filters the returned record ids according to user's constraints (e.g., bounding, etc.)

Cognitive Sorting:

a) DAB filters according to user's constraints (e.g., bounding, etc.)
b) DAB sends the first N records (according to the requested paging) of step a) to EIFFEL API
c) EIFFEL API returns the N records sorted according to NLP

The implementation was completed and demonstrated at a dedicated EGU splinter meeting co-organized by the GPP and EIFFEL projects..

3.1.4 Yellow Pages 2.0: development, testing and deployment in pre-production (UAT)

The Yellow Pages (YP) has been completely redesigned to be fully integrated in the GEOSS platform, using the same look-and-feel and adding new functionalities enabling data providers to manage their records.
The production instance is now available and fully operational on UNIGE servers at:
https://yellowpages.unepgrid.ch/
All accounts are now created and both the GEO sec (Paola De Salvo) and UNIGE team can track the different steps of the registration process.
All the content of YP1.0 has been successfully transferred to the YP2.0

A full installation guide of the YP component will be also available covering the following aspects:
Prerequisites:

1. Open network communication between app_server and database_server
2. Open network communication between app_server and smtp_server
3. Active domain SSL certificate and key

Database requirements:

- Database one of MariaDB, MySQL or PostgreSQL
- Created empty scheme with encoding UTF-8 and time zone UTC
- Crated user with permissions to DDL (Data Definition Language), DML (Data Manipulation Language), and TCL (Transaction Control Language) to the scheme
- Granted access to database from application server

E-mail requirements:

- SMTP server
- Created account for sending emails
- Connection to the SMTP server should be secured by SSL or TLS
- Granted access to smtp from application server

The installation consists in 9 steps:

- Step 1 – check and install available updates
- Step 2 – install docker and rest of the components
- Step 3 – unzip installation files
- Step 4 – change working directory
- Step 5 – import images
- Step 6 – edit environment variables
- Step 7 – set environments
- Step 8 – copy SSL certificate
- Step 9 – run containers

The domain name under the geoportal.org umbrella has not been implemented (waiting a confirmation from the responsible parties).
Still waiting that the link to the new YP is updated on the GEOportal.

3.1.5 AI Based Search

The AI Search Page was developed as a proof of concept to explore the use of artificial intelligence for data discovery within the GEOSS Platform. By leveraging natural language processing (NLP) and machine learning, the AI Search Page enables users to intuitively find relevant Earth Observation datasets, offering an enhanced search experience compared to traditional text-based methods.

3.1.5.1 Application and Functionalities Implemented

The AI Search Page includes the following implemented functionalities:

- **Natural Language Query Support**: Users can input queries in everyday language, such as “data for floods in Spain” or “land cover changes over the past decade.” The AI interprets the intent and context of these queries to return relevant results.
- **Suggested Datasets**: The AI processes user queries and provides a list of datasets that align with the user's intent.
- **Download Instructions**: If requested by the user, the system provides clear and detailed instructions on how to access and download suggested datasets.
- **Related Dataset Recommendations**: Based on the user’s query, the system can provide additional dataset recommendations upon request, enabling broader discovery and enhanced user experience.
- **User Interface**: A dedicated and intuitive search bar allows users to interact with the AI-powered functionality, ensuring ease of use.

3.1.5.2 Interfaces with GEO infrastructure

The AI Search Page interfaces with the GEO infrastructure through a link to the GEOSS Portal, directing users to its extensive data resources.

In the future, it is recommended to enhance this integration by adding a reciprocal link from the GEOSS Portal to the AI Search Page. This would provide users with an additional option for discovering data and improve the overall usability of the GEO ecosystem.

3.1.5.3 Functionalities Not Implemented

While the current implementation delivers core AI-driven search functionalities, some features remain unimplemented:

- **Bidirectional Linking with GEOSS Portal**: Although the AI Search Page links to the GEOSS Portal, a corresponding link from the GEOSS Portal to the AI Search Page has not been established. This functionality is recommended for future development to create a seamless user experience.

3.2 Community-driven Enhancements: GEO Activities, Initiatives, Flagships and communities' portals, EU Projects, communities applications

3.2.1 SDG 15.3.1 Land Degradation

Avoiding, reducing and reversing land degradation and restoring degraded land is an urgent priority to protect the biodiversity and ecosystem services that are vital to life on Earth. There is an immediate need to enhance national capacities to undertake quantitative assessments and corresponding mapping of their degraded lands.

The user wants to calculate the related SDG indicator 15.3.1 at the national scale, based on the official GPG 2.0 guidance document from UNCCD, using the GEOSS platform. The objectives of this indicator include the dissemination of knowledge on land degradation. The GEOSS Portal enables the user to independently start the computation of chosen resources in terms of land degradation and visualize the outcome in various forms and also add it to a customized dashboard.

The users shall be also enabled to add the finished dashboard in My Workspace menu and share it with the specified users.

The user could be enabled to share the dashboard with all the GEOSS users, upon verification by the Administrator.

Flow

1. The user connects to the GEOSS platform and does a search for "Land degradation".
2. The user obtains a number of resources that matches his search criteria.
3. The user can discover (or a pre-selection can be made) of the required sub-indicators (see data domain) available in the GEOSS platform and selects the most suitable for his/her needs.
4. The user can discover different data, services and knowledge and their relationship associated to the SDG 15.3.1 indicator. The user can then navigate deeper into the different sources.
5. The user discovers a dedicated model to compute the SDG indicator
6. The user realizes that there is a Service associated to this model. The GEOSS Platform associates the model to the actual processing services that enable its computation, which the user can access and run in a user-friendly way. In particular, the user can inspect the process workflow and search and select data as input to the service. In addition, the user has the capability to choose a Cloud computing platform of preference among the available (these include all the DIAS Platforms and Amazon Web Services).

7. In case the user has registered newly data, it will be possible the discover and select them as input to the service.
8. The user can now start the computation on the selected infrastructure and wait for the results
9. The user can visualize the outputs in a dedicated dashboard (that can be further elaborated/modified and shared afterwards).
10. The created dashboard can be added in My Workspace, the user who created the dashboard can chose between sharing his work with other specific users or to render it accessible to all the platform users. In this case the User who created the dashboard should become a data provider or need the Administrator authorization.
    The procedure regarding the acceptance or rejection by the Administrator is the following :
    a. Administrator can reject the dashboard creation and provide information why the rejection happened. User, that created the dashboard can then update it according to the provided information or discard the whole process.
    b. Administrator can accept the dashboard and in this case this dashboard will be accessible for both User, that created it and Users, that are looking for similar data in within the system. The data will be obtainable within the information tab.

New enhancements compared to the previous version

The possibility to add user selected AOI

All the enhancements covering the full use-case presented in the section 4.2.1 are now operational.

In particular, now users have the ability:

- to select an Area of Interest (AOI) during the Run creation based on a drawing tool (defining a specific AOI) or by selecting a given country and or region
- The dashboard functionality now allows selecting which map to show (SDG 15.3.1 indicator and/or sub-indicators); same for the graphs; possibility to add several pages.
- Select a computing backend (i.e., AWS, CreoDIAS, …)
- Share a selected dashboard.
- Search for available dashboards in the platform

It is now possible to add a user-selected AOI during the Run creation. When user is interested in creating a computation run, along with other inputs one can specify the desired Area of Interest, by enabling “expert options” below the “Workflow inputs” table.

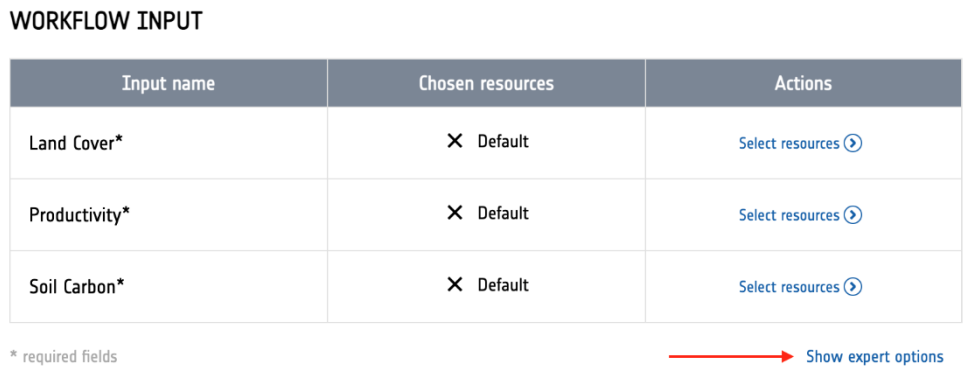


Figure 8 - Enabling expert options during run creation.

WORKFLOW INPUT

Input name	Chosen resources	Actions
Land Cover*	✕ Default	Select resources
Productivity*	✕ Default	Select resources
Soil Carbon*	✕ Default	Select resources
Area of interest	Worldwide	Set bounding box

* required fields

Hide expert options

Figure 9 - Workflow input table with a highlighted option for setting AOI.

By default, Area of Interest is set to “Worldwide”, however it can be freely changed with “Set bounding box” button, which enables selection of an area on the map, via filtering AOI tool.

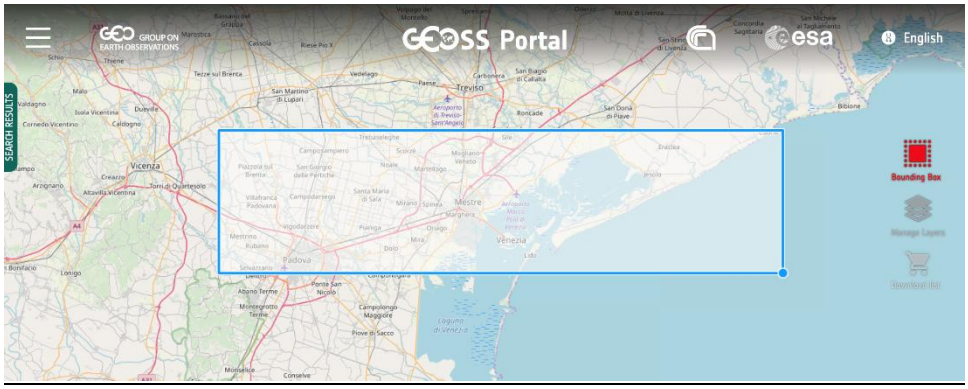


Figure 10 - Example of a custom-selected AOI

After selecting the area, user is redirected to computation run creation and may complete the inputs of the run, with the coordinates of the area filled in.

WORKFLOW INPUT

Input name	Chosen resources	Actions
Land Cover*	✕ Default	Select resources
Productivity*	✕ Default	Select resources
Soil Carbon*	✕ Default	Select resources
Area of interest	W: 11.706500923733937 S: 45.3565920768107 E: 12.605563271963636 N: 45.60205772669957	Set bounding box

* required fields

Hide expert options

Figure 11 - Example of a custom-selected AOI within the workflow input table. AOI coordinates are highlighted.

3.2.1.1 WORKFLOWS and NEW DATASETS Registration

To implement the new features of the SDG15.3.1 it has been updated the name of the model, to make it more generic from “European Model” to a more generic “Land Degradation Service”. This allows the user to run the model not only over a predefined European area, but also to some African regions and like: RWANDA, GHANA, UGANDA and SWITZERALND, ITALY, LESOTHO, and EUROPE.

New datasets have been prepared and registered by the DAB and made discoverable and accessible via the GEOSS Portal. The following datasets have been made available:

- EUROPE: Land Productivity, Soil Carbon, Land Cover
- ITALY: Land Productivity, Soil Carbon, Land Cover
- SWITZERLAND: Land Productivity, Soil Carbon, Land Cover
- LESOTHO: Land Productivity, Soil Carbon, Land Cover
- UGANDA: Land Productivity, Soil Carbon, Land Cover
- RWANDA: Land Productivity, Soil Carbon, Land Cover
- GHANA: Land Productivity, Soil Carbon, Land Cover

Another feature added is the possibility to process a map of land degradation and an excel file with statistics about the different parameters and regions of the Land degradation and the possibility to select among different cloud providers. While VLab, which enables the execution of the Land Degradation model, was successfully tested on CreoDIAS, ONDA DIAS and Sobloo DIAS, at the moment these cloud providers can’t be used because the test environments which had been provided on such platforms are no longer available. Currently only AWS and EOSC (European Open Science Cloud) are available.

3.2.2 AfriGEO Community Portal

The AfriGEO initiative seeks to identify challenges and put in place measures to enhance Africa’s participation in, and contribution to, GEOSS. This participation will support the continent’s efforts to bridge the digital divide and build a knowledge-based economy using GEO networks and GEOSS infrastructure.

The main requirement is to deliver for the AfriGEO a frontend component of the GEOSS Platform that will allow to set up on AfriGEO premises a Community portal with a look and feel present in the GEOSS Portal. Due to the time limitation, delivering the complete solution with a set-up tool and decomposed backend components is impossible. Therefore, certain functionalities, such as those requiring logging in or those not part of the Operational system (present in other environments such as SIT, UAT or Development), will not be present within this first step.

The end product is an installation package which needs to be deployed according to instructions and configured via configuration files on the User premises.

The design and solution proposed in this first step is a proof of concept. We want to clarify that this temporary solution will be scratched later in the project to make space for a new solution with a new architecture approach.

3.2.2.1 Technical specification

This chapter describes what software and hardware requirements must be met to set up the GEOSS Platform's frontend components.

AfriGEO component is a standalone static website with Vue.js (version 2) based Single Page Applications for a Search and Yellow Pages modules and static HTML5 / CSS3 / JavaScript content pages. It can be hosted on any service that provides static website support (FTP, Cloud hosting, VPS).

Minimal hosting Hardware requirements:

- CPU: minimum 2 vCPU/Cores (single-threaded), 4 vCPU (2 cores with hyperthreading or 4 physical cores) recommended
- RAM: 4 GB at minimum
- Hard Disk: 25GB at minimum, including space for the OS installation (not including the need for backups, other services, etc.)

Software:

- A Linux distribution of choice (Ubuntu/Debian/Fedora/Rocky Linux)
- A web server of choice – nginx/Apache HTTPD/Lighttpd (nginx recommended)
- Software allowing remote access possibility, to upload the web application package (for example vsftpd for FTP functionality, or properly configured SFTP on SSHD)

Libraries and plugins:

Name	URL	License
Axios	https://github.com/axios/axios	MIT License
Open Layers	https://github.com/openlayers/openlayers	BSD-2-Clause license
Vue.js	https://github.com/vuejs/vue	MIT License
Vuex	https://github.com/vuejs/vuex	MIT License

NOTE: Requirements and technical specifications will be changed when the Mirror Site Tool Scenario is developed.

3.2.2.2 Elements in the Portal

Within the installation package following elements of the portal shall be present:

- **Configuration file:**
  - Logo image source
  - Site name
  - External API URLs
  - Menu elements
  - List of views and default view

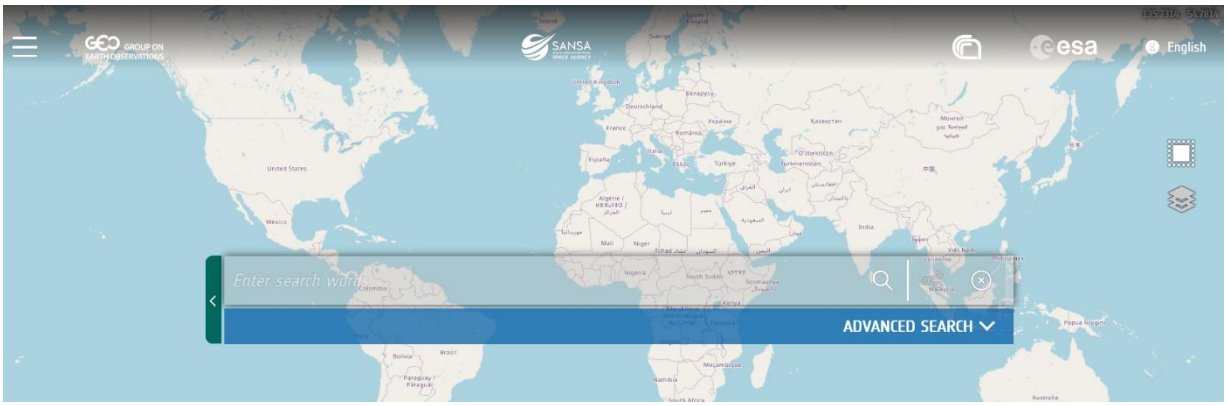


Figure 12 - AfriGEO Community Portal, homepage

The configuration file will contain all necessary configuration details, saved as a JSON text file.

- **Pages:**
  - General Information
  - Terms and Conditions
  - Release notes
  - Help Desk
  - Documentation
  - Tutorials
  - Yellow Pages

Each page will be delivered as an empty one for the User to set up its description. This will be possible via the source code of the page. The only exception will be Yellow Pages, which will fetch the data about data providers via the DAB endpoint and present them similarly to GEOSS Portal.

- **Menu:**
  - About
  - User Support
  - Community Portals (menu you will consist of static links leading to currently present Community Sites and Geoss Portal)
  - Yellow Pages

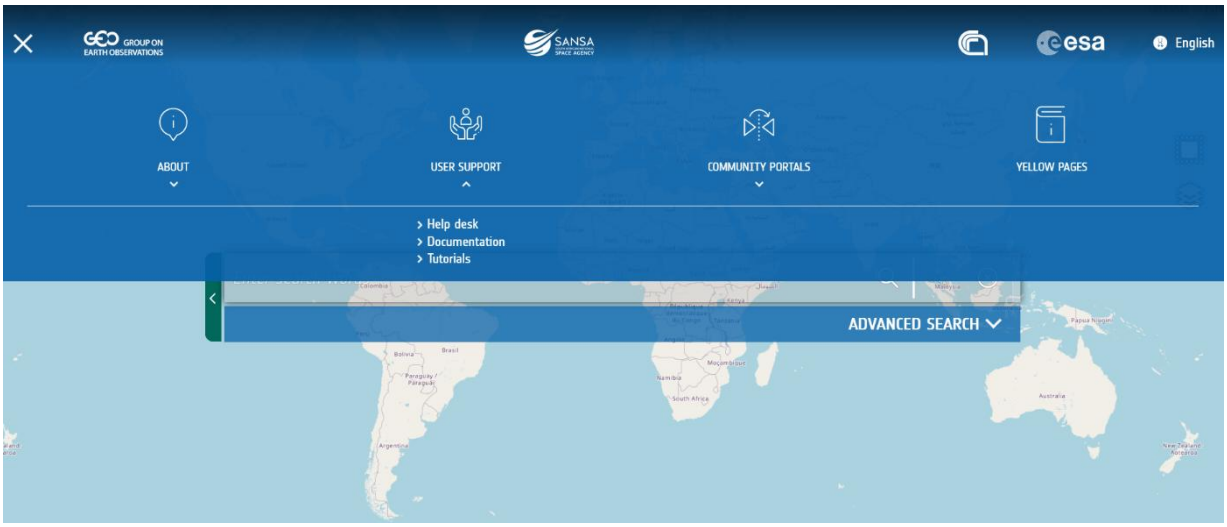


Figure 13 - AfriGEO Community Portal, Menu

- **Search component:**
  - Possibility to run a search via DAB component (dedicated endpoint to be configured via configuration files)
  - Advance search with a dedicated list of catalogues and views. A view can be chosen by default, which will be used to search for datasets. (to be decided if the view should only consist of AfriGEO or other views as well)
  - Continent and Country or Coordinates filter
  - Relation of the selected area
  - Date range filter
  - Facet filters built based on the response from the DAB component
- **Yellow Pages component**
  - Possibility to run a search for a data provider via the DAB database
  - Results sorting and pagination
  - Result entry with logo, title, description, link, traits and link sharing
- **Map component**
  - Base map provider
  - Area of Interest
  - Layers including comparison tool

3.2.2.3 List of functionalities not implemented

Hereafter there is a list of functionalities that will not be accessible due to the short implementation time or the fact that they are not yet operational.

- Geolocation and “Did you mean” component,
- Running workflow processes via VLAB,
- Enrichment of the resources,
- Saving searches,
- Tutorial mode,
- Send feedback,
- Extended View,
- Additional sources outside of DAB,
- Statistics,
- My workspace (with all its contents),
- Sign in,
- “See also” and “Popular” search hints,
- Survey.

3.2.3 Custom Dashboard feature

During the second cycle it has been finalized the Dashboard functionalities already implemented in the first cycle. The main implementation was the custom Dashboard used to reporting the results of the experiences. These functionalities are implemented on the UAT environment.

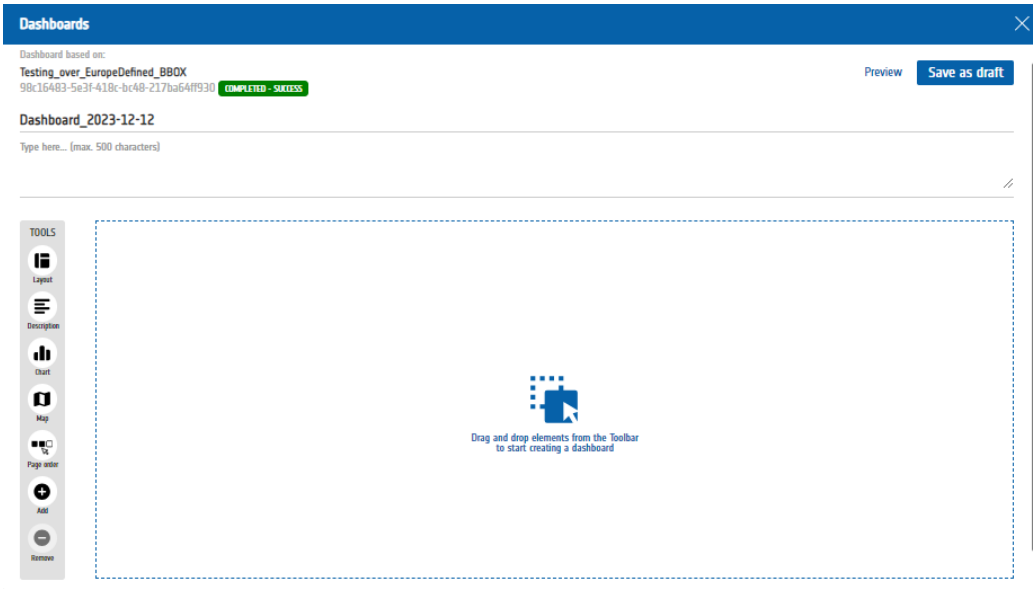


Figure 14 Custom Dashboard feature and possible customisation options

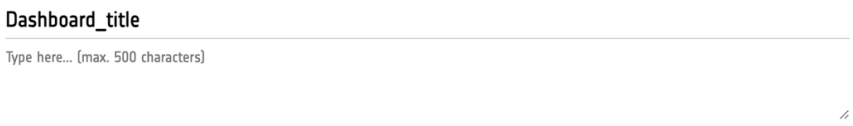
3.2.3.1 Dashboard functionality

Dashboard can be created based on finalized, successful computations performed through VLab or OpenEO service. Once the Dashboard is created, it can be shared via link with other users, or published by site administrator to make it discoverable by any Geoportal user in the Information tab. All computation outputs are downloadable via standard resource download mechanism.

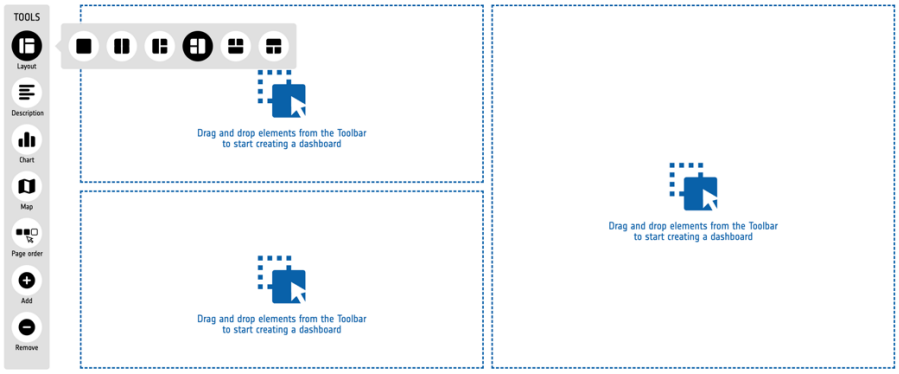
During the creation process, user can add a title and brief description on the subject of his computation. Apart of that, there are multiple drag&drop tools to make it more detailed and appealing.

3.2.3.2 Dashboard creation tools and options

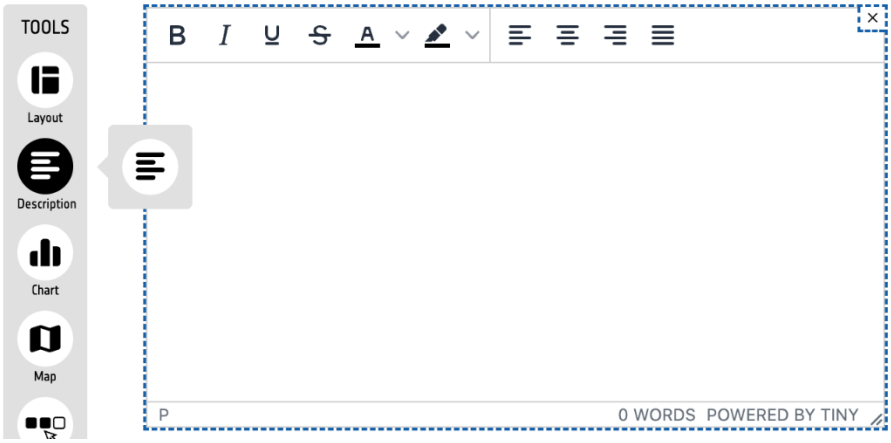
- Title and description fields - text fields visible at the search results list



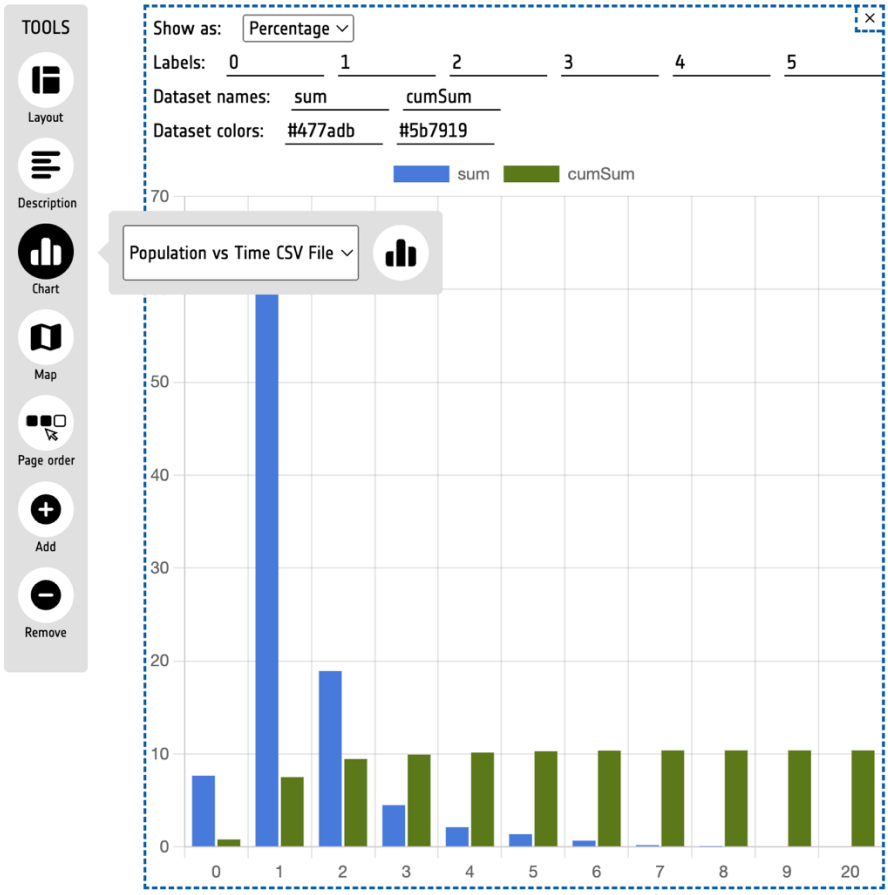
- Page layout settings - each page of the Dashboard can have it's own layout



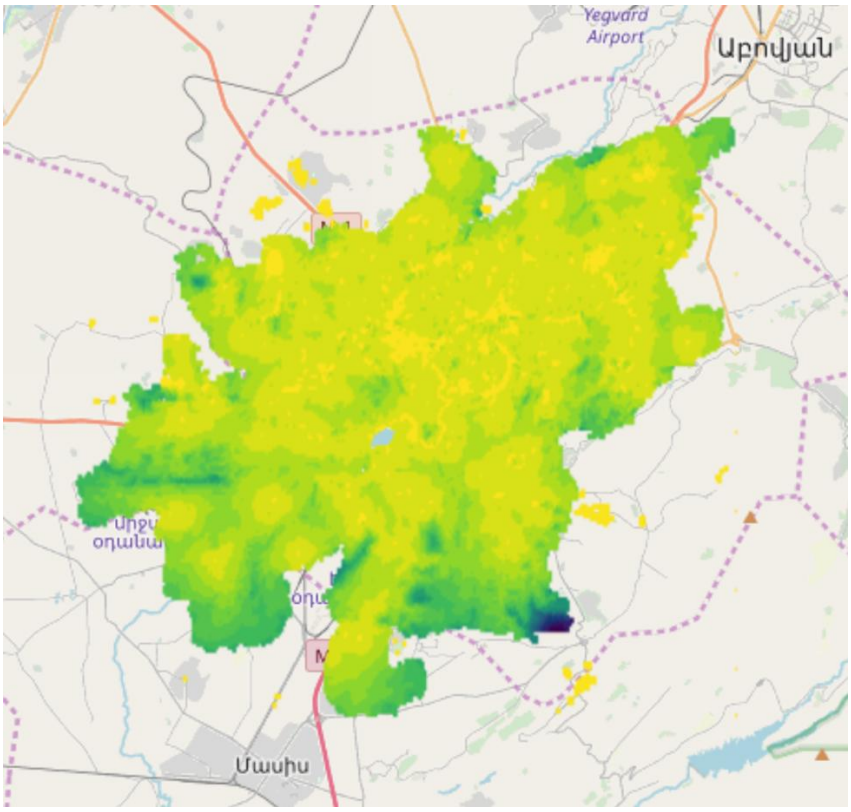
- Richtext editor - richtext lets user to create description paragraphs with standard text editor formatting options



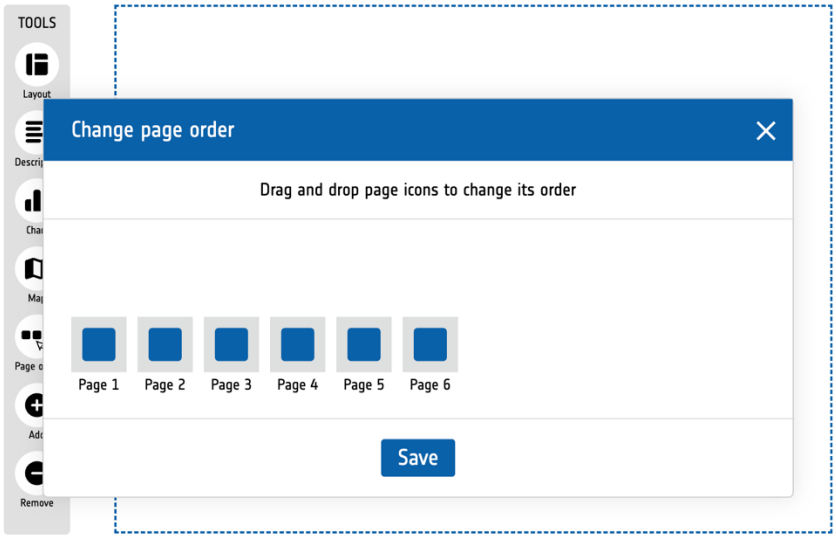
- Charts (if available) - if computation has CSV or Excel file as an output, it can be added to the dashboard as one of the elements. Additionally, user can modify the charts display data view type (percentage / numeric), add customized labels or change the colour of the plots.
  In case of CSV data, application supports multi-dimensional plots, for better data presentation.



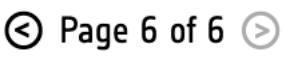
- Map (if available) - if computation has WMS or GeoTIFF file as an output, it can be added to the dashboard, as one of the interactive elements



- Page ordering - once pages are created, user can manage their order by drag&drop method



- Adding and removing page - user can add or remove pages of the dashboard



3.2.4 SDG11.7: Accessibility to urban green areas

The methodology for this use case has been established following the methodology developed in Giuliani et al. (2021) - https://doi.org/10.3390/rs13030422. The service implemented in the VLab enables users to compute urban green areas accessibility map and statistics. It will follows these different steps:

1. Select a city among the list of available cities.
2. Download the data necessary (from OpenStreetMap) to run an AccessMod model for the selected city. This step is automatically done using inAccessMod (https://doi.org/10.21105/joss.05879)
3. Green areas are automatically defined based on OSM data
4. Then these inputs are pushed to the AccessMod model is executed,
5. Outputs of the analysis are provided as map (in geotiff) and statistics (in csv)
6. Outputs are then further used in the Dashboard

The following cities have been tested to validate the service:

["Amsterdam","Berlin","Bern","Delhi","Dubai","Geneva","Goteborg","Lausanne","Lisbon","London","Lyon","Madrid","Marseille","Milan","Novocheboksarsk","Oslo","Oulan-Bator","Paris","Sion","Warsaw","Yerevan","Zurich"]

3.2.4.1 Application and functionalities implemented

The service is now available at:
https://gpp.uat.esaportal.eu/?m%3AactiveLayerTileId=osm&targetId=geoss_geodab_http%3A%2F%2Feu.essi_lab.vlab.core%2Fworkflow%2Fautogenerated-1726563166228-process&f%3Aphrase=green&f%3AdataSource=services

Under the “Services” tab

3.2.4.2 Interfaces with GEO Infrastructure

The service is implemented as a service into the VLab.

3.2.4.3 Functionalities not implemented

N/A

3.2.5 All Atlantic - Phase I

Changes to the Geoportal user interface, requested by the All Atlantic Community has been split into three phases. In the first phase of adjustments, following topics have been addressed:

- Enlarging portal logos
- Hiding resources for advanced search
- Data download process optimization
- Deleting "AtlantOS" link from the menu
- Separating "img" and "other" icons
- Shopping cart always visible
- Always showing data file type

In the followings paragraph they are explained in details.

3.2.5.1 Enlarging portal logos

Enhancement of the main community logotype to fit the larger, more horizontally oriented images in the header of the portal.

Figure 15 – Example of an enlarged portal logo

3.2.5.2 Hiding resources for advanced search

Enhancement of Advanced Search views management, letting the community administrator to choose single view as a default, unchangeable, single-value filter for the results

Figure 16 – Example of advanced searh form whose values have been customized

3.2.5.3 Data download process optimization

Multiple UI/UX changes to improve the download process across the Geoportal (including labels text changing, minor layout changes, headings changes, etc.) enhancing “Shopping Cart” pipe approach.

3.2.5.4 Deleting "AtlantOS" link from the menu

All Atlantic and AtlantOS community resources have been merged into single catalogue containing resources from both communities (governed from now on by All Atlantic)

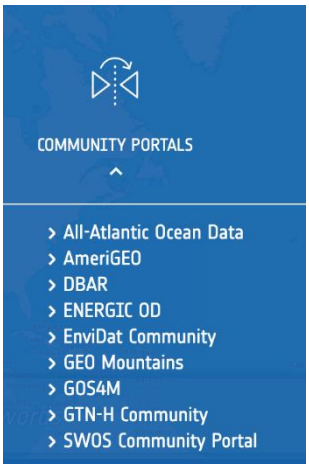


Figure 17 - Community portals menu after merging

3.2.5.5 Separating IMG and OTHER files icons

Improvement of file downloads format detection represented by icons, letting to distinguish images as PNG and JPG, and other formats as PDF, WMS service, HTML link, etc.

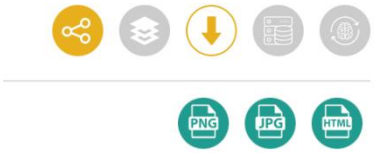


Figure 18 – Example of data types being listed in download options

Second phase of the All Atlantic suggestions, oriented mostly on the enhancement of the search results, is planned for future deliveries.

3.2.5.6 Shopping cart always visible

The shopping cart icon on the right side of the map should always be visible and clickable, not only when there are queues downloads. Opening an empty shopping cart should explain how to download a resource.

3.2.5.7 Always showing data file type

"Download" and "Add to download list" button should always show the file type icon, even when only one type is available. When there is more than one type available, the intermediate view with type selection should be displayed before opening the "Download" buttons.

3.2.6 All Atlantic - Phase II

In the second phase of adjustments to the Geoportal user interface, requested by the All Atlantic Community, following topics have been addressed:

- Adding AtlantOS logo in All Atlantic Community Portal
- Adding bounding box option in search filters, improving accessibility and user experience of the search view
- Redesign of the search results view – improving accessibility and user experience
- Distinguishing the resource type with the same name before downloading

3.2.7 All Atlantic - Phase III

In the third phase of adjustments to the Geoportal user interface, requested by the All Atlantic Community, following topics have been addressed:

- Changing link to DOI under AtlantOS logo in the Community Portal
- Replacing the AtlantOS logo to the iAtlantic logo
- Changing the button "Other" in search results – skipping the intermediate step if there is only one resource to choose from. The type of resource should be indicated by the tooltip visible after hovering over the "Download" button.
- Shortening the All Atlantic Community Portal URL

3.2.8 Nutrient Pollution in European Inland and Coastal Waters

In Europe, intensive agricultural practices together with high population density represent important sources of nutrients for fresh and coastal waters. Nutrient pollution is one of the major pressures on European aquatic ecosystems altering their condition. At present in the EU more than half of water bodies are not in good ecological status, with nutrient being one of the major causes of degradation.

Ambitious water policies are in place in the European Union (EU) for protecting and restoring aquatic ecosystems. Among these, the Urban Wastewater Treatment Directive (UWWTD) has the objective to "protect the environment from adverse effects of wastewater discharges from urban sources and specific industries".

The EU's Urban Wastewater Treatment Directive currently in force is more than 30 years old. Since its adoption in 1991, the quality of European rivers, lakes and seas has dramatically improved. The review of the Directive is one of the actions of the Zero Pollution Action Plan, one of the pillars of the European Green Deal.

In October 2022, the Commission revised the Directive, adapting it to the newest standards, in line with the results of an evaluation and on the basis of an extensive impact assessment. Impact assessments form a key part of the European Commission's "Better regulation" agenda, which seeks to design and evaluate EU policies and laws so that they achieve their objectives in the most efficient and effective way. Impact assessments collect evidence (including evaluation results) to assess whether future legislative or non-legislative EU action is justified and, if so, how it can best be designed to achieve relevant policy objectives.

One of the objectives of the revision was to improve water quality by addressing remaining urban wastewater pollution. To this aim, the GREEN model, developed by the EC Joint Research Centre, was utilized to quantify the current pressures of point and diffuse nitrogen and phosphorus emissions to European fresh and coastal waters and analyze the effects of different policy scenarios of nutrient reduction.

GREEN is one of the models documented in MIDAS, the Modelling Inventory and Knowledge Management System of the European Commission. MIDAS documents models and their contributions to Commission impact assessments. It describes a model's purpose and intended use, provides information on model structure, quality and transparency, as well as access to model documentation, useful references and the supported impact assessments.

The GEOSS Platform Plus project, in collaboration with the TIDE project led by JRC, developed a proof of concept to enable the execution of GREEN model in a multi-cloud environment. GREEN runs through the Virtual Earth Laboratory (VLab), which utilises the European cloud computing platforms, including the Copernicus DIASes and the European Open Science Cloud, for the execution of scientific models.

Taking advantage of cloud technology, VLab facilitates the sharing of scientific models and enables their exploitation via simple Web APIs, allowing to create dedicated Web applications. The GREEN Web application, developed by GEOSS Platform Plus project and the Joint Research Centre, allows the replication of GREEN model results of the impact assessment, contributing to a transparent and evidence-informed policy making process, according to the principles of the European Commission Better Regulation agenda.

Through GREEN Web application users can select an area of interest and define the settings for the simulation, including different policy scenarios.

After a few minutes, users can visualize the simulation results. By selecting one policy scenario, the user displays the resulting yearly average load of nitrogen in the entire selected area.

It is possible to compare how the different simulated policy scenarios perform. By selecting the nitrogen result, users can display the calculated total yearly average load, both to the river outlet and in the entire region.

When two policy scenarios results are selected, users can visualize the difference of nitrogen and phosphorus loads over the entire area of interest.

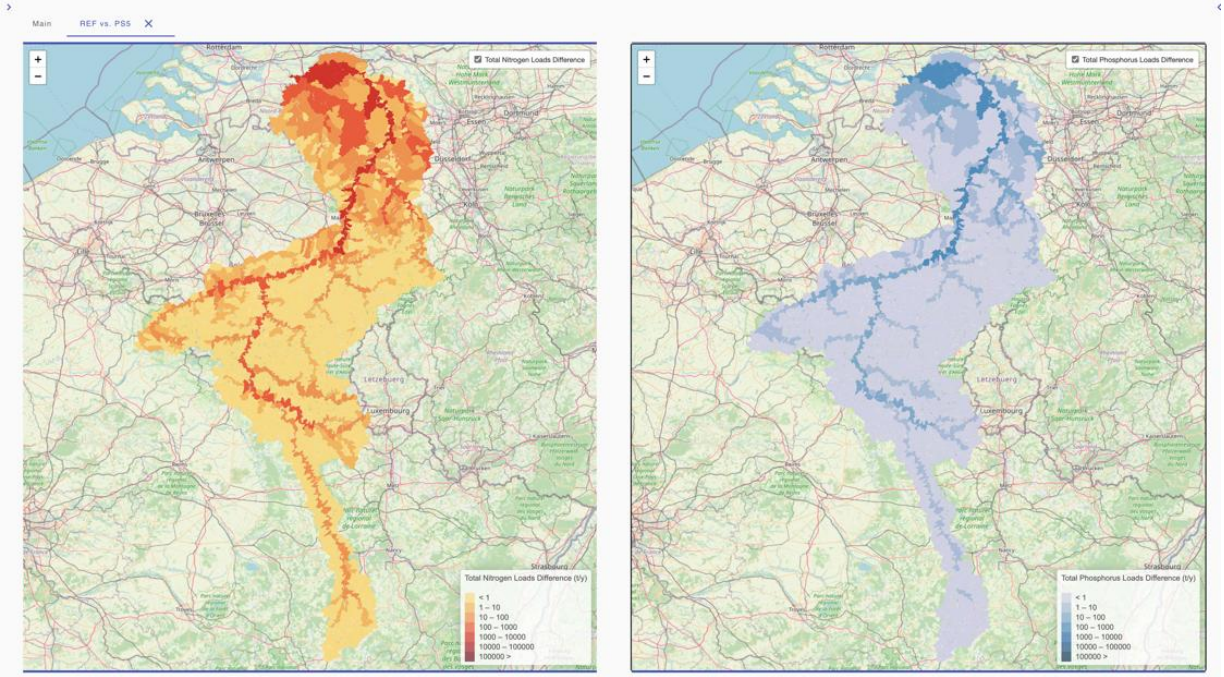


Figure 19 - Difference of nitrogen and phosphorus loads over. Meuse Basin region

3.2.9 Above-Ground Biomass (AGB) estimation using Machine Learning Techniques

The quantification of forest above-ground biomass (AGB) over large areas is used as a proxy for the quantification of carbon stocks, particularly referring to Reduced Emissions from Deforestation and forest Degradation (REDD+) projects, for the quantification of forest resources and ecosystem services, the creation of fuel maps to be used as input to wildfires spread models, and for biodiversity and climate change models. According to the definition of the Intergovernmental Panel on Climate Change (IPCC 2006), Above-Ground Biomass is defined as “All living biomass above the soil including stem, stump, branches, bark, seeds and foliage.”

The use case aims at allowing users to calculate the map of biomass based on observation points (in-situ data) and vegetation indices (VIs) from remote sensing imagery. The user can compare results obtained by different Machine Learning (ML) models. In collaboration with EC JRC, different ML models were developed to test the estimation of AGB from Sentinel products. Three different ML models can be used:

- Random Forest
- Gradient Boosting

- Multi-Layer Perceptron

It must be noted that, due to a lack of available training data, the resulting models which were utilized in the use case will require additional refinement to provide more accurate results.

The GEOSS Platform Plus project, in collaboration with EC JRC, developed a proof of concept to enable the execution of these ML models in a multi-cloud environment. The ML models run through the Virtual Earth Laboratory (VLab), which utilises the European cloud computing platforms, including the Copernicus DIASes and the European Open Science Cloud, for the execution of scientific models. The VLab framework was extended to support ML models execution.

A dedicated Web Application utilizes VLab APIs for the execution of the ML models, allowing users to define a specific configuration for the creation of the biomass map, i.e., define an area of interest, a time period and the specific ML model to use. In addition, users can visualize different biomass maps on the same area of interest calculated with different ML models and visually compare the results as depicted in Figure 20.

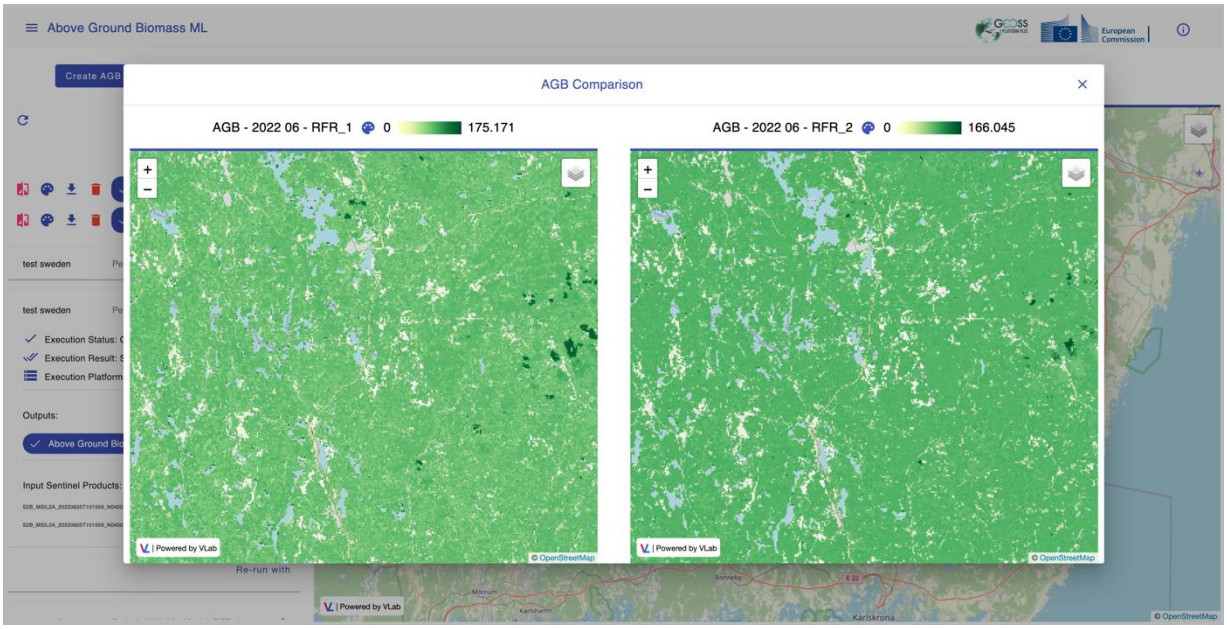


Figure 20 - Comparison of two Biomass Maps on the AGB use case Web App

3.2.10 NewLife4DryLands Use Case

This use case builds on the outcomes of the NewLif4DryLands project (funded from the LIFE financial instrument "LIFE Preparatory project – Programme for the Environment and Climate Action" of the European Commission) which extracted a set of **remote sensing-based indices and indicators used as proxies to assess quantification and mapping of Land Degradation at local scale**, trying to answer to the requests, by local institutional decision-makers, of increasingly more details difficult to reach by global/pan-European Union (EU) services (i.e., Copernicus).

The NewLif4DryLands project focused on 6 study sites representing a wide variety of ecosystems in the Mediterranean landscape as drylands, coastal or mountainous, with high or low extension, threatened from different pressures causing Land Degradation (LD). Hence, the analysis by RS data results not site-dependent rather specific for Mediterranean ecosystems identifying a proper protocol for the

monitoring of their LD status. The GPP project included 2 of the 6 sites in the use case, namely Alta Murgia National Park (Italy) and Nestos Protected Area (Greece). The calculated indexes are:

- NDVI: Normalized Difference Vegetation Index
- MSAVI: Modified Soil-Adjusted Vegetation Index
- NDWI: Normalized Difference Water Index
- MNDWI: Modified Normalized Difference Water Index
- NDSI: Normalized Difference Soil Index
- BSI: Bare Soil Index
- NBR: Normalized Burn Ratio
- SI: Salinity Index
- SSI: Soil Salinity Index

The model for creating the different RS indexes was published in the VLab framework, which utilises the European cloud computing platforms, including the Copernicus DIASes and the European Open Science Cloud, for the execution of scientific models.

Building on VLab Web APIs, a dedicated Web application was developed for a seamless search and generation of the RS indexes for the specific sites that were selected. Users can select a specific date period for the RS indexes calculation and request the execution of the model, after a few minutes the produced data is available for visualization and visual comparison with indexes calculated on the same site in other dates.

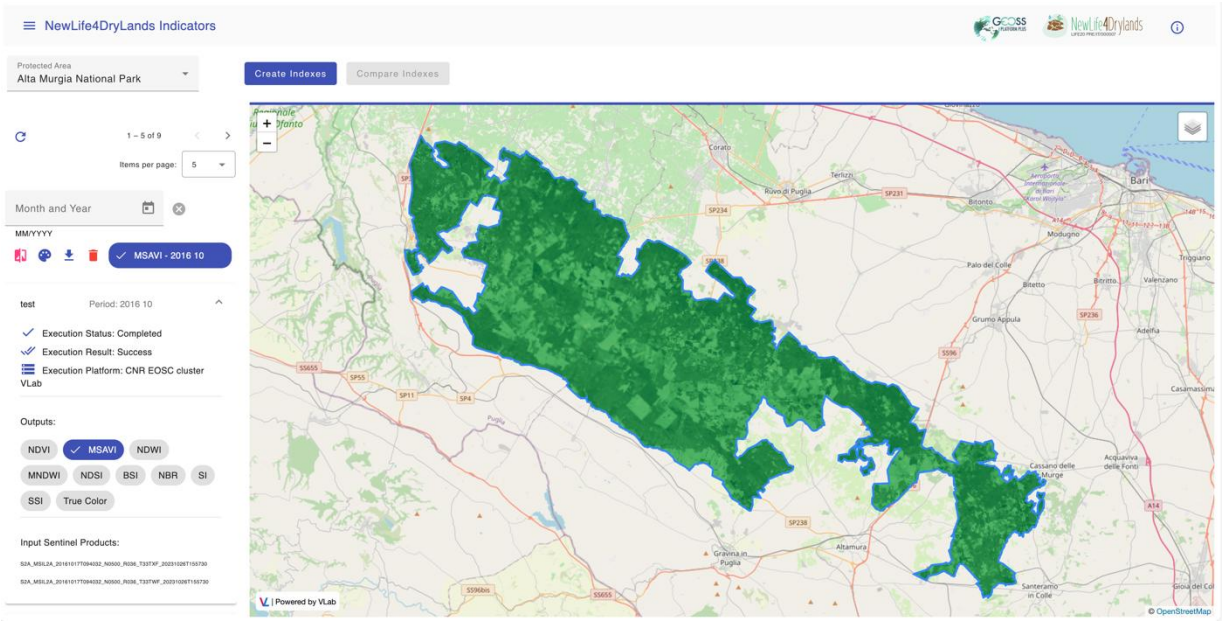


Figure 21 - MSAVI Index over Alta Murgia National Park in October 2016

3.2.11 Climate Change impact on Norovirus pandemic risk

Norovirus is a rapidly mutating and highly infectious virus, for which there are no pharmacological treatments or vaccines. It is ranked first by the WHO as potential source of infections and pandemics worldwide.

It is expected that climate change may affect the onset of epidemic outbreaks in different geographical regions due to multiple reasons: a) direct environmental changes due to modification of climate patterns; b) modification of ecological niches of the many species potentially acting as intermediate hosts for animal-to-human transmission.

The stakeholders identified for this use included the Fondazione Mayer, Careggi Hospital, Istituto Superiore di Sanità and the University of Florence. Several meetings were hold with these stakeholders to refine the use case scenario and the required datasets for its implementation. The analysis highlighted a set of challenges related to the possibility to access the health and relevant socio-economic data required for the implementation. In particular, such data have a very strict access policy which did not allow the stakeholders the sharing of such data. The collaboration with Careggi is still ongoing to define a dataset profile and a possible access agreement.

The main lessons learnt from the activity carried out for this use case include:

- Data Relevance and Quality: Ensuring that environmental data is relevant and accurate for health impact studies can be difficult. For example, the required variables need to be precise and available over long periods to understand their health impacts.
- Spatial and Temporal Scales: Environmental data is collected at various spatial and temporal scales, which may not align with health data. This mismatch can complicate analyses and interpretations.
- Data Policy and Privacy Concerns: Combining health data with environmental data raises privacy issues, especially when dealing with sensitive health information. Ensuring data security and ethical use is crucial. This translates in long processes for health data access, often depending on the specific institutions (and countries, with their specific laws) hosting the data.

One practical example of how these challenges affect the combined use of environmental and health data is the need to aggregate events by hospital due to privacy concerns. Since it's not possible to link an event (i.e., the detection of a virus) directly to a patient's address, each event is associated with the hospital that identified it. Hospitals typically serve specific geographic areas, so the environmental data used for impact analysis must align with the spatial resolution of these areas.

Finally, it is worth to note that the stakeholder's network created in GPP enabled the creation of a joint proposal for a Horizon Europe project, where the same approach proposed in GPP is applied to the evaluation of Climate Change impact to the epidemic risk from Flaviviruses (specifically West Nile and Dengue). In the writing of the proposal, the challenges identified in GPP were addressed identifying potential data providers who are part of the consortium. The project is currently in the negotiation phase.

3.2.12 AGAME Project

Providing quality controlled and up-to-date data is an important prerequisite for informed environmental policies and the implementation of management decisions especially on local and regional scale. In this respect, AGAME:

- provides consistent data products together with detailed metadata. The availability and accessibility of data and derived products will stimulate their exploitation by a wide range of users in the biodiversity sector.
- generates added value products that will facilitate the use of remote sensing data in new applications involving the vision of new operational products in the GEOSS portal that will lead to an increased understanding of Earth processes.

The data requirements as well as functional requirements to access and use these data has been developed and aligned already in an early stage of the process with users' needs and requirements. AGAME offers a service co-designed and co-developed with users that provides information of gross primary production on local scale and can be used to give direct and focused answers to specific questions from the targeted scenarios. The project adopts an end-user centred approach, benefitting from the cooperation with local stakeholders, their knowledge and expertise. Potential users have been engaged in the service design and validation in an iterative process in the different project phases.

AGAME exploits the benefit of integrating Copernicus Products (remote and local data) and other diverse data sources (local, regional or global) by delivering tailored information and services co-designed with the users. It incorporates EO data from Sentinel missions, local monitoring data and data-driven modelling in the GEOSS platform to improve biodiversity management.

By doing so, AGAME contributes to the development of the GEOSS platform by delivering information on gross primary production accessible via the GEOSS Platform.

Users Engagement

In total, we organised four virtual co-design workshops to reach out to the different user communities the AGAME project is targeting. We used Zoom as conference platform and Mural to collect and structure the inputs from the discussions. The main scope of the workshops was to collect users' needs and requirements together with initial feedback on the desired GEOSS portal functionalities. Figure 22 shows a screenshot of the SPC mural board.

Figure 22 - Screenshot of Mural board to collect and structure the user requirements and needs. The board shows the different pre-defined questions as well as the answers from the participants.

The sessions started by welcoming and introducing the project, followed by a more detailed approach to the objectives and relevant aspects. Next, users from each sector were asked to answer a set of pre-defined questions. Input was collected based on elaborated questions that we asked to answer on mural boards. The set of questions were divided into three groups: a) (meta)data, b) API (data provider); and c) non-technical questions. In addition, questions, queries, and comments about the products were shared by the users in the space for any open questions.

Contribution to the mural board was anonymous to ensure GDPR compliance. Name and contact emails were kept separately to ensure communication and collect additional inputs.

3.2.12.1 Application and functionalities implemented

AGAME Gross Primary Production data products are calculated with a data-based approach combining Earth Observation data with in-situ data. Specifically, Sentinel-2 Multispectral data are combined with ICOS data derived from eddy covariance tower systems using the XGBoost (Chen and Guestrin, 2016) machine learning algorithm to estimate gross primary production (Spinosa et al., 2024).

AGAME Gross Primary Production data products are provided through the GEOSS platform for 16 sites as grid data (raster maps) with 10 m spatial resolution. The maps are produced for the highest possible temporal resolution of every 5 days and can be retrieved for the period March 2017-June 2024. This period differs site by site depending upon in-situ data availability. The maps extent corresponds to the boundaries of the selected sites as available on DEIMS-SDR (e.g. https://deims.org/d4854af8-9d9f-42a2-af96-f1ed9cb25712). Figure 23 illustrates an example of such a GPP data product.

Figure 23 - Davos– Gross Primary Production (2023-07-05) product. Example of AGAME Gross Primary Production data product for Davos

These data products include estimations of Gross Primary Production maps with uncertainty annual products that indicates if provided estimations were compared with in-situ data for validation (depending on existence of in-situ data). An annual uncertainty layer will be provided per site and will include model's metrics of performance (Mean Absolute Error (MAE) and Root Mean Squared Error (RMSE)) in the ecosystem along the specified year as metadata. Figure 24 illustrates an example of uncertainty data product.

Figure 24 - Doñana – Gross Primary Production Uncertainty Map (2019) product. Mock-up of an AGAME Gross Primary Production of an uncertainty data product for Doñana Long-Term Socio-ecological Research Platform in 2019 within GEOSS.

After publication of the AGAME Gross Primary Production data products on the GEOSS platform, users will be able to query data for a specific site and period to get the AGAME Gross Primary Production data. User will be able to download the selected data products as GeoTIFF or use the layers as a service to be loaded in a GIS software or other web application.

AGAME Gross Primary Production data computation pipeline/workflow is available in GitHub2. This allows users to replicate AGAME Gross Primary Production data products and extend the period of analysis/ get data for upcoming years when new satellite imagery from Sentinel-2 or new in-situ data are available.

Metadata describing the AGAME Gross Primary Production data products adheres to the ISO 19115/19139 standards and will be published in the eLTER infrastructure and made available to GEOSS (see below). These metadata are based on the metadata content defined for the e-shape project but are slightly modified for the requirements of AGAME. They include the following fields:

Title
Abstract
Data license
Keywords, also used to include a reference to the eLTER facility on DEIMS.org, as well as a DOI for the data record as a whole
Method description (including instrument, platform information, and measured attributes)
Geographic bounding box or polygonTemporal extentResponsible party name
Contact email address.

A detailed data product description (AGAME project team, 2024) is provided summarising the methods applied, the potential usage and the limitation of the data product. The data product factsheet is part of the knowledge package shared also via the GEOSS Platform.

References

2 See https://github.com/eLTER-RI/agame

AGAME project team. (2024) Gross Primary Production - Data Product Factsheet [Data set]. https://b2share.eudat.eu. (DOI: https://doi.org/10.23728/B2SHARE.14832ED336A44B3C8E284996FFA3202C) [PJ1]

Chen T., and Guestrin C. (2016) XGBoost: A Scalable Tree Boosting System, in Proceedings of the 22nd ACM SIGKDD International Conference on Knowledge Discovery and Data Mining, pp. 785–794.

Spinosa, A., Eleveld, M., Mallast, U., Peterseil, J., Mobilia, V., Karisma, K., Fuentes-Monjarez, M., El Serafy, G. (2024) Automated Gross Primary Production Application for Monitoring Ecosystem Health within GEOSS. IGARSS Conference Proceedings 2024, Athens, Greece. Pp. doi: 10.1109/IGARSS53475.2024.10642481.

3.2.12.2 Interfaces with GEO Infrastructure

Data Product "Gross Primary Production"

The data storage and provision infrastructure of the AGAME project builds on common spatial data infrastructure components, which are deployed in the eLTER Cyberinfrastructure. Among others, it features a CSW endpoint via pyCSW. This CSW endpoint contains the ISO metadata representation of all data products in the AGAME project as well as the data products already generated in the previously concluded e-shape project. The metadata follow the ISO19139 encoding and are harvested by the GEO-DAB to enable discovery and rendering of the datasets in the GEOSS Portal (see Figure 25).

Besides pyCSW, it also comprises a GeoServer component that provides the WMS/WFS services to serve the actual data products as services to the GEOSS portal. The AGAME services are based on the ImageMosaic plugin for raster time-series data (https://docs.geoserver.org/stable/en/user/tutorials/imagemosaic_timeseries/imagemosaic_timeseries.html) which enables visualising a series of connected GeoTIFFs, e.g. one GPP scene every 5 days.

Figure 25 illustrates a schematic overview of the AGAME technical architecture and interface with GEOSS.

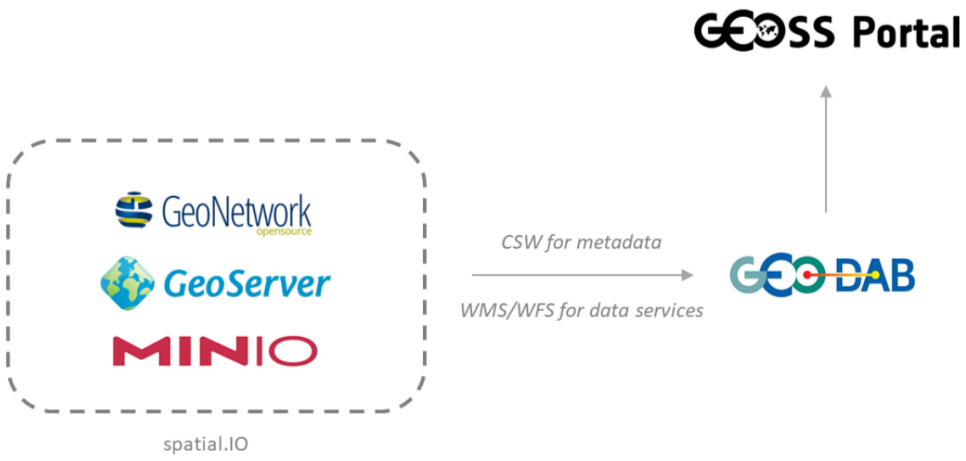


Figure 25 - Overview on the intended architecture and interface to GEOSS

Similar to the metadata requirements, service layer as well as file names will adhere a defined pattern originally devised in the e-shape project consisting of:

> [site name] - [“gross primary production”] ([temporal reference; i.e. reference years]) e.g. “*Bilos - Gross Primary Production (2020-2023)*”

The workflow for the users is as follows:

- User access the GEOSS Portal
- User selects AGAME as data catalogue
- System provides overview on the available data products from the catalogue
- User alternatively restrict keywords to 'Gross Primary Production'
- User selects metadata record
- User selects layer for visualisation
- User selects a metadata record for detailed view
- User selects using the link to access the download page (B2SHARE) for the knowledge package
- User can download and use the data product locally

The AGAME data products can be selected based on the ‘data catalogue’ AGAME (see Figure 26) and shown in the GEOSS Portal (see Figure 27).

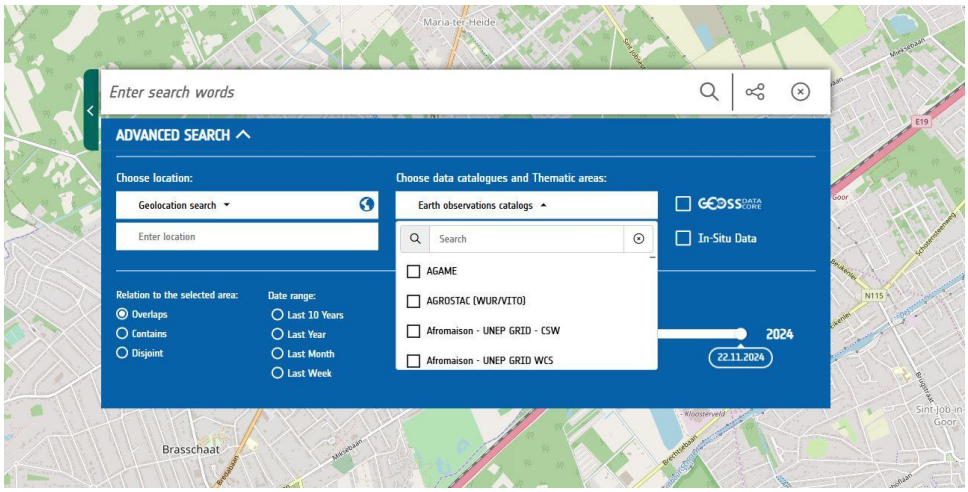


Figure 26 - Selection of the data catalogue ‘AGAME’ in the GEOSS Portal

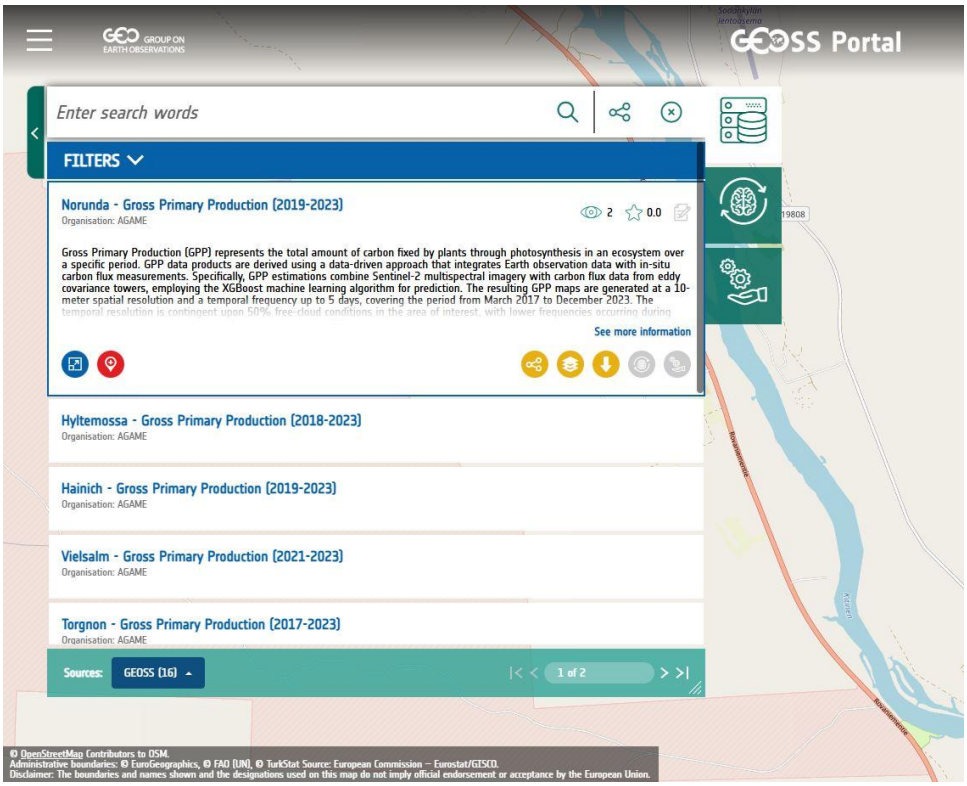


Figure 27 - Listing of the contents of the 'AGAME' data catalogue, filter keyword 'gross primary production'

The data products can be visualised in the GEOSS Portal showing the time series of the gross primary production data product (see Figure 28).

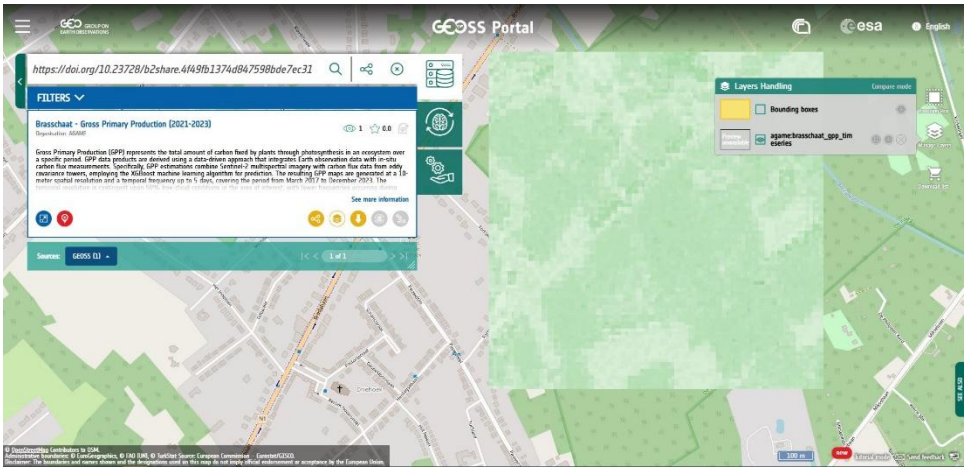


Figure 28 - Rendering of the 'gross primary production' as data layer, example Braaschat (https://deims.org/68e6a8e5-d6d2-4c8c-91c4-10e7f87ac556)

In addition, we share the Gross Primary Production data product as Knowledge package via the EUDAT Platform B2SHARE (https://b2share.eudat.eu/records/?q=AGAME). We provide all relevant information as ZIP package for download and the reference to the download package is included in the metadata. The knowledge package contains the following information:

- data layers for gross primary production (GPP) for the time period and a respective long-term observation facility (as zip archive)
- data layers for valid areas to estimate error of gross primary production for the year and a respective long-term observation facility (as zip archive)
- data error estimates per year and a respective long-term facility (as zip archive)
- data product factsheet (as pdf file)

Data license, acknowledgement, and citation information are part of the metadata provided via B2SHARE (see Figure 29).

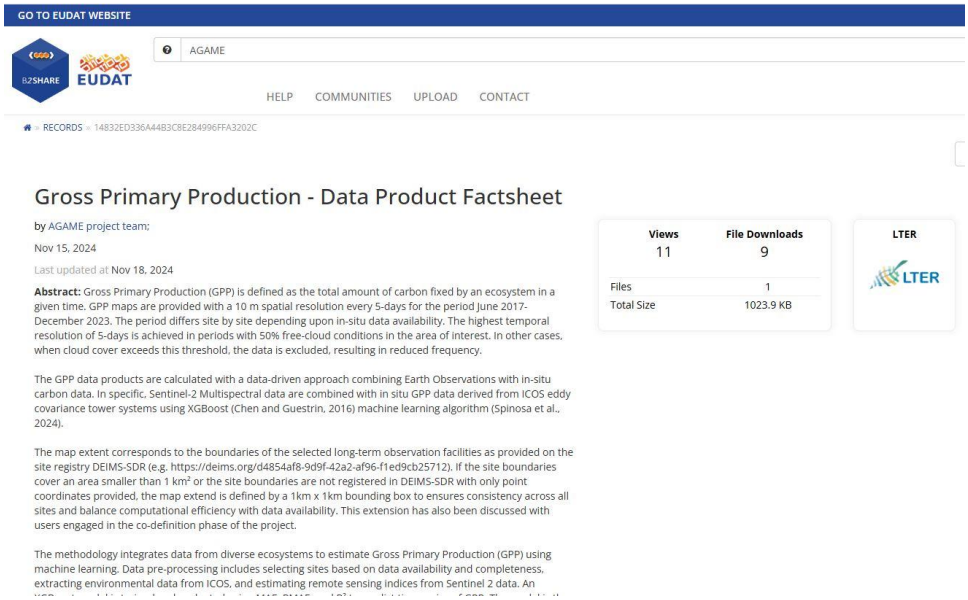


Figure 29 - AGAME Data Product Factsheet shared via B2SHARE (https://doi.org/10.23728/b2share.14832ed336a44b3c8e284996ffa3202c)

In-Situ Data on Carbon Flux

Data on carbon flux has been used for the training and validation of the model on gross primary production. As part of the implementation the metadata on ecosystem observation by the ICOS ecosystem stations has been linked to the GEOSS Portal as additional in-situ data source. Harvesting of the metadata was done via the GEO-DAB using the ISO19139 representation of the metadata shared via the ICOS Carbon Portal (https://www.icos-cp.eu/).

The workflow is as follows:

- User goes to the GEOSS Portal
- User selects 'Integrated Carbon Observation System (ICOS)' as data catalogue
- System renders the metadata provided
- User restricts under FILTERS to the 'organisation' 'ICOS ETC'
- User restricts under FILTERS to the 'keyword' 'carbon flux'
- User selects metadata record for display

- User goes to the download option and is forwarded to the ICOS Carbon Portal to accept the Data license before downloading
- User can download and use the data

Figure 30 shows the selection of the ICOS data catalogue in the GEOSS Portal and Figure 31 see overview on the selected in-situ data.

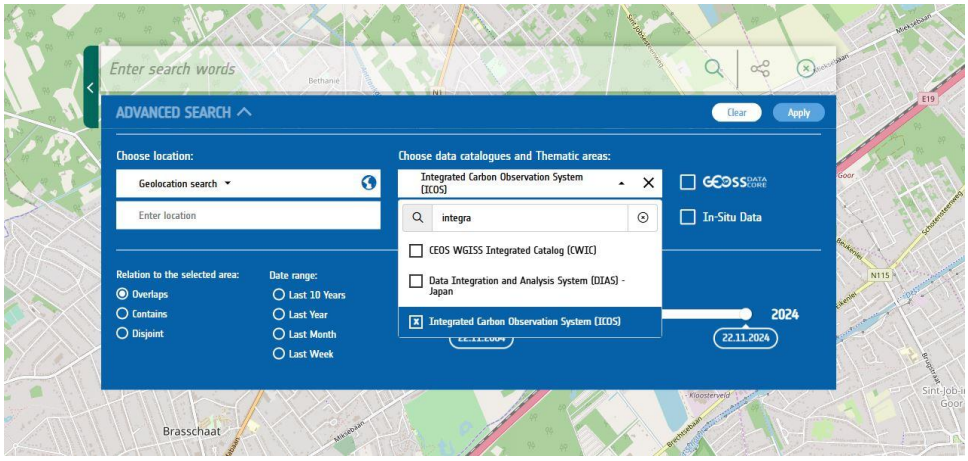


Figure 30 - Selection of ICOS as data catalogue for in-situ data on carbon flux and ecosystem data.

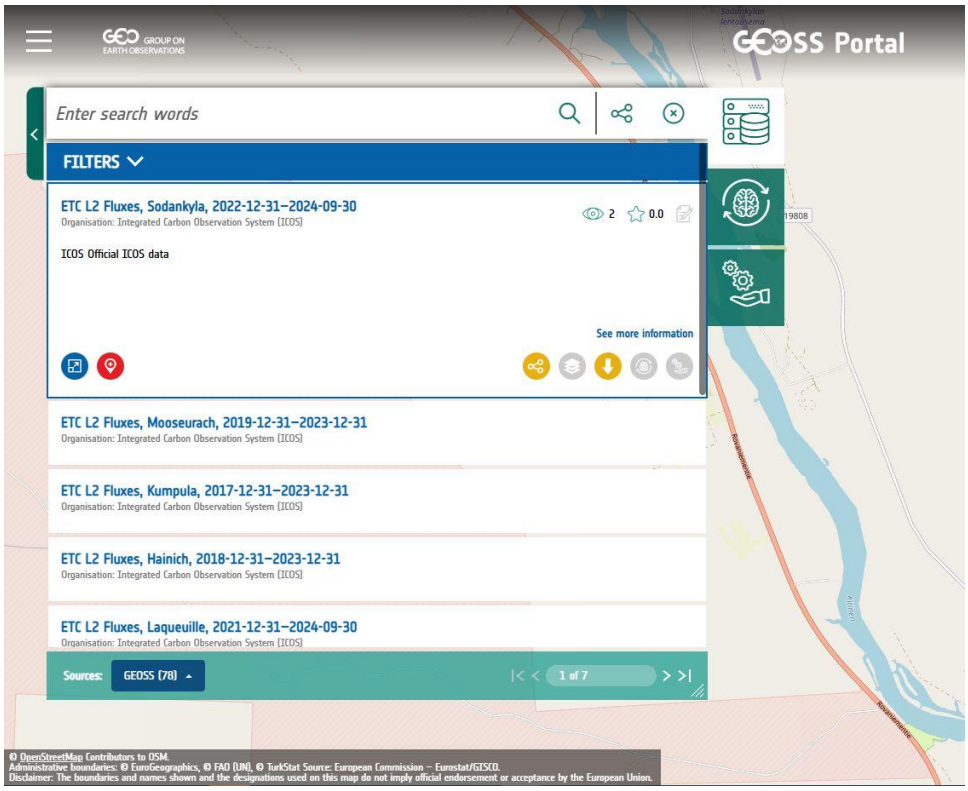


Figure 31 - Overview on in-situ metadata from ICOS on the GEOSS Portal. Metadata are provided by the ICOS Carbon Portal.

With the further development of the eLTER Catalogue, metadata on in-situ data provided by the eLTER network and research infrastructure will be provided. This enhances the discoverability of ecosystem relevant in-situ data sources via the GEOSS Portal.

3.2.12.3 Functionalities not implemented

In this section, we outline functionality currently not existing in the GEOSS Portal that would be useful in the scope of the AGAME project as well as the wider eLTER community.

Providing **additional search facet** for the advanced search of the GEOSS Portal:

As a user **I want to** discover eLTER assets (e.g. Gross Primary Production) based on the name of the eLTER facility **so I can** select the appropriate site and browse the datasets assigned for this eLTER facility

Figure 32 provides a mock-up for the additional facet, which should appear when selecting 'eLTER' as a data catalogue.

User journey steps

- User selects 'eLTER' as data catalogue
- Additional facet is provided for searching based on the name of the eLTER facility
- User can define the name based on the site names provided by the DEIMS API
- The GEOSS Portal performs the discovery and renders the results

Technical interface and data

- Site facet
  - The data products will include a reference to the corresponding (eLTER) site
  - This reference will link to DEIMS via the DEIMS.ID (e.g. https://deims.org/d4854af8-9d9f-42a2-af96-f1ed9cb25712)
  - This ID can be used to access one of the DEIMS API (REST, WFS, ...) to get further information about a site. For instance, the name of a site, a textual description, images or detailed information about the ecosystem (https://deims.org/docs/export.html)
  - (https://deims.org/docs/export.html)
- A reference to the corresponding eLTER standard observation (GPP, https://vocabs.lter-europe.net/so/090)

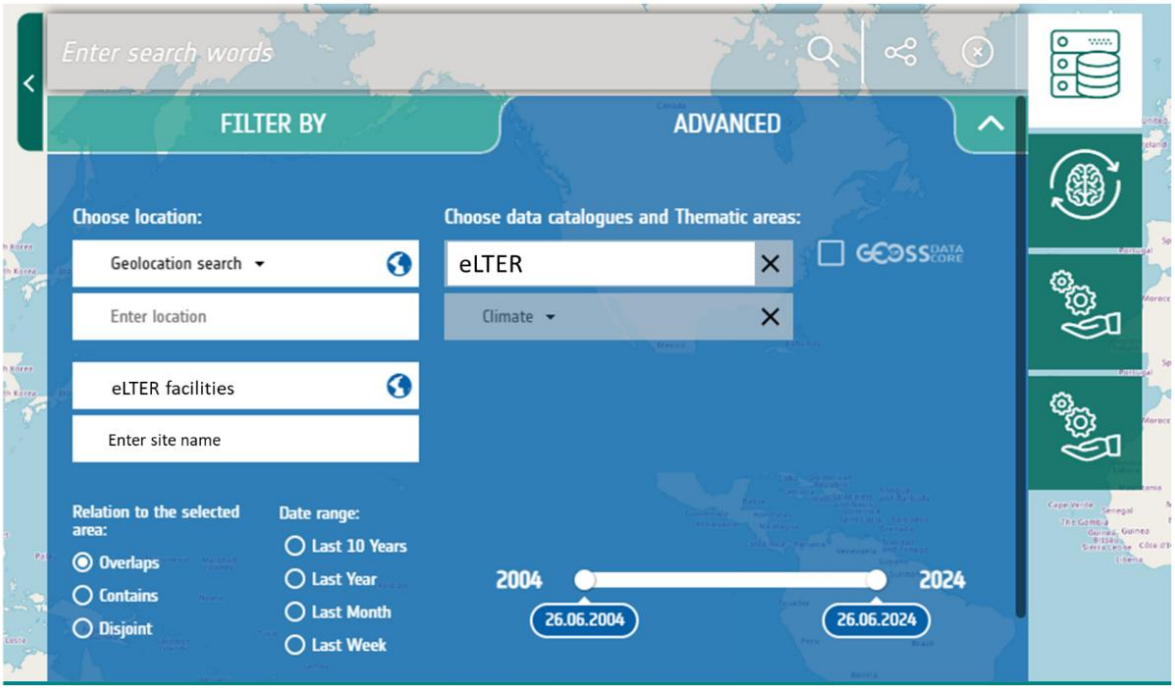


Figure 32 Mock-up for additional facet in Advanced Search when selecting eLTER as 'Data Catalogue'

Providing functionality to **view time series of spatial raster data product** when provided as time mosaic:

As a user **I want to** visualise the Gross Primary Production data product provided with a temporal resolution of approximately 5 days automated **so I can** have an overview on the changes of the Gross Primary Production for my area and being able to evaluate and draw conclusions.

By this, users should be able to easily visualize the AGAME Gross Primary Productivity products in a map. The platform should allow users to search for a site and visualize a map for a selected time.

User journey steps:

- The user discovers the Gross Primary Production data product
- GEOSS Portal identifies the resource as 'image time series' or 'time mosaic'
- The first date of the image time series is loaded and the list of available times is rendered
- The time series viewer is provided
- The user can either select on point in time to visualise the raster image, or
- The user can use the 'time series viewer' play button to loop through all the available raster images in the 'image time series'

Figure 33 provides a Mock-up for the time series viewer for raster image time series.

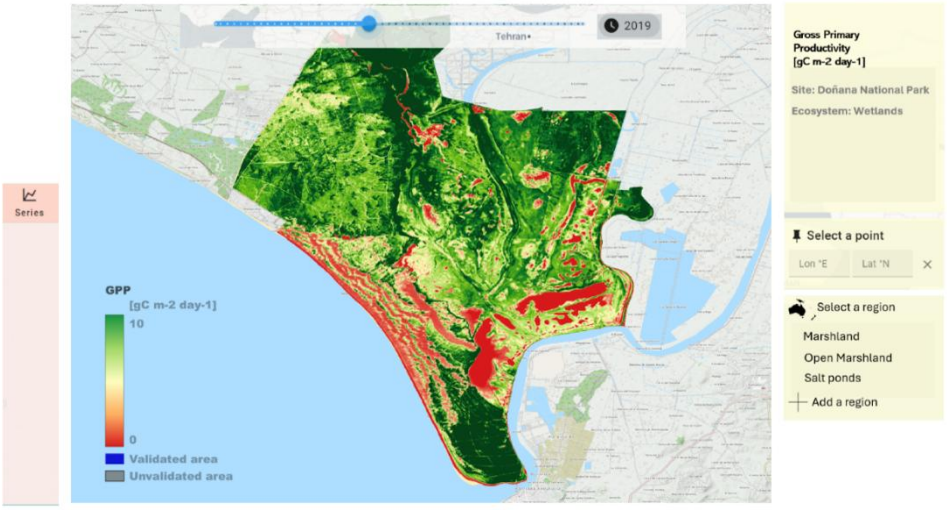


Figure 33 - Mock-up for visualising the spatial raster data product as image time series

Providing functionality to **extract information from the provided raster image data set (time series)**:

a) Extract values for **single location** (pixel)

As a user **I want to** extract the values from a single location (pixel) for the whole time series provided by the image raster time series **so I can** view (and maybe download) the graph of values for this location.

Users should be able to generate time series plots for a defined period and a point or region of interest (predefined or defined by the user) within the maps' extent. Users should be able to get statistics out of the time series data including trends, mean, maximum, minimum and visualize them in plots. Users should be able to download the generated time series data and statistics in .csv format for further analysis.

Figure 34 provides a mock-up to extract the values for a point of interest (pixel) from a time series of raster images.

User journey steps:

- The user selects a raster image time series data product (e.g. AGAME Gross Primary Production with temporal resolution of 5 days)
- The raster image is shown and the extraction tools is activated
- The user selects a location (pixel) within the data provided
- The GEOSS Portal extracts the values for this pixel along the time series provided
- The results are rendered as graph
- A download link is provided to download the extracted values (including reference to the metadata as part of the provenance)

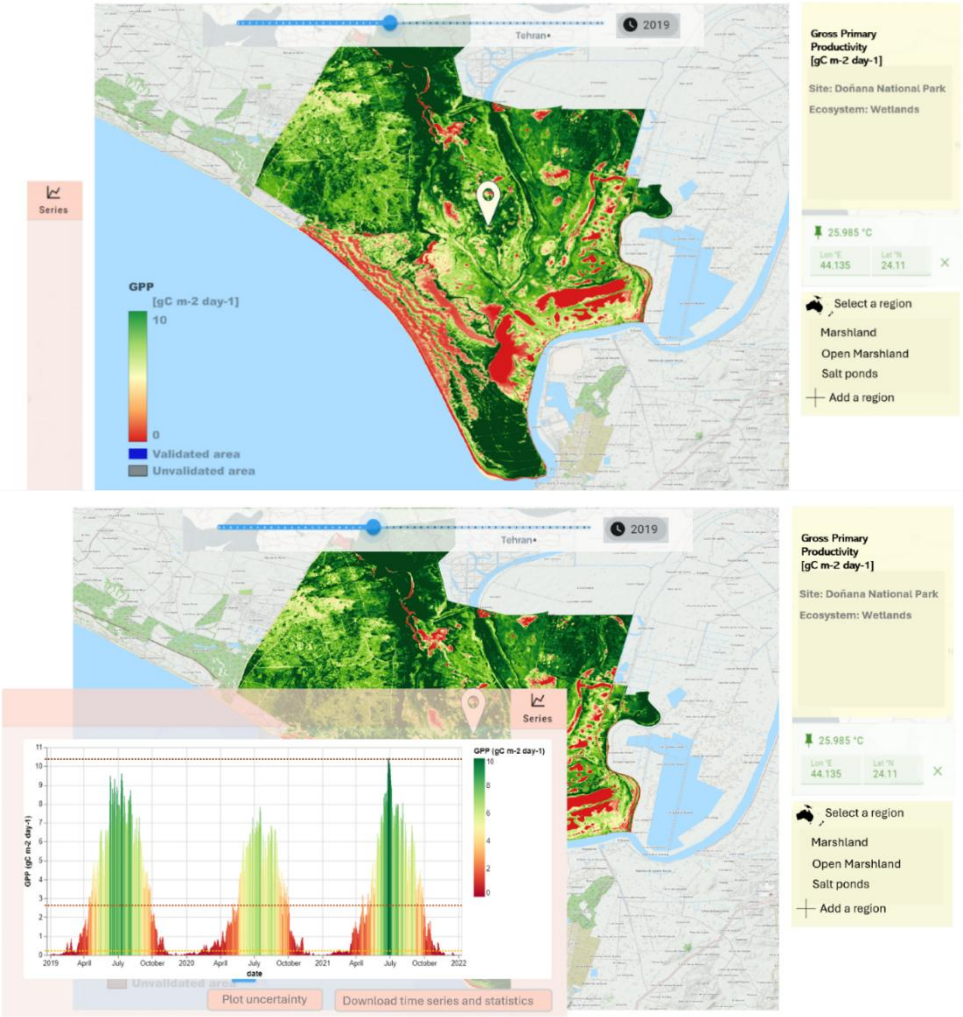


Figure 34 - Mock-up for extracting time series of values from raster image time series for the single point (pixel)

b) Extract values for an **area of interest** (polygon)

This follows the same logic as the extraction of values for a single point, but, in this case, an area of interest is defined by the user and values are averaged for the single point in time. The results are again rendered as graph and the results are provided to the user as download (including provenance).

Figure 35 - provides a mock-up for the extraction of values for an area of interest time series

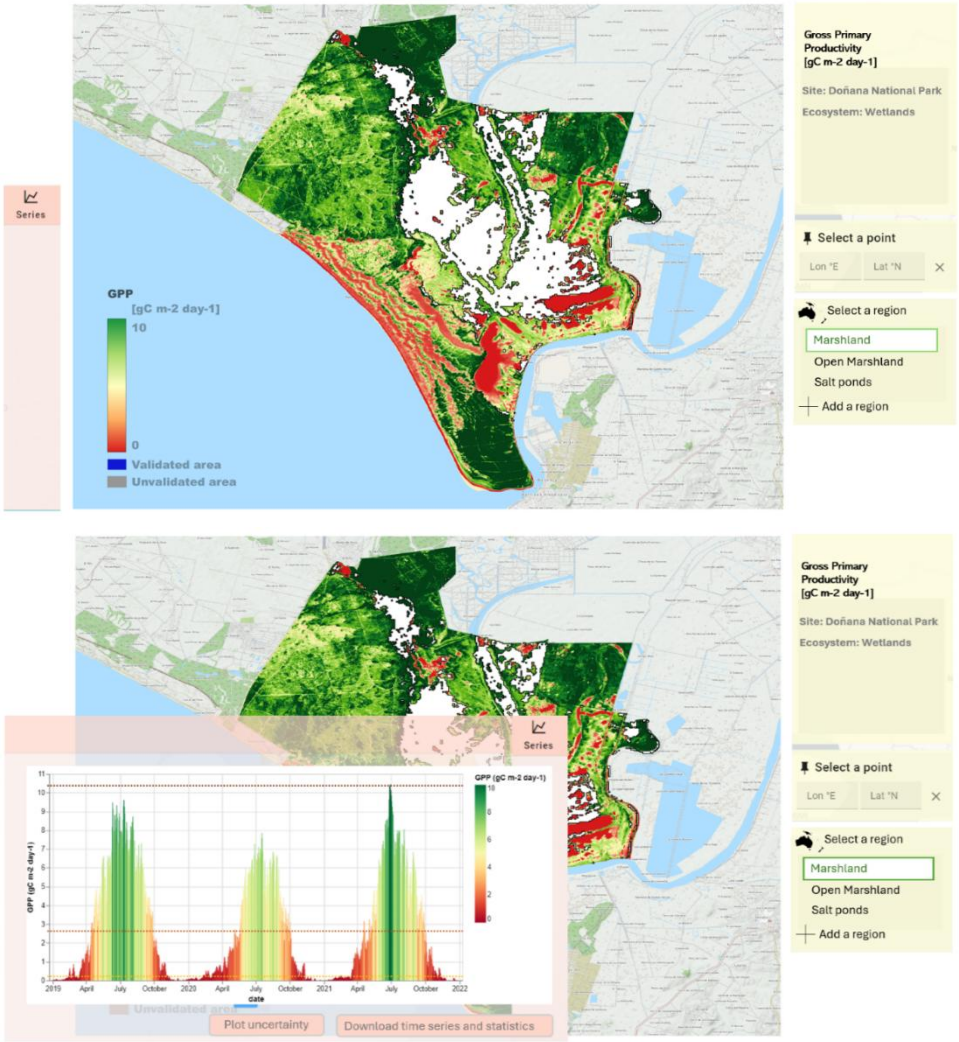


Figure 35 - Mock-up for extracting time series of values from raster image time series for an area of interest (polygon)

As a user I want to get information on uncertainty of the GPP estimations in a point or area of interest. The uncertainty data can be retrieved from the Annual Uncertainty Maps and plotted with the Gross Primary Productivity model predictions. Figure 36 illustrates the visualization of uncertainty of Gross Primary Productivity prediction time series.

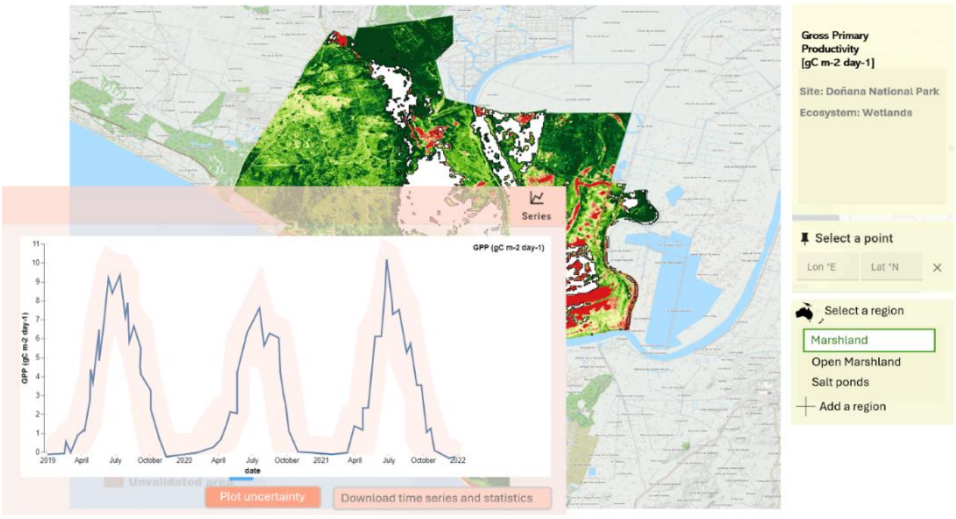


Figure 36 - Mock-up showing the uncertainties for the extracted information

Providing functionality to **access information as knowledge package** using a custom dashboard

> **As a** User **I want to** access and visualise information on Gross Primary Production for a selected long-term observation site combined with additional information on the eLTER facility and the data product **so I can** use the information in the communication and daily work.
>
> The background information serves to have a more detailed and combined visualisation of the information to enhance the usability and uptake of the data product. This includes e.g. the description of the location, the data product preview and a graph on the values in time. This could also be used to assess the fitness of use of the data.
>
> User journey steps:

- The user accesses the custom dashboard (note: here open question on how this can be discovered)
- The user selects a location of interest based on the name of the eLTER facility
- The user selects the Gross Primary Production dashboard
- The information on the eLTER facility is rendered (name, description, location) provided by the DEIMS API
- The information on the Gross Primary Production product is rendered provided as description
- The map (with the first point in time) is rendered
- The averaged values for the whole time series and area are calculated
- The graph is rendered and shown for the user

Figure 37 provides a mock-up for the custom dashboard for visualising information on the location combined with information on the data product as actionable knowledge.

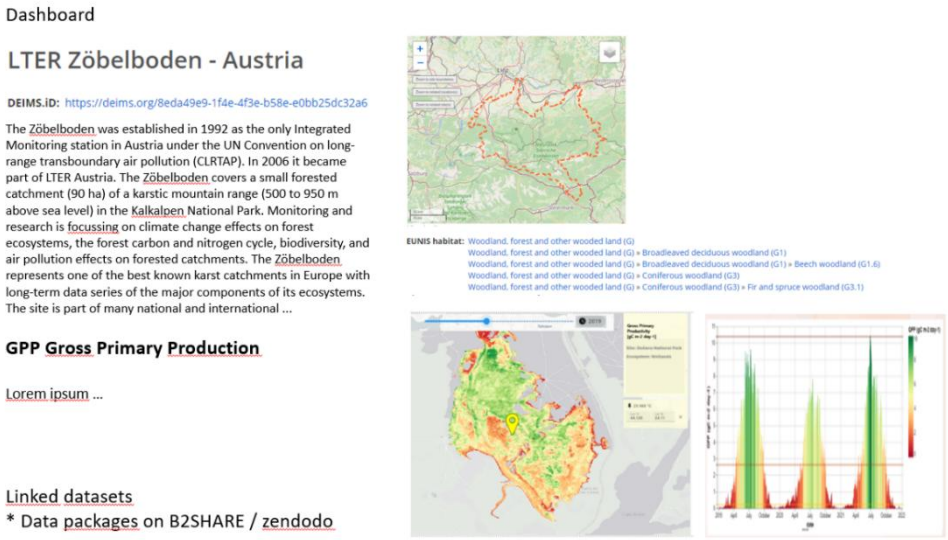


Figure 37 - Mock-up for a custom dashboard providing information as knowledge package to the user

3.2.13 Maps4GPP

Agronomy in-situ data plays a pivotal role in enhancing the precision and reliability of global crop mapping. There are several institutes, projects and programs providing agronomy in-situ data in a standardized way (data providers) that can be used in support of GEOGLAM essential agricultural variables (EAV). One of these data providers is the ESA funded WorldCereal project, that collected and harmonized agronomy in-situ data for crop mapping. In addition, there are other data providers serving standardized data or offer data harmonized for specific use (Analysis Ready Data - ARD). Currently, there is no central place where these different ARD data sets can be found and used. Therefore, Maps4GPP aims to strengthen the agronomy in-situ data component of the Global Earth Observation System of Systems (GEOSS) platform as a central hub where users can explore and download data (human-readable) and integrate agronomy in-situ data in dedicated applications (machine-readable). The initiative aims to ease the finding, use and contribution of data and demonstrate the enhanced value of harmonized agronomy in-situ data in generating crucial spatial layers for regional crop productivity analyses and assessments of agricultural externalities

3.2.13.1 Application and functionalities implemented

We actively engaged with the crop mapping community by organizing a webinar, an on-line survey, and meetings to learn from experiences in finding and working with agronomy in-situ data and to capture specific needs and requirements for an online in-situ data repository. The community includes many different organizations such as FAO, WFP, European Environmental Agency, JRC, CGIAR-CIMMYT, Agriculture and Agri-Food Canada, NASA crop harvest, INTA Argentina, RadiantEarth, UCLouvain etc. and projects such as WorldCereal. In general, the community showed a strong support for a better availability of harmonized agronomy in-situ data within the GEOSS platform

First, we drafted a list of possible data providers and approached them to register as data provider in the GEOSS platform. Two, relevant initiatives were selected: the WorldCereal harmonized in-situ data and AGROSTAC harmonized agronomy in-situ data. The data sets were registered in the yellow pages. Next, interfaces between the dataset hosts and GEO DAB were defined (see next section), checked and tested for proper functioning.

Next, functionality was implemented to explore and leverage the WorldCereal and AGROSTAC harmonized in-situ data repositories. Users can explore and select data sets (collections) based on available metadata. The selected data sets can be downloaded completely or after filtering for a selection of crop types, quality, and a selection of variables (quantities). In more detail the workflow is as follows:

- User accesses GEO portal
- User selects thematic area (harmonized agronomy in-situ data) and one of the catalogs:
    - WorldCereal harmonized in-situ data repository
    - AGROSTAC harmonized in-situ data repository
- System returns list of available harmonized data sets for selected catalog
- User sets specific filters in “advanced” tab (filter data sets by region and year range)
- User sets specific filters in “filter by” tab (filter data sets by crop, variable and confidence level)
- User selects and inspects available harmonized data sets by checking metadata: license, description, confidence, citation, organization, reference to the original dataset, and curation done on the original dataset
- User selects one or more data sets and downloads data of selected data sets for selected filters:

- WorldCereal: crop type(s)/land cover(s)/irrigation type(s), confidence level, boundary box, year range
- AGROSTAC: crop type(s), variable(s)/quantity(ies), boundary box, year range

In addition to exploring and downloading harmonized agronomy in-situ data, the user can generate a land cover map via the WorldCereal processing system using the harmonized in-situ data of the WorldCereal repository. A land cover map is a basic layer to explore and monitor land use, crop production and externalities. See also GEOGLAM EAVs (https://agvariables.org/about-eavs). In more detail:

- User logs on the GEO portal as the mapping service is only available after log-on.
- User selects thematic area (harmonized agronomy in-situ data) and catalog WorldCereal
- User selects and activates the WorldCereal service set via the GEO portal by selecting one of the data sets offered by WorldCereal harmonized in-situ data repository.
- User logs on to the WorldCereal system
- User defines a boundary box, growing season of interest
- The WorldCereal processing system generates and returns a land cover map (GeoTiff format) showing the presence of different land covers. The map is based on existing global algorithms that were trained using the WorldCereal harmonized in-situ reference data repository (summer 2024).
- The user visualizes the crop type map in the GEO portal
- The user saves the crop type map in the user's personal space of the GEOSS platform.

In addition, we:

- Explored, evaluated, and recommended an infrastructure to host the harmonized agronomy in-situ reference data repository developed in WorldCereal including the guidelines on sharing and harmonizing in-situ reference data.

Registered the WorldCereal harmonized in-situ data repository and guidelines in the GKH

3.2.13.2 Interfaces with GEO Infrastructure

The selected and registered harmonized in-situ data repositories, WorldCereal and AGROSTAC, have a documented API.

The complete documentation of the WorldCereal OGC Data APIs can be found as swagger publication. See following links:

- https://ewoc-rdm-api.iiasa.ac.at/swagger/index.html.
- https://worldcereal.github.io/worldcereal-documentation/rdm/explore.html

These APIs give access to the public harmonized data sets of WorldCereal without credentials. Besides, specific URLs were provided to access certain background information e.g. the WorldCereal legend, the way confidence score are calculated, and dates are derived from year/season:

- https://ewoc-rdm-ui.iiasa.ac.at/details/WorldCereal_crop_legend_ui_v2_20240709.pdf
- https://ewoc-rdm-ui.iiasa.ac.at/details/WorldCereal_irrigation_legend_ui_v2_20240709.pdf
- https://ewoc-rdm-ui.iiasa.ac.at/details/WorldCereal_ConfidenceScoreCalculations_v1_1.pdf
- https://ewoc-rdm-ui.iiasa.ac.at/details/WorldCereal_DerivingValidityTime_v1_1.pdf

The complete documentation of the AGROSTAC Data APIs can be found through the following links:

- https://agrostac.wenr.wur.nl/register.html
- https://agrostac.org/en

Most harmonized data sets, provided by AGROSTAC, are open and made available under their original licenses (DATA_ACCESS = OPEN). The data is accessible via a personal access token received after registration. The crop types and quantities used have dedicated API request to retrieve their descriptions.

Concerning the DAB implementation, two levels are distinguished:

1. First level: retrieve harmonized in-situ reference data sets (collections). The GEOSS platform regularly retrieves the harmonized in-situ reference data sets. The available metadata is used to do filtering within GEOSS platform and support the user in providing the necessary information to explore and select data sets.
2. Second level: retrieve observations (~ items). The GEOSS platform retrieves data of the selected data sets by filtering the API response on-the-fly. These items are not presented in the UI but can be downloaded.

Interoperability of the WorldCereal repository

GEO DAB used the following services:

- GET COLLECTIONS (/collections)
- GET METADATA OF COLLECTION (/collections/{collectionId}/metadata/items)
- GET ITEMS FROM COLLECTION (/collections/{collectionId}/items)
- GET LAND COVER TYPE: (/eotypes/LandCoverType)
- GET CROP TYPE: (/eotypes/CropType)
- GET IRRIGATION TYPES: (/eotypes/IrrigationType)

GEO DAB harvests Collections (first level) and executes distributed queries for retrieving items/features (second level).

1. search for worldcereal data source or using the worldcereal view
2. search for worldcereal collection using croptypes and irrigationtypes
3. search for worldcereal collection using multiple crop types

To secure technical performance GEO DAB selects collections (harmonized data sets) with a maximum of 10000 observations/records.

Interoperability of the AGROSTAC repository

GEO DAB used the following services:

https://agrostac.wenr.wur.nl/agrostac/datasets (get info on collections for level 1)

https://agrostac.wenr.wur.nl/agrostac/overview? (get info on collections for level 1)

https://agrostac.wenr.wur.nl/agrostac/crops? (get info on collections for level 1)

https://agrostac.wenr.wur.nl/agrostac/cropdatabyarea (get item data for level 2)

Crop types of AGROSTAC are mapped to the WorldCereal crop type codes to allow one crop specific filtering for both catalogs. The mapping is static and is based on the current crop list in AGROSTAC. Data of crops, not listed in the mapping, are excluded.

3.2.13.3 Functionalities not implemented

Concerning use case UC-MPS-04 (generate crop maps) a first version was implemented which has limited functionality. This first version is based on existing global algorithms that were trained using the WorldCereal harmonized in-situ reference data repository (version June 2024). In this version the re-training of algorithms, using extra local harmonized reference data, is not possible. The re-training facility will become available later in WorldCereal Phase 2. However, this is too late to incorporate in this use case within GPP. We recommend to upgrade this implementation in the future allowing the use of harmonized reference data from GEOSS platform (e.g. WorldCereal harmonized in-situ reference data combined with other harmonized data).

3.2.14 GEOSS Portal Landing Page

The GEOSS Portal Landing Page was developed as part of the third set of applications to enhance user interaction and engagement with the GEOSS Platform. It serves as a gateway to GEOSS resources, offering intuitive navigation, educational content, and access to practical use cases. The landing page is designed to address the needs of GEO communities and align with the broader goals of the GEOSS infrastructure.

3.2.14.1 Application and Functionalities Implemented

The landing page includes the following implemented functionalities:

- **Structured Navigation**: Provides clear and intuitive paths to essential sections, such as About, Thematic Areas, Catalogues, Community Portals, Use Cases, and News.
- **SEO Optimisation**: Incorporates metadata and schema to enhance the landing page's visibility in search engine results.
- **Educational Content**: Highlights practical use cases and GEO initiatives to increase user awareness and understanding.
- **Analytics Integration**: Utilises Matomo Analytics to track user behaviour and engagement, providing actionable insights for future improvements.
- **Cookie Notice**: Displays a banner consistent with privacy regulations, informing users of cookie usage and collecting consent.
- **Article Management**: Provides an Admin Console for content managers to create, edit, and publish articles dynamically.

3.2.14.2 Interfaces with GEO Infrastructure

The landing page integrates seamlessly with the broader GEO infrastructure:

- Directs users to the GEOSS Portal for detailed data discovery and access.
- Links to Community Portals to highlight specific GEO-related initiatives and use cases.
- Interfaces with analytics systems (Matomo) to track and analyse user engagement across GEO-related platforms.

- Supports thematic resource discovery, enabling efficient navigation to GEO catalogues and datasets.

3.2.14.3 Functionalities not implemented

An **advanced Content Management System (CMS)** was not included in the scope of this project. However, it could be considered for future development to provide more robust content creation and management features.

3.3 Re-usability, Re-producibility, Replicability enhancements

3.3.1 The Virtual Earth Laboratory (VLab)

The Virtual Earth Laboratory (VLab) is a framework that implements all required orchestration functionalities to automate the technical tasks required to execute a model on different computing infrastructures, minimizing the possible interoperability requirements for both model developers and users. VLab is conceived as a framework to support a science-informed decision-making process, which requires the generation of knowledge from collected data and scientific models. Although, current cloud technologies provide valuable solutions for addressing several of the Big Earth Data challenges. Building a workflow that implements a scientific process to generate knowledge on a multi-cloud environment is a complex task requiring multiple expertise on policy needs, different scientific domains, data and model interoperability, cloud services management. Therefore, it is necessary to automate, as much as possible, the technical tasks, in order to lower the existing barriers and allow the different stakeholders to focus on their specific fields of expertise.

Through VLab, modelers can publish models developed in different programming languages and environments. After being published on VLab, a model becomes available as a resource on the web for machine-to-machine interaction. Using the VLab RESTful APIs, software developers can build mobile and desktop applications exploiting the framework capabilities to run models. In this way, developers can build applications tailored to end-users, including policy-makers and decision-makers, widening the scope of models and their potential user audience.

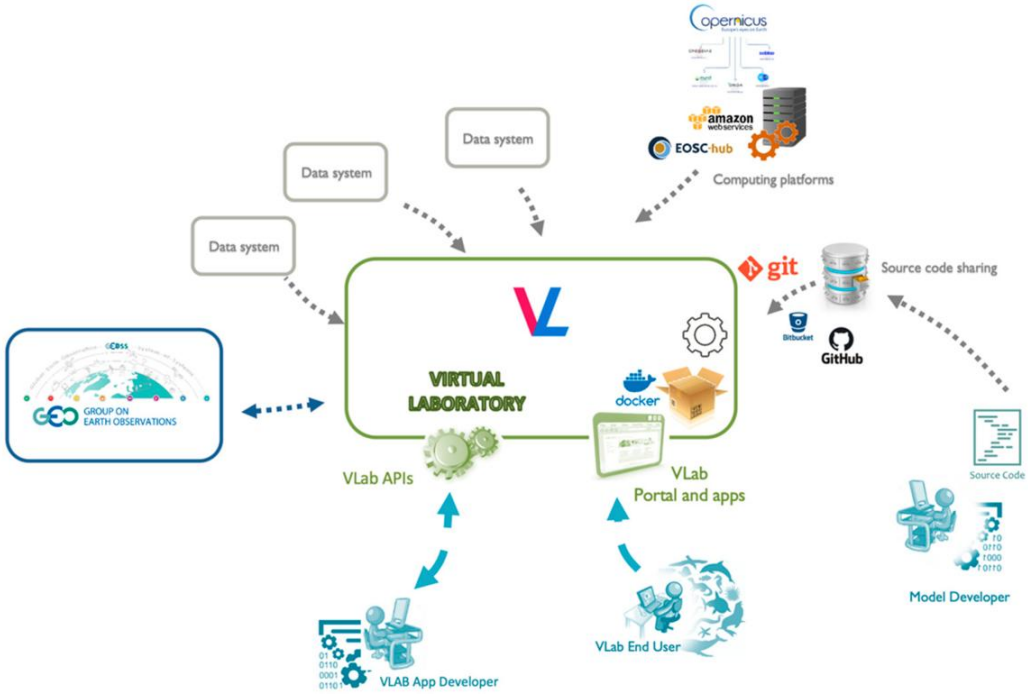


Figure 38 - Conceptual Framework of VLab Experimentation

VLab was developed in the context of different H2020 projects: ECOPotential, ERA-PLANET, ESOC-hub, and EDGE. In the context of GPP project, VLab was improved to support new requirements coming from the identified use cases. In particular, VLab APIs were enhanced to provide additional metadata about the produced outputs and request the execution on a specific cloud platform. Besides, a proof-of-concept component was implemented to enhance the support of multi-cloud environments. Currently, VLab was successfully tested on commercial cloud platforms (AWS) as well as the European cloud

computing platforms, including the Copernicus DIASes and the European Open Science Cloud, for the execution of scientific models.

Supporting Open Science Paradigm

In line with the GEO Statement on Open Knowledge, VLab contributes to support the concepts of Reproducibility, Replicability and Reusability – the pillars of the Open Science paradigm. Table 2 lists the current support of these three concepts by the VLab framework.

	Description	Supported	Required Enhancements
Reproducibility	Reproduce an experiment with same data and model implementation	Supported	
Replicability	Replicate an experiment using different data and same model implementation	Partially Supported [Users must know which datasets to use]	Enhancements required to automatically detect datasets which comply (at least syntactically and semantically) with model implementation requirements
Reusability	Reuse/apply the approach in different contexts, change the model implementation and/or data sources	Partially Supported [Same as above + users must know that two implementations realize the same model]	Same as above + need to semantically characterize model implementations

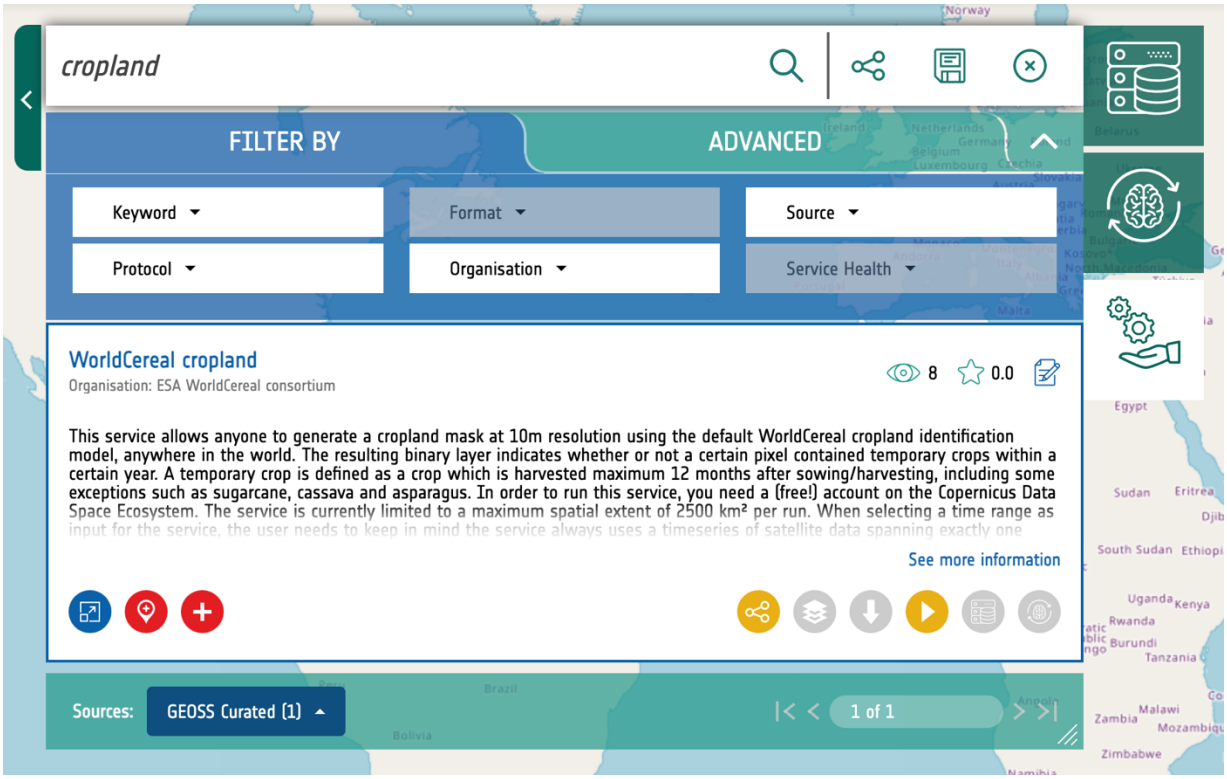
Table 2 - VLab Support for Open Science Paradigm

3.3.2 OpenEO interoperability

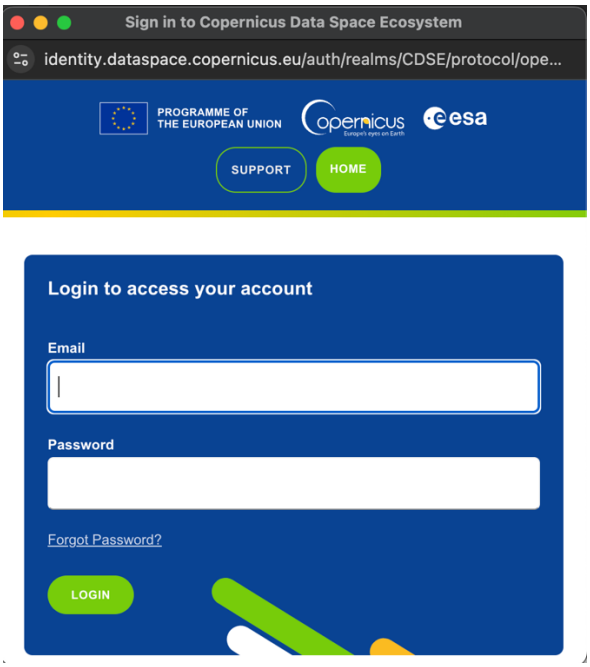
Implementation of OpenEO service is based upon already existing GEOSS Curated Resources functionality, which lets administrator to create entry with specific options and make it discoverable within the GEOSS Search.

In terms of current GPP project scope, thanks to the cooperation with VITO, within the scenario MAPS4GPP - Use Case 4 a single resource with OpenEO workflow initiator has been created, to support the WorldCereal computations model.

However this integration can be easily propagated for any other OpenEO client, service or model. Key part is to define proper process ID and service URL during the entry creation, which will let to distinguish and define desired computation process. The generic approach allows to use Geoportal as an entry point for other services integration, with simple custom GEOSS Curated Resource configuration.



Computations (workflow triggers) are available for registered Geoportal user, with additional SSO login to the Copernicus service. Once the workflow is triggered, user is asked to provide credentials.



After successful login, window with model configuration options appears and user can trigger a run on the OpenEO platform using its built in API. Run is now started in OpenEO service and also automatically saved in “Saved Runs” list for Geoportal user. Once the run is complete and successful, user can use an output data and create a new entry using the Dashboard functionality.

4. Requirements traceability

4.1 User Requirement traceability

This section presents the traceability matrix between the system required capabilities and the Use cases, User requirements found in document [RD-6] and the Jira Issue, together with the information if the capability has been implemented on the operational platform or the proof of concept.

User Req.	UR Title	Section	System Req.	Use Case	Environment /JIRA Ticket
UR-AFG-01	A dedicated portal for the AfriGEO community	3.2.2	SR-NFC-002	UC-AFG-01	Delivered Package
UR-AFG-02	The AfriGEO search keywords	3.2.2	SR-NFC-001	UC-AFG-01	Delivered Package
UR-AFG-03	The AfriGEO Region of Interest	3.2.2	SR-NFC-001	UC-AFG-01	Delivered Package
UR-AFG-04	The AfriGEO search domain	3.2.2	SR-NFC-001	UC-AFG-01	Delivered Package
UR-AFG-05	The AfriGEO filtering capabilities	3.2.2	SR-NFC-002	UC-AFG-01	Delivered Package
UR-AFG-06	Accessing data, information and knowledge from AfriGEO	3.2.2	SR-FUN-009	UC-AFG-02	Delivered Package
UR-LDG-01	SDG indicator 15.3.1 computation service discovery	3.2.1	SR-FUN-003 SR-FUN-005 SR-FUN-007 SR-FUN-008 SR-FUN-009 SR-FUN-012	UC-LDG-01	UAT
UR-ECS-01	Communication with the EIFFEL system	3.1.3	SR-FUN-004 SR-FUN-006 SR-FUN-007 SR-FUN-008 SR-FUN-013	UC-ECS-01	UAT

UR-LDG-02	SDG indicator 15.3.1 computation service execution	3.2.1	SR-FUN-003	UC-LDG-01	UAT
UR-LDG-03	Visual representation of SDG indicator 15.3.1 computations	3.2.1**Error ! Reference source not found**	SR-FUN-003	UC-LDG-01	UAT
UR-LDG-04	My Workspace Dashboard	3.2.3	SR-FUN-003	UC-LDG-01	UAT
UR-LDG-05	Acceptance of the visualizations	3.2.3	SR-FUN-003 SR-FUN-006 SR-FUN-007 SR-FUN-008 SR-FUN-009	UC-LDG-01	UAT
UR-CSP-01	Community Portal package access	3.1.2	SR-FUN-002	UC-COM-01	UAT
UR-CSP-02	Community Portal General Configuration	3.1.2	SR-FUN-002	UC-COM-01	UAT
UR-CSP-03	Views Selection	3.1.2	SR-FUN-002	UC-COM-01	UAT
UR-CSP-04	Views Setup	3.1.2	SR-FUN-002	UC-COM-01	UAT
UR-CSP-05	Link to the Community Portal from the GEOSS Portal	3.1.2	SR-FUN-002	UC-COM-02	UAT
UR-CSP-06	Community Portal information	3.1.2	SR-FUN-002	UC-COM-02	UAT
UR-CSP-07	Administration rights	3.1.2	SR-FUN-002	UC-COM-02	UAT
UR-CSP-08	Add Community Portal in the Community Portal section	3.1.2	SR-FUN-002	UC-COM-02	UAT
UR-YPG-02	Wizard Registration	3.1.4	SR-FUN-001	UC-YPG-01	UAT
UR-YPG-03	Terms of Service Acceptance	3.1.4	SR-FUN-001	UC-YPG-01	UAT
UR-YPG-04	User Notifications	3.1.4	SR-FUN-001	UC-YPG-01	UAT
UR-YPG-05	Data Modification\Deletion Identifier	3.1.4	SR-FUN-001	UC-YPG-01	UAT
UR-YPG-06	Data Provider Account Request	3.1.4	SR-FUN-001	UC-YPG-01	UAT
UR-YPG-07	Search and Visualization of Registered Data Providers	3.1.4	SR-FUN-001	UC-YPG-01	UAT
UR-YPG-08	Widget download	3.1.4	SR-FUN-001	UC-YPG-02	UAT
UR-YPG-09	Widget Installation	3.1.4	SR-FUN-001	UC-YPG-02	UAT
UR-YPG-10	Yellow Pages Authorization	3.1.4	SR-FUN-001	UC-YPG-02	UAT
UR-YPG-11	Yellow Pages Authorization Response	3.1.4	SR-FUN-001	UC-YPG-02	UAT
UR-YPG-12	Data Modification	3.1.4	SR-FUN-001	UC-YPG-02	UAT
UR-YPG-13	Data Provider Account Management	3.1.4	SR-FUN-001	UC-YPG-02	UAT
UR-YPG-14	Data Provider Registration Process Status	3.1.4	SR-FUN-001	UC-YPG-02	UAT
UR-GSA-01	Urban Green Spaces Accessibility Model	3.2.4	SR-FUN-005 SR-FUN-007 SR-FUN-008 SR-FUN-009 SR-FUN-010 SR-FUN-011	UC-GSA-01	UAT

			SR-FUN-012 SR-FUN-013		
UR-GSA-02	GSA Data	3.2.4	SR-FUN-004 SR-FUN-007 SR-FUN-008 SR-FUN-009 SR-FUN-011 SR-FUN-013	UC-GSA-01	UAT
UR-ATL-01	Discovery and Access to the EMODnet Marine Physics Datasets	3.1.1 3.2.5 3.2.6 3.2.7	SR-FUN-004 SR-FUN-006 SR-FUN-008 SR-FUN-009 SR-FUN-011 SR-FUN-013	UC-ATC-01	UAT
UR-ATL-02	Discovery and Access to the Brazilian Observatory Service	3.1.1 3.2.5 3.2.6 3.2.7	SR-FUN-005 SR-FUN-006 SR-FUN-007 SR-FUN-008 SR-FUN-009 SR-FUN-011 SR-FUN-012 SR-FUN-013	UC-ATC-02	UAT
UR-MEB-01	Discovery and Access to the Ospar Data	3.1.1	SR-FUN-004 SR-FUN-006 SR-FUN-007 SR-FUN-008 SR-FUN-009 SR-FUN-011 SR-FUN-013	UC-MEB-01	UAT
UR-MEB-02	Discovery and Access to the Ospar Intermediate Assessment	3.1.1	SR-FUN-004 SR-FUN-006 SR-FUN-007 SR-FUN-008 SR-FUN-009 SR-FUN-011 SR-FUN-013	UC-MEB-04	UAT
UR-MEB-03	Discovery and Access to the EMODnet Biology	3.1.1	SR-FUN-004 SR-FUN-006 SR-FUN-007 SR-FUN-008 SR-FUN-009 SR-FUN-011 SR-FUN-013	UC-MEB-05	UAT

UR-MEB-04	Discovery and Access to the EMODnet Biology - non-indigenous species	3.1.1	SR-FUN-004 SR-FUN-006 SR-FUN-007 SR-FUN-008 SR-FUN-009 SR-FUN-011 SR-FUN-013	UC-MEB-06	UAT
UR-MEB-05	Discovery and Access to the Joint Copernicus Marine – tracking whales' data	3.1.1	SR-FUN-004 SR-FUN-006 SR-FUN-007 SR-FUN-008 SR-FUN-009 SR-FUN-011 SR-FUN-013	UC-MEB-07	UAT
UR-MEB-06	Discovery and Access to the Soft Corals Article	3.1.1	SR-FUN-004 SR-FUN-006 SR-FUN-007 SR-FUN-008 SR-FUN-009 SR-FUN-011 SR-FUN-013	UC-MEB-02	UAT
UR-MEB-07	Discovery and Access to the Ecosystem Services Article	3.1.1	SR-FUN-004 SR-FUN-006 SR-FUN-007 SR-FUN-008 SR-FUN-009 SR-FUN-011 SR-FUN-013	UC-MEB-03	UAT
UR-MAB-01	Discovery and Access to the EMODnet Bathymetry services	3.1.1	SR-FUN-005 SR-FUN-006 SR-FUN-007 SR-FUN-008 SR-FUN-009 SR-FUN-011 SR-FUN-012 SR-FUN-013	UC-MAB-01	UAT
UR-MAC-01	Discovery and Access to the EMODnet Chemistry, EU baseline	3.1.1 3.2.5 3.2.6 3.2.7	SR-FUN-004 SR-FUN-006 SR-FUN-007 SR-FUN-008 SR-FUN-009 SR-FUN-011 SR-FUN-013	UC-MAC-01	UAT

UR-MAC-02	Discovery and Access to the EMODnet Chemistry, Marine Litter	3.1.1 3.2.5 3.2.6 3.2.7	SR-FUN-004 SR-FUN-006 SR-FUN-007 SR-FUN-008 SR-FUN-009 SR-FUN-011 SR-FUN-013	UC-MAC-02	UAT
UR-JRC-01	GREEN Model shared in VLab	3.2.8	SR-FUN-010	UC-JRC-01	UAT
UR-JRC-02	GREEN Model input data	3.2.8	SR-FUN-010	UC-JRC-01	UAT
UR-JRC-03	GREEN Model parameters	3.2.8	SR-FUN-010	UC-JRC-01	UAT
UR-JRC-04	GREEN Web Application	3.2.8	SR-FUN-010	UC-JRC-01	UAT
UR-JRC-05	AGB ML Model shared in VLab	3.2.9	SR-FUN-010	UC-JRC-02	UAT
UR-JRC-06	Support of multiple AGB ML models in VLab	3.2.9	SR-FUN-015	UC-JRC-02	UAT
UR-JRC-07	GEO DAB Sentinel Products Coverage query	3.2.9	SR-FUN-014	UC-JRC-02	UAT
UR-JRC-08	GEOSS Portal enhancements for input selection	3.2.9	SR-FUN-014	UC-JRC-02	UAT
UR-JRC-09	GEOSS Portal enhancements for ML models	3.2.9	SR-FUN-015	UC-JRC-02	UAT
UR-JRC-10	GEOSS Portal dashboard for Above Ground Biomass (AGB) maps	3.2.9	SR-FUN-015	UC-JRC-02	UAT
UR-CCP-01	Norovirus Risk Maps Model based on ecological niches	3.2.11	SR-FUN-005 SR-FUN-007 SR-FUN-008 SR-FUN-009 SR-FUN-010 SR-FUN-012 SR-FUN-013	UC-CCP-01	UAT
UR-CCP-02	Norovirus epidemiologic data	3.2.11	SR-FUN-004 SR-FUN-007 SR-FUN-008 SR-FUN-009 SR-FUN-011 SR-FUN-013	UC-CCP-01	UAT
UR-CCP-03	IPCC scenarios data	3.2.11	SR-FUN-004 SR-FUN-007 SR-FUN-008 SR-FUN-009 SR-FUN-011 SR-FUN-013	UC-CCP-01	UAT
UR-CCP-04	Species Distribution data	3.2.11	SR-FUN-004 SR-FUN-007 SR-FUN-008 SR-FUN-009 SR-FUN-011 SR-FUN-013	UC-CCP-01	UAT

UR-CCP-05	GWP/VLab Enhancement	3.2.11	SR-FUN-010	UC-CCP-01	UAT
UR-AGA-01	Gross Primary Production product discovery	3.2.12	SR-FUN-004	UC-AGA-01	UAT
UR-AGA-02	Gross Primary Production product visualization	3.2.12	SR-FUN-004 SR-FUN-007 SR-FUN-008 SR-FUN-009	UC-AGA-01	UAT
UR-AGA-03	Gross Primary Production training materials discovery	3.2.12	SR-FUN-004 SR-FUN-007 SR-FUN-008 SR-FUN-009	UC-AGA-01	UAT
UR-AGA-04	Gross Primary Production computation service execution	3.2.12	SR-FUN-004 SR-FUN-005 SR-FUN-006 SR-FUN-010 SR-FUN-012	UC-AGA-01	UAT
UR-AGA-05	Gross Primary Production product specification/definition	3.2.12	SR-FUN-004	UC-AGA-01	UAT
UR-AGA-06	Gross Primary Production product support/feedback	3.2.12	SR-FUN-004	UC-AGA-01	UAT
UR-AGA-07	Gross Primary Production product /workflow integration into eLTER cyberinfrastructure	3.2.12	SR-FUN-011	UC-AGA-02	UAT
UR-AGA-08	Gross Primary Production product documentation	3.2.12	SR-FUN-007 SR-FUN-008 SR-FUN-009 SR-FUN-011 SR-FUN-013	UC-AGA-02	UAT
UR-AGA-09	Gross Primary Production training materials discovery	3.2.12	SR-FUN-007 SR-FUN-008 SR-FUN-009 SR-FUN-011 SR-FUN-013	UC-AGA-02	UAT
UR-AGA-10	Gross Primary Production product Metadata	3.2.12	SR-FUN-007 SR-FUN-008 SR-FUN-009 SR-FUN-011	UC-AGA-02	UAT
UR-AGA-11	Gross Primary Production product support/feedback	3.2.12	SR-FUN-011	UC-AGA-02	UAT
UR-AGA-12	Gross Primary Production product specifications/definition	3.2.12	SR-FUN-011	UC-AGA-02	UAT
UR-AGA-13	Gross Primary Production Metadata specification and provision	3.2.12	SR-FUN-007 SR-FUN-008 SR-FUN-009 SR-FUN-011	UC-AGA-03	UAT
UR-AGA-14	Gross Primary Production product – API – data provision	3.2.12	SR-FUN-011	UC-AGA-03	UAT

UR-AGA-15	Gross Primary Production product documentation/knowledge package	3.2.12	SR-FUN-011 SR-FUN-013	UC-AGA-03	UAT
UR-AGA-16	Gross Primary Production product quality check	3.2.12	SR-FUN-11	UC-AGA-03	UAT
UR-AGA-17	Gross Primary Production product communication channels	3.2.12	SR-FUN-011 SR-FUN-013	UC-AGA-03	UAT
UR-AGA-18	Gross Primary Production product data policies	3.2.12	SR-FUN-11	UC-AGA-03	
UR-MPS-01	Host WorldCereal repository	3.2.13		UC-MPS-01	UAT
UR-MPS-02	Register WorldCereal in-situ data and guidelines	3.2.13	SR-FUN-006 SR-FUN-007 SR-FUN-008	UC-MPS-01	UAT
UR-MPS-03	Registration of in-situ data providers	3.2.13	SR-FUN-011	UC-MPS-02	UAT
UR-MPS-04	Thematic area “in-situ data crop” accessibility through the GEOSS Portal	3.2.13	SR-FUN-006	UC-MPS-03	UAT
UR-MPS-05	Discovery, access and inspection of WorldCereal or AGROSTAC harmonized in-situ reference data	3.2.13	SR-FUN-004 SR-FUN-007 SR-FUN-008 SR-FUN-009	UC-MPS-03	UAT
UR-MPS-06	Crop map generation parameters definition	3.2.13	SR-FUN-005 SR-FUN-006 SR-FUN-012	UC-MPS-04	UAT, Partially
UR-MPS-07	Access and trigger WorldCereal processing module	3.2.13	SR-FUN-005 SR-FUN-006 SR-FUN-010 SR-FUN-012	UC-MPS-04	UAT, Partially
UR-MPS-08	Visualization of crop map and saving in personal workspace	3.2.13	SR-FUN-005 SR-FUN-006 SR-FUN-007 SR-FUN-012	UC-MPS-04	UAT, Partially
UR-HAR-01	Discovery of Harmonia data on urban heat fluxes and heat emissions	3.1.1	SR-FUN-04	UC-HAR-01	UAT
UR-HAR-02	Access and analysis of Harmonia data on urbanheat fluxes and heat emissions	3.1.1	SR-FUN-09	UC-HAR-01	UAT

Table 3 - Requirements traceability

4.2 Scenarios vs system required capabilities

#	Code	Title	System Requirements
1.	S1	Resources discovery and access with linked information	SR-FUN-002 – Mirror Site SR-FUN-003 – SDG - 15.3.1 Dashboard SR-FUN-004 – Data discovery (with relationships to associated concepts) SR-FUN-005 – Service Discovery (with relationships to associated concepts) SR-FUN-006 – Information Discovery (with relationships to associated concepts) SR-FUN-007 – Inspection of search results SR-FUN-008 – Selection of search results SR-FUN-009 – Access to selected resource SR-FUN-016 – AI-Powered Data Discovery and Access
2.	S2	Service Use	SR-FUN-003 – SDG - 15.3.1 Dashboard SR-FUN-010 – Service execution SR-FUN-014 – Support Sentinel Product Coverage SR-FUN-015 – Support ML models
3.	S3	Resources Registration	SR-FUN-003 – SDG - 15.3.1 Dashboard SR-FUN-011– Data provision (registration) SR-FUN-012 – Services provision (registration) SR-FUN-013 – Information provision (registration)
4.	S4	Promotion and collaboration.	SR-FUN-011– Data provision (registration) SR-FUN-012 – Services provision (registration) SR-FUN-013 – Information provision (registration) SR-FUN-017 – GEOSS Landing Page
5.	S5	Data providers (registration)	SR-FUN-001 – Yellow Pages Management
6.	S6	Exploiting discovery and access capabilities	SR-FUN-002 – Mirror Site SR-FUN-003 – SDG - 15.3.1 Dashboard SR-NFC-001 – Configurability of search domain SR-NFC-002 – Portal Customizability
7.	S7	Discovering experiment results	SR-FUN-006 – Information Discovery (with relationships to associated concepts) SR-FUN-007 – Inspection of search results SR-FUN-008 – Selection of search results SR-FUN-009 – Access to selected resource SR-FUN-013 – Information provision (registration)
8.	S8	Reproducing an experiment	SR-FUN-006 – Information Discovery (with relationships to associated concepts) SR-FUN-007 – Inspection of search results SR-FUN-008 – Selection of search results SR-FUN-009 – Access to selected resource SR-FUN-010 – Service execution SR-FUN-013 – Information provision (registration)

#	Code	Title	System Requirements
9.	S9	Replicating an experiment	SR-FUN-003 – SDG - 15.3.1 Dashboard SR-FUN-004 – Data discovery (with relationships to associated concepts) SR-FUN-006 – Information Discovery (with relationships to associated concepts) SR-FUN-007 – Inspection of search results SR-FUN-008 – Selection of search results SR-FUN-009 – Access to selected resource SR-FUN-010 – Service execution SR-FUN-013 – Information provision (registration)
10.	S10	Reusing an experiment	SR-FUN-003 – SDG - 15.3.1 Dashboard SR-FUN-004 – Data discovery (with relationships to associated concepts) SR-FUN-005 – Service Discovery (with relationships to associated concepts) SR-FUN-006 – Information Discovery (with relationships to associated concepts) SR-FUN-007 – Inspection of search results SR-FUN-008 – Selection of search results SR-FUN-009 – Access to selected resource SR-FUN-010 – Service execution SR-FUN-013 – Information provision (registration)

Table 4 - Scenarios vs system required capabilities

4.3 System requirement capabilities vs User requirements

#	Code	Title	Linked User Requirements
1.	SR-FUN-001	Yellow Pages Management	UR-YPG-01- Graphic Banner UR-YPG-02- Wizard Registration UR-YPG-03- Terms of Service Acceptance UR-YPG-04- User Notifications UR-YPG-05- Data Modification\Deletion UR-YPG-06 – Data Provider Account Request UR-YPG-07- Search and Visualization of Registered Data Providers UR-YPG-08- Widget download UR-YPG-09- Widget Installation UR-YPG-10 – Yellow Pages Authorization UR-YPG-11 – Yellow Pages Authorization Response UR-YPG-12 – Data Modification UR-YPG-13 – Data Provider Account Management UR-YPG-14 – Data Provider Registration Process Status
2.	SR-FUN-002	Community Portal	UR-CSP-01 – Community Portal package access UR-CSP-02 – Community Portal General Configuration UR-CSP-03 – Views Selection UR-CSP- 04 - Views Setup UR-CSP-05 - Request to link a Community Portal UR-CSP-06 – Community Portal information UR-CSP-07 – Administration rights UR-CSP-08 – Linking a Community Portal
3.	SR-FUN-003	SDG – 15.3.1 Dashboard	UR-LDG-01 – SDG indicator 15.3.1 computation service discovery UR-LDG-02 – SDG indicator 15.3.1 computation service execution UR-LDG-03 – Visual representation of SDG indicator 15.3.1 computations UR-LDG-04 – My Workspace Dashboard UR-LDG-05 - Acceptance of the visualizations
4.	SR-FUN-004	Data Discovery (with relationships to associated concepts)	UR-EIF-01 – Discovery of Eiffel Pilot 3 data UR-EIF-03 – Discovery of Eiffel Pilot 4 data UR-ATL-01 – Discovery and Access to the EMODnet Marine Physics Datasets UR-MAC-01 – Discovery and Access to the EMODnet Chemistry, EU baseline UR-MAC-02 – Discovery and Access to the EMODnet Chemistry, Marine Litter UR-MEB-01 – Discovery and Access to the Ospar Data UR-MEB-02 – Discovery and Access to the Ospar Intermediate Assessment UR-MEB-03 – Discovery and Access to the EMODnet Biology

#	Code	Title	Linked User Requirements
			UR-MEB-04 – Discovery and Access to the EMODnet Biology - non-indigenous species UR-MEB-05 – Discovery and Access to the Joint Copernicus Marine – tracking whales' data UR-MEB-06 – Discovery and Access to the Soft Corals Article GPP EC Grant Agreement no. 101039118 Deliverable D2.6 Page 52 of 79 UR-MEB-07 – Discovery and Access to the Ecosystem Services ArticleUR-CCP-02 - Norovirus epidemiologic data UR-CCP-03 – IPCC scenarios data UR-CCP-04 – Species Distribution data UR-GSA-02 – GSA Data UR-MPS-05 – Discovery, access and inspection of WorldCereal or AGROSTAC harmonized in-situ reference data UR-AGA-01 – Gross Primary Production product discovery UR-AGA-02 – Gross Primary Production product visualization UR-AGA-03 – Gross Primary Production training materials discovery UR-AGA-04 – Gross Primary Production computation service execution UR-AGA-05 – Gross Primary Production product specification/definition UR-AGA-06 – Gross Primary Production product support/feedback UR-HAR-01 – Discovery of Harmonia data on urban heat fluxes and heat emissions
5.	SR-FUN-005	Service Discovery (with relationships to associated concepts)	UR-LDG-01 – SDG indicator 15.3.1 computation service discovery UR-EIF-03 – Discovery of Eiffel Pilot 4 data UR-ATL-02 – Discovery and Access to the Brazilian Observatory Service UR-CCP-01 - Norovirus Risk Maps Model based on ecological niches. UR-GSA-01 – Urban Green Spaces Accessibility Model UR-MPS-06 – Crop map UR-MPS-07 – Access and trigger WorldCereal processing module UR-MPS-08 – Visualization of crop map and saving in personal workspace UR-AGA-04 – Gross Primary Production computation service execution UR-MAB-01 – Discovery and Access to the EMODnet Bathymetry services
6.	SR-FUN-006	Information Discovery (with relationships to associated concepts)	UR-LDG-05- Acceptance of the visualizations UR-AFG-06 - Accessing data, information and knowledge from AfriGEOSS UR-ATL-01 – Discovery and Access to the EMODnet Marine Physics Datasets UR-ATL-02 – Discovery and Access to the Brazilian Observatory Service

#	Code	Title	Linked User Requirements
			UR-MAC-01 – Discovery and Access to the EMODnet Chemistry, EU baseline UR-MAC-02 – Discovery and Access to the EMODnet Chemistry, Marine Litter UR-MEB-01 – Discovery and Access to the Ospar Data UR-MEB-02 – Discovery and Access to the Ospar Intermediate Assessment UR-MEB-03 – Discovery and Access to the EMODnet Biology UR-MEB-04 – Discovery and Access to the EMODnet Biology - non-indigenous species UR-MEB-05 – Discovery and Access to the Joint Copernicus Marine – tracking whales' data UR-MEB-06 – Discovery and Access to the Soft Corals Article GPP EC Grant Agreement no. 101039118 Deliverable D2.6 Page 52 of 79 UR-MEB-07 – Discovery and Access to the Ecosystem Services ArticleUR-MAB-01 – Discovery and Access to the EMODnet Bathymetry services UR-EIF-01 – Discovery of Eiffel Pilot 3 data UR-EIF-03 – Discovery of Eiffel Pilot 4 data UR-LDG-01 – SDG indicator 15.3.1 computation service discovery UR-ATL-02 – Discovery and Access to the Brazilian Observatory Service UR-MAB-01 – Discovery and Access to the EMODnet Bathymetry services UR-CCP-01 - Norovirus Risk Maps Model based on ecological niches UR-MPS-02 – Register WorldCereal in-situ data and guidelines UR-MPS-04 – Thematic area "in-situ data crop" UR-MPS-06 – Crop map UR-MPS-07 – Access and trigger WorldCereal processing module UR-MPS-08 – Visualization of crop map and saving in personal workspace UR-AGA-04 – Gross Primary Production computation service execution
7.	SR-FUN-007	Inspection of search results	UR-LDG-01 – SDG indicator 15.3.1 computation service discovery UR-LDG-04 – My Workspace Dashboard UR-LDG-05- Acceptance of the visualizations UR-EIF-01 – Discovery of Eiffel Pilot 3 data UR-EIF-02 – Access and visualization of Eiffel Pilot 3 data UR-EIF-03 – Discovery of Eiffel Pilot 4 data UR-EIF-04 – Access and visualization of Eiffel Pilot 4 data UR-AFG-06 - Accessing data, information and knowledge from AfriGEOSS UR-ATL-02 – Discovery and Access to the Brazilian Observatory Service

#	Code	Title	Linked User Requirements
			UR-MAC-01 – Discovery and Access to the EMODnet Chemistry, EU baseline UR-MAC-02 – Discovery and Access to the EMODnet Chemistry, Marine Litter UR-MEB-01 – Discovery and Access to the Ospar Data UR-MEB-02 – Discovery and Access to the Ospar Intermediate Assessment UR-MEB-03 – Discovery and Access to the EMODnet Biology UR-MEB-04 – Discovery and Access to the EMODnet Biology - non-indigenous species UR-MEB-05 – Discovery and Access to the Joint Copernicus Marine – tracking whales' data UR-MEB-06 – Discovery and Access to the Soft Corals Article GPP EC Grant Agreement no. 101039118 Deliverable D2.6 Page 52 of 79 UR-MEB-07 – Discovery and Access to the Ecosystem Services ArticleUR-MAB-01 – Discovery and Access to the EMODnet Bathymetry services UR-CCP-01 - Norovirus Risk Maps Model based on ecological niches UR-CCP-02 - Norovirus epidemiologic data UR-CCP-03 – IPCC scenarios data UR-CCP-04 – Species Distribution data UR-GSA-01 – Urban Green Spaces Accessibility Model UR-GSA-02 – GSA Data UR-MPS-02 – Register WorldCereal in-situ data and guidelines UR-MPS-05 – Discovery, access and inspection of WorldCereal or AGROSTAC harmonized in-situ reference data UR-MPS-08 – Visualization of crop map and saving in personal workspace UR-AGA-02 – Gross Primary Production product visualization UR-AGA-03 – Gross Primary Production training materials discovery UR-AGA-08 – Gross Primary Production product documentation UR-AGA-09 – Gross Primary Production training materials discovery UR-AGA-10 – Gross Primary Production product Metadata UR-AGA-13 – Gross Primary Production Metadata specification and provision
8.	SR-FUN-008	Selection of search results	UR-LDG-01 – SDG indicator 15.3.1 computation service discovery UR-LDG-04 – My Workspace Dashboard UR-LDG-05- Acceptance of the visualizations UR-EIF-01 – Discovery of Eiffel Pilot 3 data UR-EIF-02 – Access and visualization of Eiffel Pilot 3 data UR-EIF-03 – Discovery of Eiffel Pilot 4 data UR-EIF-04 – Access and visualization of Eiffel Pilot 4 data UR-AFG-06 - Accessing data, information and knowledge from AfriGEOSS

#	Code	Title	Linked User Requirements
			UR-ATL-01 – Discovery and Access to the EMODnet Marine Physics Datasets UR-ATL-02 – Discovery and Access to the Brazilian Observatory Service UR-MAC-01 – Discovery and Access to the EMODnet Chemistry, EU baseline UR-MAC-02 – Discovery and Access to the EMODnet Chemistry, Marine Litter UR-MEB-01 – Discovery and Access to the Ospar Data UR-MEB-02 – Discovery and Access to the Ospar Intermediate Assessment UR-MEB-03 – Discovery and Access to the EMODnet Biology UR-MEB-04 – Discovery and Access to the EMODnet Biology - non-indigenous species UR-MEB-05 – Discovery and Access to the Joint Copernicus Marine – tracking whales' data UR-MEB-06 – Discovery and Access to the Soft Corals Article GPP EC Grant Agreement no. 101039118 Deliverable D2.6 Page 52 of 79 UR-MEB-07 – Discovery and Access to the Ecosystem Services ArticleUR-MAB-01 – Discovery and Access to the EMODnet Bathymetry services UR-CCP-01 - Norovirus Risk Maps Model based on ecological niches UR-CCP-02 - Norovirus epidemiologic data UR-CCP-03 – IPCC scenarios data UR-CCP-04 – Species Distribution data UR-GSA-01 – Urban Green Spaces Accessibility Model UR-GSA-02 – GSA Data UR-MPS-02 - Register WorldCereal in-situ data guidelines UR-MPS-05 – Discovery, access and inspection of WorldCereal or AGROSTAC harmonized in-situ reference data UR-AGA-02 – Gross Primary Production product visualization UR-AGA-03 – Gross Primary Production training materials discovery UR-AGA-08 – Gross Primary Production product documentation UR-AGA-09 – Gross Primary Production training materials discovery UR-AGA-10 – Gross Primary Production product Metadata UR-AGA-13 – Gross Primary Production Metadata specification and provision
9.	SR-FUN-009	Access to selected resource	UR-LDG-01 – SDG indicator 15.3.1 computation service discovery UR-LDG-04 – My Workspace Dashboard UR-LDG-05- Acceptance of the visualizations

#	Code	Title	Linked User Requirements
			UR-AFG-06 - Accessing data, information and knowledge from AfriGEOSS UR-EIF-02 – Access and visualization of Eiffel Pilot 3 data UR-EIF-04 – Access and visualization of Eiffel Pilot 4 data UR-ATL-01 – Discovery and Access to the EMODnet Marine Physics Datasets UR-ATL-02 – Discovery and Access to the Brazilian Observatory Service UR-MAC-01 – Discovery and Access to the EMODnet Chemistry, EU baseline UR-MAC-02 – Discovery and Access to the EMODnet Chemistry, Marine Litter UR-MEB-01 – Discovery and Access to the Ospar Data UR-MEB-02 – Discovery and Access to the Ospar Intermediate Assessment UR-MEB-03 – Discovery and Access to the EMODnet Biology UR-MEB-04 – Discovery and Access to the EMODnet Biology - non-indigenous species UR-MEB-05 – Discovery and Access to the Joint Copernicus Marine – tracking whales' data UR-MEB-06 – Discovery and Access to the Soft Corals Article GPP EC Grant Agreement no. 101039118 Deliverable D2.6 Page 52 of 79 UR-MEB-07 – Discovery and Access to the Ecosystem Services ArticleUR-MAB-01 – Discovery and Access to the EMODnet Bathymetry services UR-MAB-01 – Discovery and Access to the EMODnet Bathymetry services UR-CCP-01 - Norovirus Risk Maps Model based on ecological niches UR-CCP-02 - Norovirus epidemiologic data UR-CCP-03 – IPCC scenarios data UR-CCP-04 – Species Distribution data UR-GSA-01 – Urban Green Spaces Accessibility Model UR-GSA-02 – GSA Data UR-MPS-05 – Discovery, access and inspection of WorldCereal or AGROSTAC harmonized in-situ reference data UR-AGA-02 – Gross Primary Production product visualization UR-AGA-03 – Gross Primary Production training materials discovery UR-AGA-08 – Gross Primary Production product documentation UR-AGA-09 – Gross Primary Production training materials discovery UR-AGA-10 – Gross Primary Production product Metadata UR-AGA-13 – Gross Primary Production Metadata specification and provision UR-HAR-02 – Access and analysis of Harmonia data on urban heat fluxes and heat emissions
10.	SR-FUN-010	Service Execution	UR-LDG-02 – SDG indicator 15.3.1 computation service execution

#	Code	Title	Linked User Requirements
			UR-LDG-04 – My Workspace Dashboard UR-CCP-01 - Norovirus Risk Maps Model based on ecological niches UR-CCP-05 – GWP/VLab Enhancement UR-GSA-01 – Urban Green Spaces Accessibility Mode UR-MPS-07 – Access and trigger WorldCereal processing module UR-AGA-04 – Gross Primary Production computation service execution (Note: For AGAME static provision of data products using computation services are implemented in the first iteration)
11.	SR-FUN-011	Data Provision (Registration)	UR-EIF-02 – Access and visualization of Eiffel Pilot 3 data UR-EIF-04 – Access and visualization of Eiffel Pilot 4 data UR-ATL-01 – Discovery and Access to the EMODnet Marine Physics Datasets UR-ATL-02 – Discovery and Access to the Brazilian Observatory Service UR-MAC-01 – Discovery and Access to the EMODnet Chemistry, EU baseline UR-MAC-02 – Discovery and Access to the EMODnet Chemistry, Marine Litter UR-MEB-01 – Discovery and Access to the Ospar Data UR-MEB-02 – Discovery and Access to the Ospar Intermediate Assessment UR-MEB-03 – Discovery and Access to the EMODnet Biology UR-MEB-04 – Discovery and Access to the EMODnet Biology - non-indigenous species UR-MEB-05 – Discovery and Access to the Joint Copernicus Marine – tracking whales' data UR-MEB-06 – Discovery and Access to the Soft Corals Article GPP EC Grant Agreement no. 101039118 Deliverable D2.6 Page 52 of 79 UR-MEB-07 – Discovery and Access to the Ecosystem Services ArticleUR-MAB-01 – Discovery and Access to the EMODnet Bathymetry services UR-CCP-02 - Norovirus epidemiologic data UR-CCP-03 – IPCC scenarios data UR-CCP-04 – Species Distribution data UR-GSA-01 – Urban Green Spaces Accessibility Model UR-GSA-02 – GSA Data UR-MPS-03 - Register in-situ data providers UR-AGA-07 – Gross Primary Production product /workflow integration into eLTER cyberinfrastructure UR-AGA-08 – Gross Primary Production product documentation UR-AGA-09 – Gross Primary Production training materials discovery UR-AGA-10 – Gross Primary Production product Metadata UR-AGA-11 – Gross Primary Production Product support/feedback

#	Code	Title	Linked User Requirements
			UR-AGA-12 – Gross Primary Production product specification / definition UR-AGA-13 – Gross Primary Production Metadata specification and provision UR-AGA-14 – Gross Primary Production product API - data provision UR-AGA-15 – Gross Primary Production product documentation/knowledge package UR-AGA-16 – Gross Primary Production product quality check UR-AGA-17 – Gross Primary Production product communication channels UR-AGA-18 – Gross Primary Production product data policies
12.	SR-FUN-012	Service Provision (Registration)	UR-LDG-01 – SDG indicator 15.3.1 computation service discovery UR-LDG-02 – SDG indicator 15.3.1 computation service execution UR-ATL-02 – Discovery and Access to the Brazilian Observatory Service UR-MAB-01 – Discovery and Access to the EMODnet Bathymetry services UR-EIF-03 – Discovery of Eiffel Pilot 4 data UR-CCP-01 - Norovirus Risk Maps Model based on ecological niches UR-GSA-01 – Urban Green Spaces Accessibility Model UR-MPS-06 – Crop map UR-MPS-07 – Access and trigger WorldCereal processing module UR-MPS-08 – Visualization of crop map and saving in personal workspace UR-AGA-04 – Gross Primary Production computation service execution (Note: AGAME workflow could be GPP EC Grant Agreement no. 101039118 Deliverable D2.6 Page 73 of 79 deployed in a cloud computing infrastructure such as VLabs to provide a computation service. AGAME Gross Primary Production computation services could be registered later in GEOSS platform based on metadata defined in the service definition model and allow the service to be discoverable in GEOSS Platform. The computation service will allow users to replicate AGAME Gross Primary Production products and extend the period of analysis for upcoming years when new satellite imagery from Sentinel-2 is available.)
13.	SR-FUN-013	Information Provision (Registration)	UR-LDG-03 – Visual representation of SDG indicator 15.3.1 computations UR-ATL-01 – Discovery and Access to the EMODnet Marine Physics Datasets UR-ATL-02 – Discovery and Access to the Brazilian Observatory Service UR-MAC-01 – Discovery and Access to the EMODnet Chemistry, EU baseline UR-MAC-02 – Discovery and Access to the EMODnet Chemistry, Marine Litter

#	Code	Title	Linked User Requirements
			UR-MEB-01 – Discovery and Access to the Ospar Data UR-MEB-02 – Discovery and Access to the Ospar Intermediate Assessment UR-MEB-03 – Discovery and Access to the EMODnet Biology UR-MEB-04 – Discovery and Access to the EMODnet Biology - non-indigenous species UR-MEB-05 – Discovery and Access to the Joint Copernicus Marine – tracking whales' data UR-MEB-06 – Discovery and Access to the Soft Corals Article GPP EC Grant Agreement no. 101039118 Deliverable D2.6 Page 52 of 79 UR-MEB-07 – Discovery and Access to the Ecosystem Services ArticleUR-MAB-01 – Discovery and Access to the EMODnet Bathymetry services UR-EIF-01 – Discovery of Eiffel Pilot 3 data UR-EIF-03 – Discovery of Eiffel Pilot 4 data UR-CCP-01 - Norovirus Risk Maps Model based on ecological niches UR-CCP-02 - Norovirus epidemiologic data UR-CCP-03 – IPCC scenarios data UR-CCP-04 – Species Distribution data UR-GSA-01 – Urban Green Spaces Accessibility Model UR-GSA-02 – GSA Data UR-AGA-08 – Gross Primary Production product documentation UR-AGA-09 – Gross primary production training material discovery UR-AGA-15 – Gross Primary Production product documentation/knowledge package UR-AGA-17 – Gross Primary Production product communication channels
14.	SR-FUN-014	Support Sentinel Product Coverage	UR-JRC-07: GEO DAB Sentinel Products Coverage query UR-JRC-08: GWP enhancements for input selection
15.	SR-FUN-015	Support ML models	UR-JRC-06: Support of multiple AGB ML models in VLab UR-JRC-09: GEOSS Portal enhancements for ML models UR-JRC-10: GEOSS Portal dashboard for AGB maps
16.	SR-FUN-016	AI-Powered Data Discovery and Access	UR-AIP-01: Natural Language Query Processing UR-AIP-02: Relevant Dataset Suggestions UR-AIP-03: Download Instructions UR-AIP-04: Related Dataset Recommendations UR-AIP-05 – User Interface for AI-Powered Search GPP EC Grant Agreement no. 101039118 Deliverable D2.6 Page 74 of 79 UR-AIP-06 – Security and Privacy
17.	SR-FUN-017	GEOSS Portal Landing Page	UR-LP-01: Structured Layout UR-LP-02: Direct Navigation UR-LP-03: SEO Optimization

#	Code	Title	Linked User Requirements
			UR-LP-04: Analytics Integration UR-LP-05: Article Management UR-LP-06: Cookie Notice
18.	SR-NFC-001	Configurability of search domain	UR-AFG-02 - The AfriGEO search keywords UR-AFG-03 - The AfriGEO Region of Interest UR-AFG-04 - The AfriGEO search domain UR-CSP-03 - Views Selection UR-CSP- 04 - Views Setup
19.	SR-NFC-002	Portal customizability	UR-AFG-01 - A dedicated portal for the AfriGEO community UR-AFG-05 - The AfriGEO filtering capabilities UR-CSP-01 – Community Portal package access UR-CSP-02 – Community Portal General Configuration UR-CSP-05 - Request to link a Community Portal UR-CSP-06 – Community Portal information UR-CSP-07 – Administration rights UR-CSP-08 – Linking a Community Portal

Table 5 - System vs User Requirements Traceability

Annex A. References

[RD-1] D2.1 Use Cases Description and User Requirements Document – v1.0

[RD-2] D2.2 Functional and non-functional enhancements specification - v1.0

[RD-3] D3.1 Enhanced GEOSS Platform v1 with 1st set of applications

[RD-4] D3.2 Enhanced GEOSS Platform User Manual v1 with 1st set of applications

[RD-5] D3.3 The GEOSS Overarching Architecture

[RD-6] D2.3 Use Cases Description and User Requirements Document – v2.0

[RD-7] D2.4 Functional and non-functional enhancements specification v2.0

[RD-8] D3.4 Enhanced GEOSS Platform v2 with 2nd set of applications

[RD-9] D3.5 Enhanced GEOSS Platform User Manual v2 with second set of applications

[RD-10] D2.5 Use Cases Description and User Requirements Document – v3.0

[RD-11] D2.6 Functional and non-functional enhancements specification v3.0

[RD-12] D3.6 The GPP Vision for GEOSS Evolution

[WR-1] https://www.earthobservations.org/article.php?id=458

Annex B. Figures and Tables

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Annex C. GEO DAB Standards

The table below provides an overview of all the standards handled by the GEO DAB

OGC CSW 2.0.2 AP ISO 1.0	INPE
OGC CSW 2.0.2 ebRIM EO	CKAN/DKAN
OGC CSW 2.0.2 ebRIM CIM	DCAT
ESRI GEOPORTAL 10	GI-cat
OAI-PMH 2.0	ESRI GEOPORTAL 10
OpenSearch 1.1	NCML-OD
OpenSearch 1.1 ESIP	BCODMO
OpenSearch GENESI DR	NCML-CF
CKAN	NetCDF-CF 1.4
CUAHSI HIS-Central	FTP populated with supported metadata types
ESRI REST API 10.3	WAF Web Accessible Folders
OGC WCS	GeoNetwork (2.2.0 or greater)
OGC WMS	Ecological Markup Language 2.1.1
OGC WFS 1.0.0, 1.1.0, 2.0.0	NERRS (National Estuarine Research Reserve System)
OGC WMTS	HMA CSW 2.0.2 ebRIM/CIM
OGC SOS 1.0.0, 2.0.0, 2.0.0 Hydro Profile	HDF
OGC WPS 1.0.0	IADC DB (MySQL)
OGC CSW 2.0.0 Core	GrADS-DS
OGC CSW 2.0.2 AP ISO 1.0	FedEO
OGC CSW 2.0.2 ebRIM/EO AP	ARPA DB (based on Microsoft SQL)
OGC CSW 2.0.2 ebRIM/CIM AP	ESRI Map Server
IRIS Station	SHAPE files (FTP)
IRIS Event	KISTERS Web - Environment of Canada
HYRAX THREDDS SERVER 1.9	Environment Canada Hydrometric data (FTP)
OAI-PMH 2.0 - Harvesting	OpenSearch 1.1
GBIF	Earth Engine
DIF	RASAQM
HYDRO	EGASKRO
UNAVCO	SITAD (Sistema Informativo Territoriale Ambientale Diffuso)
CDI 1.04, 1.3, 1.4	File System
ISO19115-2	GDACS
THREDDS 1.0.1, 1.0.2	GeoRSS 2.0
THREDDS-NCISO 1.0.1, 1.0.2	Degree catalog service 2.2
THREDDS-NCISO-PLUS 1.0.1, 1.0.2	OpenSearch GENESI DR
Healthsites API Json	

Table 6 - Standards handled by the GEO DAB

Annex D. Terminology

Acronyms and Abbreviations

EDGE	European Direction in GEOSS Common Infrastructure Enhancements
BON	Biodiversity Observation Network
CA	Consortium Agreement
CAMS	Copernicus Atmosphere Monitoring Service
C3S	Copernicus Climate Change Service
CEOS	Committee on Earth Observation Satellites
CLMS	Copernicus Land Monitoring Service
CMEMS	Copernicus Marine Environment Monitoring Service
CNR-IIA	Consiglio Nazionale delle Ricerche – Istituto per l'Inquinamento Atmosferico
CO	Confidential
DESCA	Development of a Simplified Consortium Agreement
DEL	Deliverable
DG	Directorate-General
DN	Direct Negotiation
DOW	Description of Work
EAB	External Advisory Board
EC	European Commission
EGU	European Geosciences Union
EMS	Emergency Management Service
EO	Earth Observation
EOP	Earth Observation Programme
ESA	European Space Agency
ESAW	European Ground System Architecture Workshop
ESRIN	European Space Research Institute
EU	European Union
FP7	Seventh Framework Programme
GA	Grant Agreement
GCI	GEOSS Common Infrastructure
GEO	Group on Earth Observation
GEO DAB	GEO Discovery and Access Broker
GEOSS	Global Earth Observation System of Systems
GFOI	Global Forest Observation Initiative
GLAM	Global Agriculture Monitoring
GPE	GEOSS Portal Enhancements
GSNL	Geohazard Supersites and Natural Laboratories
GWOS	Global Wetlands Observing System
H2020	Horizon 2020

INT	Internal Note
IPR	Intellectual Property Right
JRC	Joint Research Centre
MOM	Minutes of Meeting
OTH	Other
PD	Project Director
PP	Programme Participants
PQMP	Project Quality Management Plan
PRE	Presentation
PSB	Project Strategic Board
PU	Public Usage
QA	Quality Assurance
QAS	Quality Assurance Support
RE	Restricted
SDG	Sustainable Development Goal
SUS	System Usability Scale
TBD	To Be Defined
TEP	Thematic Exploitation Platform
UNICEF	United Nations International Children's Emergency Fund
USGS	United States Geological Survey
UTB	User and Technical Board
WBS	Work Breakdown Structure
WGISS	Working Group on Information Systems and Services
WP	Work Package
WPL	Work Package Leader
UTF-8	8-bi Unicode Transformation Format
UTC	Coordinated Universal Time
RDBMS	Relational Database Management System
DDL	Data Definition Language
DML	Data Manipulation Language
TCL	Transaction Control Language
SMTP	Simple Mail Transfer Protocol
SSL	Secure Sockets Layer
TLS	Transport Layer Security
SPA	Single-page Application
API	Application Programming Interface
REST	Representational State Transfer
CORS	Cross-Origin Resource Sharing
CSP	Content Security Policy

Table 7 - Acronyms and Abbreviations