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Contribution to the GEOSS Ecosystem Task and to the GEOSS Data Core

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Main Authors:	Paolo Mazzetti, Stefano Nativi, Mattia Santoro

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Outline

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Executive Summary

The ECOPOTENTIAL project as a whole has a strong link with GEO and GEOSS activities. Its work plan includes several actions directly or indirectly contributing to the development of GEO and GEOSS. Moreover, the GEO 2017-2019 Work Programme cites ECOPOTENTIAL as a major contribution to the GEO Global Ecosystem Initiative (GEO ECO).

The ECOPOTENTIAL Work Package 10 on "ECOPOTENTIAL Virtual Laboratory Platform" is specifically dedicated to the design, implementation and operation of the ECOPOTENTIAL VLAB, a virtual environment supporting the activities of the ecosystem community-of-practice. It aims at addressing specific objectives of the project including the provision of open and interoperable access to data and knowledge, and the support of the development of new prototype products and ecosystem services, based on improved access to (notably via GEOSS) and long-term storage of ecosystem Earth Observation data and information.

On May 2017, the second release of the VLAB allowed data discovery and access from multiple EO and in-situ data sources and systems, and run of workflows. In the following months, tutorial and dissemination activities helped modelists to port an initial set of workflows on the VLAB. A joint activity with ESA allowed developing a GEOSS Portal Mirror for the VLAB, presented at the GEO 2017 Week in Washington, October 2017. WP10 is now collecting feedback to advance the VLAB towards the next major releases planned in May 2018 and May 2019.

Based on the second release of the VLAB, it is possible to evaluate the existing and potential contribution to GEO and GEOSS.

The ECOPOTENTIAL VLAB is a direct contribution to the GEO Global Ecosystem Initiative (GEO ECO), providing one of the main results for the "Ecosystem models and e-laboratories" activity. It also contributes to other activities aiming at the development and implementation of knowledge-based policies in the ecosystem domain.

The technical achievements of the WP10 contribute to the GEOSS Common Infrastructure (GCI) and GEO EVOLVE tasks. In particular, the VLAB, with the ported models, is a valuable prototype of how GEOSS might support workflows run and sharing of knowledge artifacts.

In a more general sense, the ECOPOTENTIAL VLAB is an example of how dedicated tools can help to document and implement the transition from data to knowledge in support of the GEO User Needs and Gap Analysis Task.

Finally, the ECOPOTENTIAL project contributes to the GEOSS DataCORE through the interoperability between the ECOPOTENTIAL VLAB and the GEOSS Platform which makes ECOPOTENTIAL data, products and workflows freely available in GEOSS.

1 INTRODUCTION

The contribution to GEO and GEOSS is one of the main objectives of the H2020 ECOPOTENTIAL (Improving Future Ecosystem Benefits through Earth Observations) project. The SC5-16-2014 call for "Making Earth Observation and Monitoring Data usable for ecosystem modelling and services" specifically asked for the undertaking of "pilot actions in selected protected areas to further developing the Global Earth Observation System of Systems (GEOSS)"(European Commission 2013). It also expected impact in terms of "new prototype products and ecosystem services, based on improved access to (notably via GEOSS) and long-term storage of ecosystem Earth Observation data and information" and more generally achieving "strong European support and leadership within the GEO Ecosystem tasks". In ECOPOTENTIAL project "open and interoperable access to data and knowledge is assured by a GEO Ecosystem Virtual Laboratory Platform, fully integrated in GEOSS", making the ECOPOTENTIAL Virtual Laboratory and related applications a major way for implementing the GEO and GEOSS contribution by ECOPOTENTIAL.

In the ECOPOTENTIAL Work Plan, the Work Package 10 on "*ECOPOTENTIAL Virtual Laboratory Platform*" is specifically dedicated to the design, implementation and operation of the ECOPOTENTIAL VLAB (European Commission 2015). Task 10.4 on "*Coordination and interoperability with the GEO/GEOSS GCI and other significant initiatives*" assures that "A specific attention will be paid to GEO for the integration of the ECOPOTENTIAL capacities in GEOSS. A sustained interaction with the GEO governance, in particular with the GEOSS Infrastructure Implementation Board will assure the alignment of the ECOPOTENTIAL platform with the GEOSS targets, requirements and architecture."

The ECOPOTENTIAL VLAB architectural document explicitly states that it aims at providing the technical platform for addressing a general requirement of the SC5-16-2014 call: "recovering existing data, supporting new measurements and observations, synthesis and interpretation of data for making all information and knowledge available to scientists, policy makers, citizens and other concerned stakeholders to provide a full picture of the state and temporal evolution of ecosystems in existing internationally recognised protected areas" (Nativi, Mazzetti, and Santoro 2016). This makes the VLAB a valuable contribution to GEO and GEOSS, not limited to the Ecosystem Tasks, but more generally to all the GEO Tasks aiming at knowledge generation and support to informed policy-making, in particular, referring to the United Nations Sustainable Development Goals (SDG).

The following sections describe how the activities in ECOPOTENTIAL WP10 aimed at alignment with the GEOSS targets, requirements and architecture. Section 2 describes the past and on-going activities for the implementation, operation, dissemination and exploitation of the ECOPOTENTIAL VLAB to summarize current achievements. Section 3 discusses how the VLAB vision, approach and current implementation is aligned with GEOSS, contributing to GEO and GEOSS tasks and activities.

2 ECOPOTENTIAL WP10 ACTIVITIES RELEVANT FOR GEO/GEOSS TASKS

2.1 PARTICIPATION IN GEO TASKS AND BOARDS

During the period from June 2015 to May 2017 members of ECOPOTENTIAL WP10 working groups participated in GEO activities as members of GEO Boards and GEO Tasks working groups.

- Antonello Provenzale from CNR-IGG, coordinator of ECOPOTENTIAL, is:
  - Leader of the GEO Global Ecosystem Initiative (GEO ECO) Initiative
- Stefano Nativi from CNR-IIA, leader of ECOPOTENTIAL WP10, is:
  - Alternate member of the GEO Programme Board representing Italy
  - Co-leader of the Knowledge Base tool development activity in the User Needs and Gap Analysis Foundational Task
  - Contributor of the GEOSS Common Infrastructure (GCI) Operations Foundational Task, leading the GEO Discovery Access Broker (DAB) activity;
  - Contributor of the GEOSS-EVOLVE Foundational Task, co-leading the GEOSS Architecture and Evolution activity
- Joan Masó from CREAF, leader of ECOPOTENTIAL T10.3, is:
  - Alternate member of the GEO Programme Board representing Spain
  - Contributor of the GEOSS In-Situ Earth Observation Resources Foundational Task representing ENEON
- Ivette Serral from CREAF is:
  - Contributor of the GEOSS In-Situ Earth Observation Resources Foundational Task representing ENEON
- Elisa Palazzi from CNR-ISAC is:
  - Co-leader of the Geo Global Network for Observation and Information in Mountain Environments (GEO-GNOME)
- Mattia Santoro from CNR-IIA is:
  - Contributor of the GEOSS Common Infrastructure (GCI) Operations Foundational Task.
  - Contributor of the GEOSS-EVOLVE Foundational Task
  - Contact person for the GEO DAB technical support team to GEO Secretariat for the registration and brokering of new data systems in GEOSS.
- Gregory Giuliani from UNIGE is:
  - Contributor of the Capacity Building Coordination Foundational Task
  - Contributing member of the GEOSS Common Infrastructure (GCI) Operations Foundational Task.

This strong participation of people involved in ECOPOTENTIAL WP10 allowed a clear alignment of ECOPOTENTIAL WP10 objectives and outcomes with GEO and GEOSS requirements. On the other side, they allowed a contribution by ECOPOTENTIAL to GEO and GEOSS.

2.2 RELEASE OF THE ECOPOTENTIAL VIRTUAL LABORATORY PLATFORM

On May 2017, WP10 released the second version of the ECOPOTENTIAL VLAB. It extends the first version with the possibility to run pre-defined scientific business processes (workflows) implementing selected storylines. The general objective is supporting the generation of indicators for PA managers and policy-makers. In WP10, several activities allowed to port selected algorithms and models in the VLAB:

- Earth Observation Data for Ecosystem Monitoring – EODESM (CNR-IIA and UNSW)
- Despeckling module (CERTH)
- Phylogenetic Diversity Estimation (CNR-IIA)

In the period between June 2017 and January 2018, WP10 enhanced the VLAB towards the release of the third version planned for May 2018. Main activities include:

- Redesign of the test portal
- Integration of an experimental user portal using GEOSS Mirror technology and enhancements, in collaboration with ESA

2.3 TRAINING ACTIVITIES

WP10 organized some training activities dedicated to ECOPOTENTIAL Consortium partners:

- Dedicated audiocons with ecosystem modelling experts for porting models in the VLAB (in collaboration with WP6 on "EO-based Ecosystem Modelling")
- Organization of a Webinar for ecosystem models porting in the VLAB held on 25th January and 2nd February 2018.

2.4 JOINT ACTIVITIES WITH MODELERS

Specific joint activities with ecosystem modelling experts were carried out in collaboration with CERTH and Task 6.4 "Develop and deploy ecosystem monitoring data services":

- On June 2017, CNR-IIA and UNSW ported the (EODESM) system in the VLAB
- On June 2017, CNR-IIA ported a Phylogenetic Diversity Estimation model in the VLAB
- On June 2017, CNR-IIA and CERTH ported a Despeckling module in the VLAB
- On September-October 2017, CNR-IIA and UNSW enhanced the EODESM system in the VLAB
- On December 2017 – January 2018, CNR-IIA and IST started the porting of the MOHID model in the VLAB
- On December 2017 – January 2018, CNR-IIA and EPFL started the porting of a metapopulation presence forecast model in the VLAB

Figure 1 Capacity for European Classification of Land Cover and Land Cover Change within the Virtual Laboratory: outputs of the EODESM model

2.5 DISSEMINATION

2.5.1 PARTICIPATION IN THE GEO WEEK 2017

On October 2017, CNR-IIA as coordinator of WP10, participated in the GEO Week 2017. During the GEO Week, the VLAB was presented and demonstrated:

- P. Blonda and P. Mazzetti presented *P. Blonda, P. Mazzetti , "From Data to Knowledge: Biodiversity and Ecosystem, the Ecopotential scenario"* in the "GEO in ACTION" side-event.
- G. Colangeli (ESA) gave live demonstration of the ECOPOTENTIAL use-case in the ESA booth in the exhibition area

Figure 2 Guidi Colangeli (ESA; on the right at the PC) giving a demonstration of the ECOPOTENTIAL VLab to Gilles Ollier (European Commission) at the GEO XIV Week Exhibition in Washington (October 2018). From top, clockwise: Carmela Marangi (CNR), Guido Colangeli (ESA), Palma Blonda (CNR), Joost Van Bemmelen (ESA), Gilles Ollier (EC), Paolo Mazzetti (CNR), Stefano Nativi (CNR)

2.5.2 OTHERS

On September 2017, P. Mazzetti presented *S. Nativi, P. Mazzetti, M. Santoro, I. Manakos, G. Kordelas, R. Lucas, "The GEO ECOPOTENTIAL Virtual Laboratory: a virtual research environment for ecosystem open science"* at the ESA EO Open Science 2017.

3 CONTRIBUTIONS TO GEO TASKS AND ACTIVITIES

3.1 CONTRIBUTION TO THE GEO GLOBAL ECOSYSTEM INITIATIVE (GEO ECO)

The GEO ECO initiative recognizes that "Knowledge-based conservation, management and restoration policies are urgently needed in order to ensure delivery of ecosystem benefits in the face of increasing anthropogenic pressures", and that "Fundamental to all these is effective monitoring, understanding and modelling of the state and trends in ecosystem functions and services". To this aim, GEO ECO identifies seven major activities for the period 2017-2019. One of them relates to "Ecosystem models and e-laboratories" (GEO 2016).

The ECOPOTENTIAL project, co-funded by the European Union in the Horizon 2020 Framework programme for Research and Innovation, is the major resource for the GEO ECO initiative.

The ECOPOTENTIAL VLAB contributes to GEO ECO in several different ways:

a) **The ECOPOTENTIAL VLAB is a direct contribution to the "Ecosystem models and e-laboratories" activity in GEO ECO**. It implements an e-laboratory for accessing ecosystem data and products, and running knowledge-generation models. It is expected that the experience in incorporating models, and feedback from model developers and policy-makers will help to improve the ECOPOTENTIAL VLAB to fully achieve its objective of becoming a platform for knowledge generation for informed policy-making in the ecosystem domain, by 2019.
b) The ECOPOTENTIAL VLAB focuses on accessing data and products and making models for knowledge generation accessible by policy-makers. In this way, **it contributes to assure that the "GEO ECO Initiative will make data, products, information and knowledge available to a broad range of stakeholders, to allow the development and implementation of such knowledge-based policies"** (GEO 2016)
c) **The ECOPOTENTIAL VLAB training and dissemination activities contribute to the GEO ECO User engagement objectives** by helping to create a cohesive community of policy-makers, model developers, data scientists and data engineers working in the ecosystem science domain.

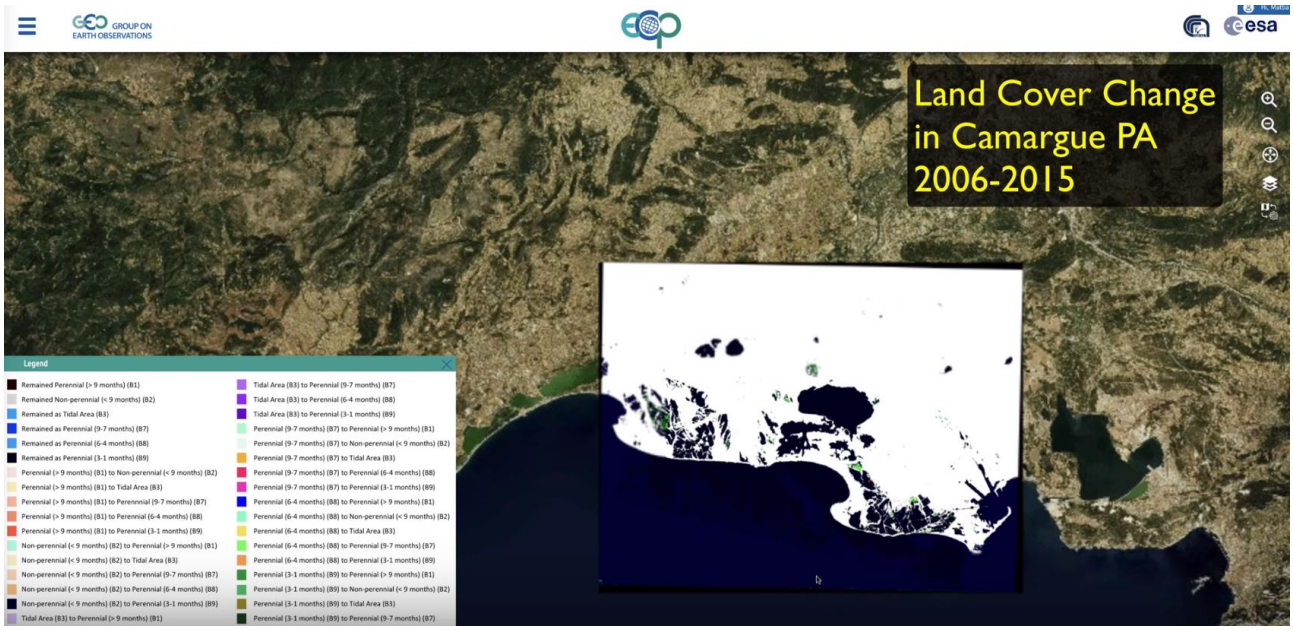

Figure 3 – EODESM model run in the ECOPOTENTIAL VLAB at the GEO Week 2017 Exhibition

3.2 CONTRIBUTION TO THE GEOSS COMMON INFRASTRUCTURE (GCI) OPERATIONS

Although ECOPOTENTIAL is a research and innovation project, while the GEOSS Common Infrastructure (GCI) Operations Task general objective is to "Operate and maintain a user driven GEOSS Common Infrastructure (GCI) to discover and access GEOSS resources (e.g. datasets and services)", there are several aspects where the ECOPOTENTIAL WP10 activities provide a valuable contribution to the task.

1. The GEOSS Common Infrastructure (GCI) Operations Task activities for the 2017-2019 period include improvements of the GEOSS Portal to:
    a. *Better respond to user needs*, by developing an "enhanced user interface exposing new and evolved capabilities that are useful, i.e., that respond to user needs, as opposed to technology mandates", and
    b. *Improve user experience*, by making the enhanced GEOSS Portal pursuing "intuitiveness and ease of use".

    The joint activity of ECOPOTENTIAL and ESA to develop a dedicated Portal for the ECOPOTENTIAL VLAB, based on the GEOSS Portal Mirror technology, allowed experimenting a specific enhancement of the GEOSS Portal. **It supports the semantic navigation** (Figure 4) using an ontology developed in ECOPOTENTIAL (Figure 5) and including both ecosystem science concepts like Ecosystem, Protected Area, Storyline and information science and engineering concepts like Workflow, Data, etc. **It also provides access to Workflows, allowing running them and visualizing the output**.

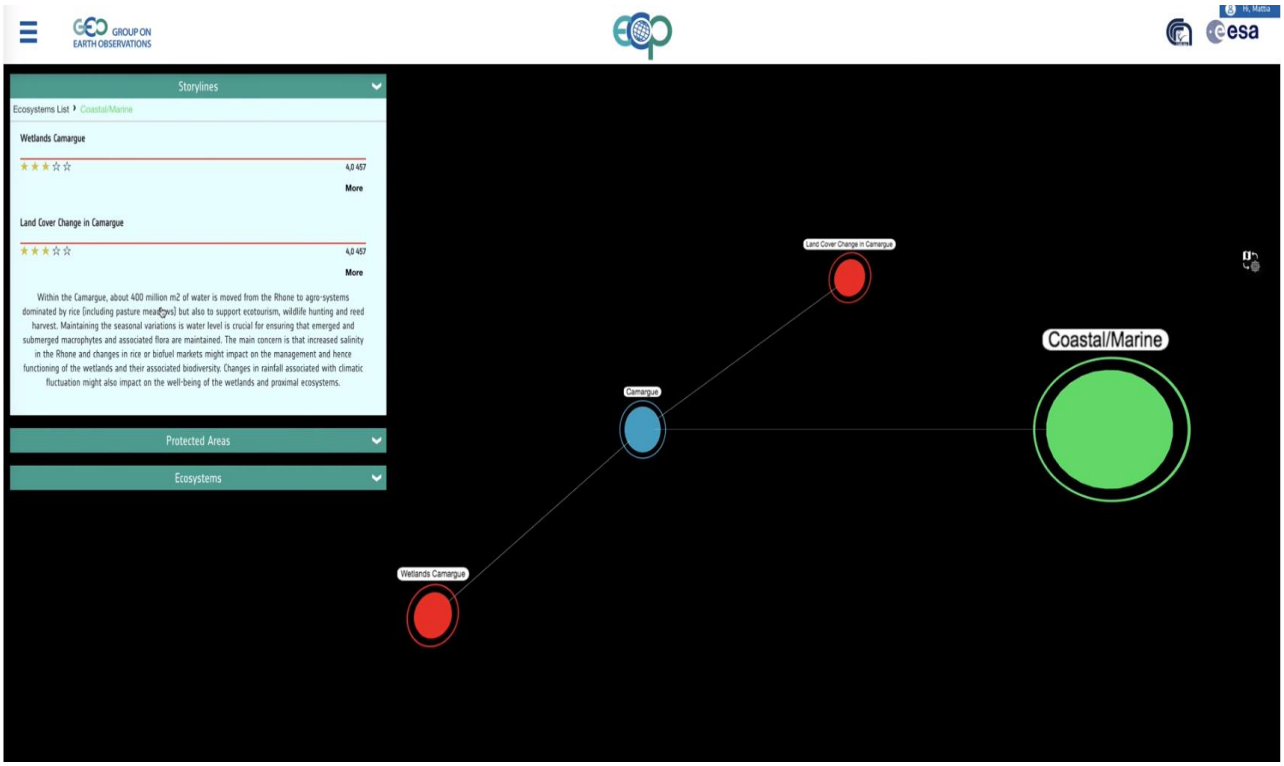

Figure 4 – The ECOPOTENTIAL VLAB Portal developed by ESA. The Portal allows concept navigation to find runnable Workflows implementing Storylines. Ecosystems (in green) link to Protected Areas (in blue) which link to Storylines (in red). [Video available at https://www.youtube.com/watch?v=OWgbEdxSWyM]

2. The GEOSS Common Infrastructure (GCI) Operations Task activities for the 2017-2019 period include improvements of the GEO Discovery Access Broker (DAB) to:
    a. "Broker the additional resource providers (data, information and knowledge, including the databases generated by the SBA user needs process)".
    b. "Support the functionalities required by the knowledge base to manage non-data resources (e.g. documents, workflows and semantic resources)"

The ECOPOTENTIAL VLAB handles knowledge artifacts such as Workflows represented in Business Process Model and Notation (BPMN) format, and as source/executable code. They can be discovered, visualized and run (Figure 6). This is a valuable example on how the GCI could support discovery and use of workflows and algorithms developed by communities. The ECOPOTENTIAL VLAB is also based on an ontology developed in ECOPOTENTIAL and including both ecosystem science concepts such as Ecosystem, Protected Area, Storyline and information science and engineering concepts like Workflow, Data, etc. Finally, the VLAB brokers existing data sources and databases developed by the community to store data and products.

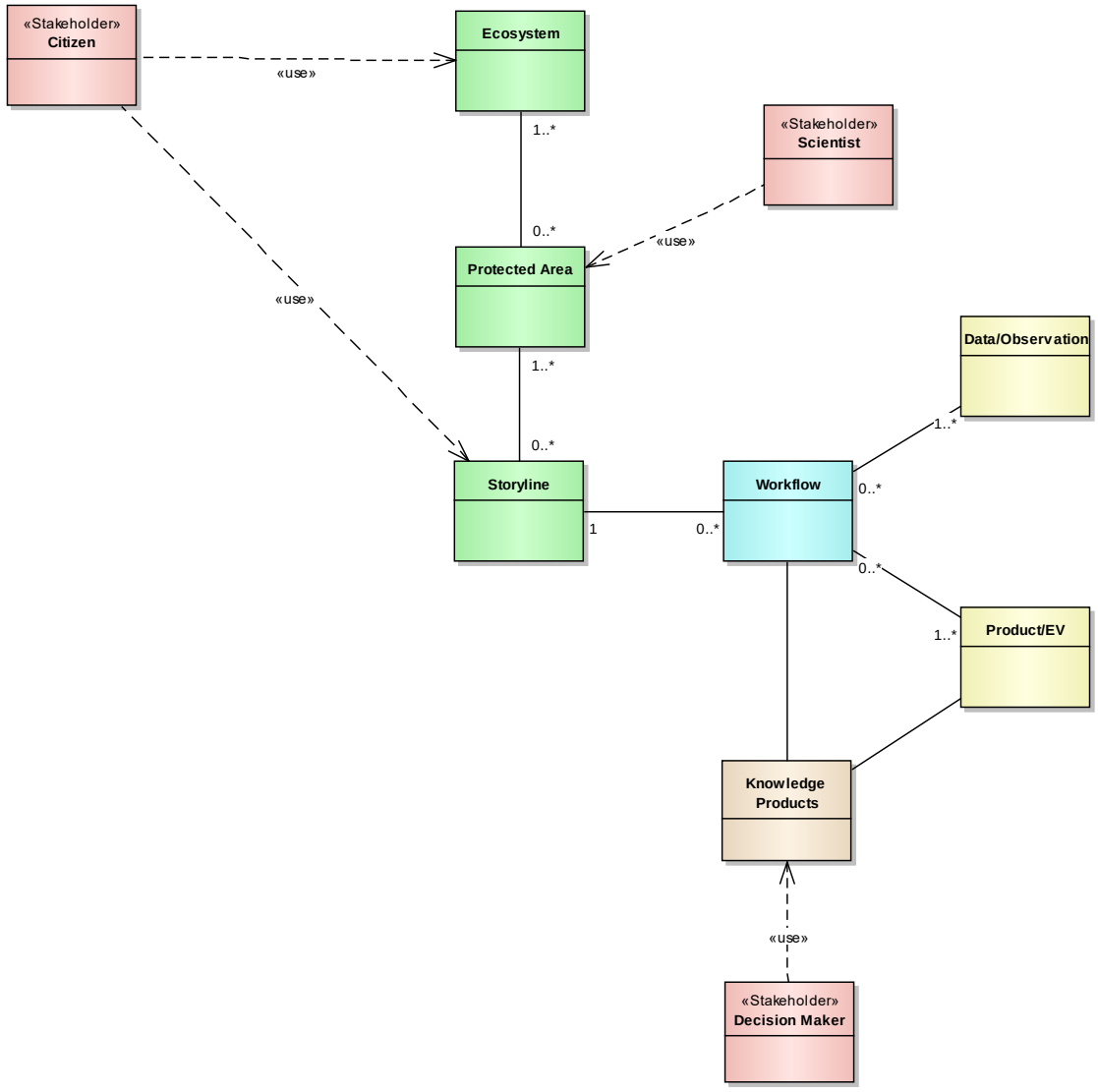

Figure 5 – The ECOPOTENTIAL ontology showing main concepts from ecosystem science (in green), data science (data/product), data engineering (in blue) and actors (in red).

3. The GEOSS Common Infrastructure (GCI) Operations Task activities for the 2017-2019 period include the development of Pilots/Applications to "Create a set of significant User-driven Pilots utilizing the resources available in the GCI to demonstrate its usability, effectiveness and importance for users and decision making". **The ECOPOTENTIAL VLAB, and the workflows ported on it, especially those specifically dedicated to support informed policy-making clearly show usability, effectiveness and importance of GEOSS.** For example, the EODESM model allows evaluating land cover changes in Protected Areas based on well-known taxonomy (Food and Agricultural Organisation's Land Cover Classification System - LCCS2 - taxonomy).

3.3 CONTRIBUTION TO GEO EVOLVE

The GEO EVOLVE task has the following main objectives:

1. To advance and evolve the GEOSS architecture based on the architectural principles described in the GEO Strategic Plan 2016-25, the analysis of the evolving landscape for technology and production/ consumption of Earth Observation (EO) data products and services, and the specific user requirements coming from the GEO Flagships and Initiatives;
2. To conduct research and development activities, in collaboration with public, private, and voluntary sectors, to develop and test new functionalities, solutions, and components, including those needed to advance the GCI, to support the GEO Strategic Plan objectives and user needs;
3. To prepare documentation and training materials needed to support the transition from development to operations of the new components and solutions identified.

The activities in ECOPOTENTIAL WP10 provide a clear contribution to these objectives:

As a major contribution to the GEO ECO Initiative, **the requirements collected by ECOPOTENTIAL and addressed by the VLAB, are an important contribution to the analysis of "the specific user requirements coming from the GEO Flagships and Initiatives"**. Indeed, ECOPOTENTIAL WP9 "Requirements of future protected areas", WP11 "EO supported policy development and integration" and WP12 "Capacity building and knowledge exchange", collect requirements from different stakeholders and for different objectives. In a co-design approach, their input contribute to the elicitation of system requirements for the implementation of the ECOPOTENTIAL VLAB.

Moreover, ECOPOTENTIAL is a research and development activity **developing and testing new functionalities with particular reference to workflows and knowledge bases support**. It may be an important contribution for the evolution of GEO/GEOSS. Indeed, the ECOPOTENTIAL VLAB demonstrates: a) a possible encoding of expert knowledge as a scientific business process diagram (in BPMN notation); b) the generation of knowledge from shared information (data, products, Essential variables).

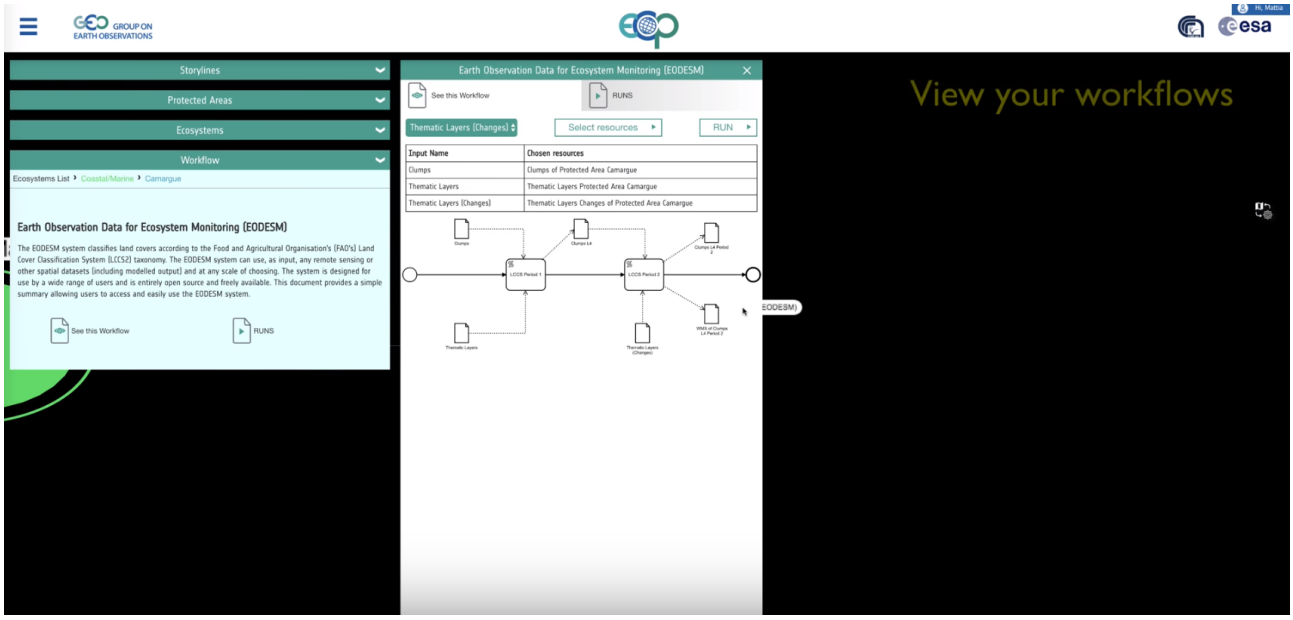

Figure 6 – Workflow representation, documentation and running in the ECOPOTENTIAL VLAB

3.4 CONTRIBUTION TO USER NEEDS AND GAP ANALYSIS

The User Needs and Gap Analysis task aims at establishing "a comprehensive overview of user needs […]. Of particular interest are those information needs that are linked to indicators supporting the advocacy and monitoring of the Sustainable Development Goals (SDGs)".

The ECOPOTENTIAL VLAB provides an example of how dedicated tools can support such objectives. Workflows for informed policy-makers are typically scientific business processes to generate indicators from EO and in-situ data and products. Specific indicators can be used to assess and monitor the status towards SDG targets and goals. Therefore, **a VLAB based on the ECOPOTENTIAL experience can help GEOSS to document the transition from data to information (e.g. Essential variables) and knowledge (indices, indicators) and to identify observation gaps**. Indeed, specific models for the generation of indicators for the assessment of SDG Goals and Targets could be ported in the VLAB and run with GEOSS data for monitoring indicators, or running "what-if" scenarios.

3.5 CONTRIBUTION TO ADVANCING GEOSS DATA SHARING PRINCIPLES

The Advancing GEOSS Data Sharing Principles Foundational task aims at "promoting free, full, open and timely access to Earth observation datasets, products and services". In particular, one of the specific objectives of the task is to "address legal interoperability of datasets across various SBAs, through recommended mechanisms to share data as part of GEOSS DataCORE or compatible open licenses". The Data-CORE (Data Collection of Open Resources for Everyone) is a distributed pool of documented datasets with full, open and unrestricted access at no more than the cost of reproduction and distribution.

The ECOPOTENTIAL project participates in the Pilot on Open Research Data in Horizon 2020 which requires that "users can normally access, mine, exploit, reproduce and disseminate openly accessible research data free of charge" (European Commission Directorate-General for Research & Innovation 2017). This is implemented assuring that **the ECOPOTENTIAL Virtual Laboratory Platform will be fully interoperable with the GCI and the GEOSS Web Portal and its resources will contribute to the GEOSS Data Core** (European Commission 2015).

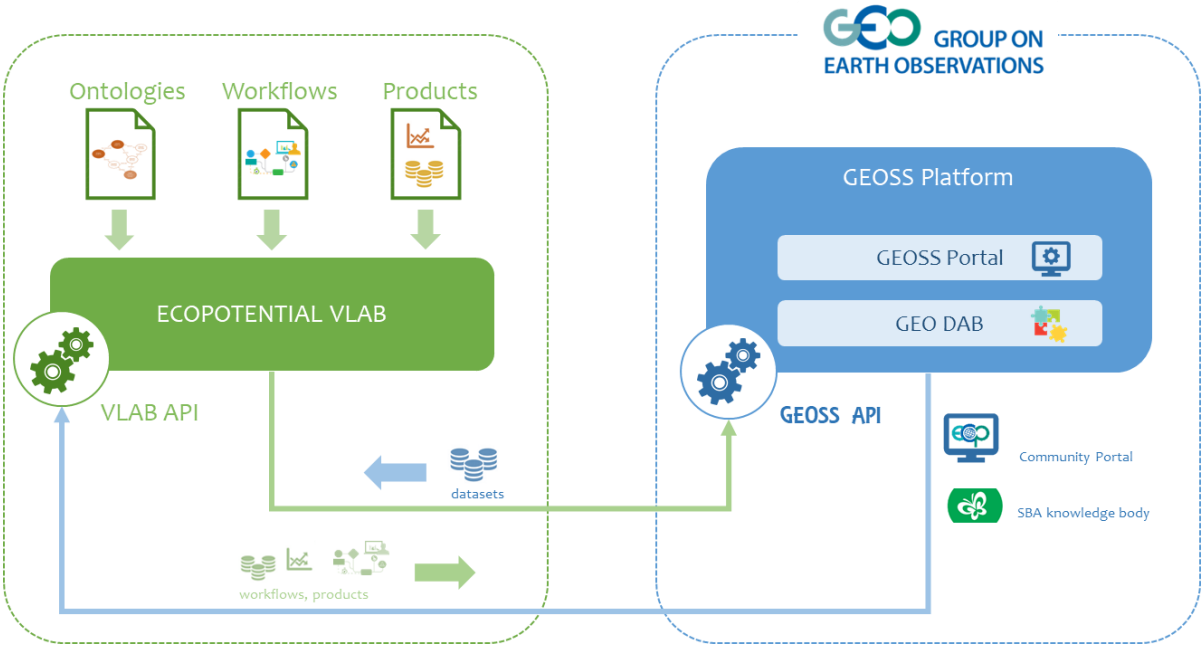

Figure 7 - Interoperability between the ECOPOTENTIAL VLAB and the GEOSS Platform

The design of the ECOPOTENTIAL VLAB defines how it will be interoperable with the GEOSS Platform (Figure 7). The interoperability is implemented through APIs for discovery and access of resources. **The ECOPOTENTIAL VLAB APIs expose resources accessed by the VLAB (data, products, workflows) making them accessible by the GEOSS Platform** to build Community Portals and SBA knowledge bodies.

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