

EuroGEOSS: an Interdisciplinary Approach to Research and Applications for Forestry, Biodiversity and Drought

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Abstract - GEOSS envisions a future wherein decisions and actions for the benefit of humankind are informed by coordinated, comprehensive and sustained Earth observations and information. Ultimately, this requires the ability to integrate information across scientific domains to address issues at regional and global levels. EuroGEOSS, an EC-sponsored FP7 project, has built an initial operating capability (IOC) in the three strategic areas of drought, forestry and biodiversity to facilitate and demonstrate multi-disciplinary applications. EuroGEOSS has implemented a brokering service that allows finding and accessing data from a wide range of standards and domain-specific practices including the use of a semantically rich querying capability. The paper presents the functionalities achieved by EuroGEOSS. The paper also presents the impact of advanced services through an assessment of societal benefits of the extended information availability.

Keywords: GEOSS, interoperability, broker, benefits, information systems, forests, drought, biodiversity

1. INTRODUCTION

Many of the major challenges facing humans on a global scale involve complex interactions with the environment. The need to address these with interdisciplinary approaches for both data and information for decision-making has been broadly recognized [ICSU, 2010]. In Europe, several initiatives have been created to improve the interoperability or exchange of data for more effective decision-making. The ‘Infrastructure for Spatial Information in Europe’ (INSPIRE) directive (EC, 2007) provides measures that address exchange, sharing, access and use of interoperable spatial data and services in Europe. INSPIRE will contribute to establishing global standards for geospatial data and information. It will also serve as a backbone for the proposed European Shared Environmental Information System (SEIS) (EC, 2008). SEIS is a decentralized but integrated web-enabled information system based on a network of public information providers sharing environmental data and information. With SEIS, environmentally relevant data and information will be stored in environmental databases throughout the European Union and will be interconnected and compatible.

This approach of a distributed, coordinated system of systems is under development on a global scale as the Global Earth Observation System of Systems (GEOSS). It is a framework to integrate the earth observation efforts of the 140 Group on Earth Observation (GEO) members and participating organizations. A major role of GEOSS is to promote scientific connections between the observation systems that constitute the system of systems and the need for more effective information for improved decision-making in nine areas (Figure 1). Such

interactions should promote the introduction of new scientific techniques and technologies in the component observing systems.

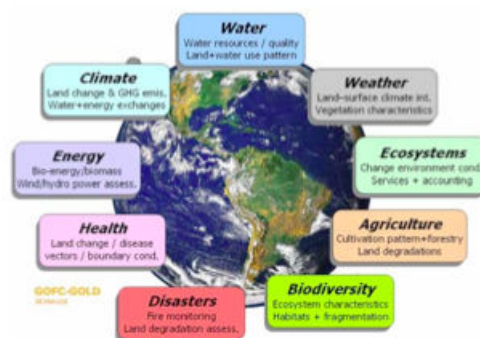


Figure 1: GEOSS addresses nine societal benefit areas and the application of coordinated earth observations for improved decision making.

In the creation of GEOSS, advanced system development is essential for creating sufficient interoperability across multiple disciplines. EuroGEOSS, a large-scale integrated research project for the European Commission, addresses this need; EuroGEOSS demonstrates the added value to the scientific community and society of making existing systems and applications interoperable. The project is building an initial operating capacity for Europe in the three strategic areas of Drought, Forestry and Biodiversity. It then addresses the application of this capability for applications in Africa.

2. EUROGEOSS MULTI-DISCIPLINARY APPROACH

To enable real progress in multi-disciplinary science, it is necessary not only to document data and services in a more complete and coherent manner, but also to describe and document analytical methodologies and models, for turning them into services and workflows available for re-use by other communities of scientists. To enable users from different domains to perform interdisciplinary and contextual searches based on these descriptions, the usability and functionality for service discovery needs improvement. These are key challenges that are addressed by EuroGEOSS

To develop and demonstrate advanced interoperability, EuroGEOSS built an initial operating capacity for a European Environment Earth Observation System with the goal to further develop an advanced operating capacity. The Advanced Capability provides access not just to data but also to analytical models made understandable and useable by scientists from different disciplinary domains (Figure 2). Thus, successful

implementation of inter-disciplinary interoperability requires advanced modeling from multi-scale heterogeneous data sources, expressing models as workflows of geo-processing components reusable by other communities with the ability to use natural language to interface with the models. In addition, provision should be made for the Web 2.0 communities in respect to user interactions and resource discovery.

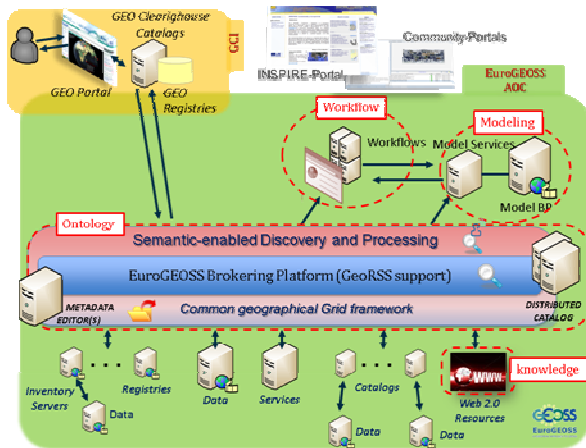


Figure 2: EuroGEOSS Evolution

In its System of Systems implementation, the EuroGEOSS adopts the Information Modeling Approach (MDA) by sharing metadata and implementing systems interoperability through international standards. This is achieved by making use of Service-Oriented Architecture (SOA) and related technology. However the multi-disciplinary environment, which characterizes the EuroGEOSS capacity, requires the support of diverse discipline-specific data models and protocols (i.e. standards). This is a challenge for system developers that must implement a plethora of different interoperability protocols and data models. To address this issue, an extended SOA approach can conveniently be used to provide a harmonized access service: the SOA-brokering approach (see Figure 3).

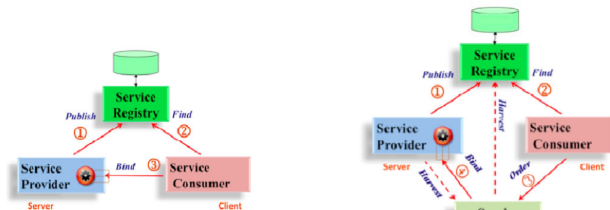


Figure 3: Introduction of a service broker (right) facilitates multi-discipline interoperability

The keys to moving forward have been through providing a systematic approach to metadata and then addressing a framework for common nomenclature and appropriate ontologies using open source tools to the greatest extent reasonable.

2.1 A Forestry Initial Operating Capacity

The Forestry IOC was achieved giving priority to the development of federated metadata catalogues and a map viewer, which were then integrated into the EuroGEOSS broker

(Figure 4). The IOC Metadata Catalogue was developed based on the open source package GeoNetwork v2.4.3 and populated with spatial and non-spatial metadata from the European Forest Data Centre at JRC. Metadata adjustments have been made to fit Dublin Core elements and ensure compliance with INSPIRE and relevant ISO standards (19115/19119 and 19139).

The Metadata Catalogue functionalities and interface have been adjusted to meet the specific forestry theme requirements. As a result the IOC Catalogue provides search, discovery and preview facilities of spatial and non – spatial metadata. The catalogue successfully harvests metadata from national and local forestry catalogues such as those of the national Spanish spatial data infrastructure (IDEE), and is accessible through the EuroGEOSS broker so that its resources are easily usable by the GEOSS community.

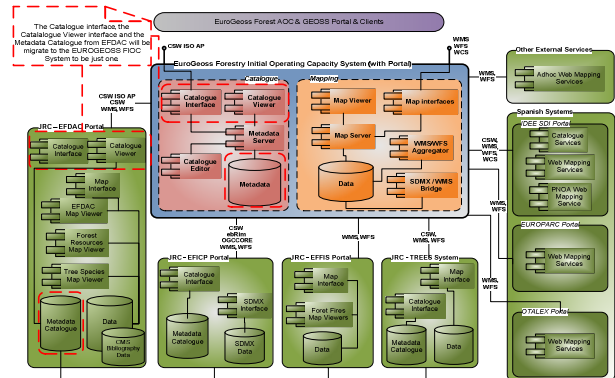


Figure 4: EuroGEOSS Forest Information System

2.2 A Biodiversity Initial Operating Capacity

A Digital Observatory for Protected Areas (DOPA) has been created as a component of the GEO-BON observation network (Figure 5) by the Joint Research Centre in collaboration with other international organizations including the Global Biodiversity Information Facility (GBIF), the UNEP-World Conservation Monitoring Centre (WCMC), Birdlife International and the Royal Society for the Protection of Birds (RSPB). DOPA is conceived as a set of distributed databases combined with open, interoperable web services to provide decision makers and researchers with means to assess, monitor and forecast the state and pressure of protected areas at the global scale. DOPA started from an isolated system focusing on Africa and evolved towards a distributed set of web services allowing through a single graphical user interface the visualization at the global scale of species data (maps of species distribution and species occurrences), boundaries of protected areas and maps of habitats replaceability.

A significant element of DOPA is eHabitat, a Web Processing Service designed to compute the likelihood of finding ecosystems with equal properties (Dubois et al., 2010). By developing eHabitat according to Model Web principles, end-users can define the thematic layers for input to the model from various sources. These input layers are discovered using standards-based catalogues, which are a fundamental component of Model Web and generic Spatial Data Infrastructures (see GEO-AIP3, 2011). eHabitat can integrate data ranging from remote sensing data to socio-economical indicators, thus offering a huge potential for multi-disciplinary modeling. The use of eHabitat in conjunction with other modeling services, typically a climate change modeling service for ecological forecasting in protected areas, stresses a number of challenges as errors and uncertainty easily propagate through

these services (Skøien et al, 2011). This issue, addressed in the UncertWEB project (www.uncertweb.org) requires the development of new means to assess, quantify and describe uncertainties when coupling together web services.

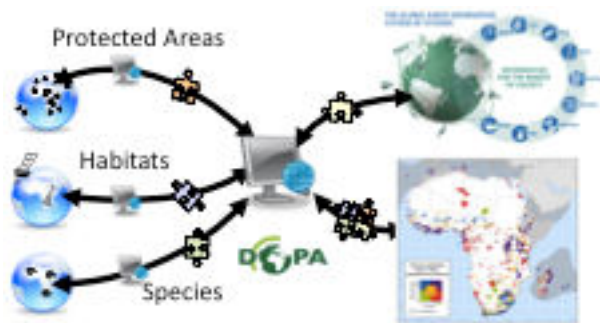


Figure 5 DOPA provides biodiversity assessments

The key role played by metadata and catalogues was further highlighted by the development by GBIF of the metadata catalogue with a specialized profile using the Ecological Metadata Language to better support needs for species names datasets and natural history collections, and for multiple natural languages. A metadata sharing service has been established based on the Open Archive Initiative, harvesting metadata from the participating GBIF catalogues and integrating them into the EuroGEOSS broker.

2.3 A Drought Initial Operating Capacity

The Drought IOC was achieved using a series of web services to discover, view, and access drought data. The outcome is to connect drought data providers on the three scale levels (continental, national/international, regional/local), forming an interoperable European Drought Observatory (EDO) that contributes to a future Global Drought Early Warning System. During the last year, key developments have included creation of a web catalogue service (CSW) and a web mapping service (WMS). The metadata catalogue was structured using the metadata editor tool CatMDEdit, which is currently available in version 4.6.5. The catalogue currently has more than 200 INSPIRE compliant metadata entries. For this, drought specific keywords were used in the metadata to allow for more refined searches in the catalogue. These keywords are currently in the process of being translated into multiple languages.

The provision of a WMS for drought established the first interoperable service infrastructure. The services can be identified in the metadata catalogue and viewed in the EDO map viewer (Figure 6).

Ultimately, what is needed is a thorough description of data with metadata and additional information regarding the derivation of data sets, the quality of the data sets, etc. These data are required when exchanging data sets for analysis by drought experts. The next developments are to create a more detailed description of drought data sets for search and discovery as well as drought analysis. Also, the integration of metadata model descriptions with existing metadata specifications is under development.

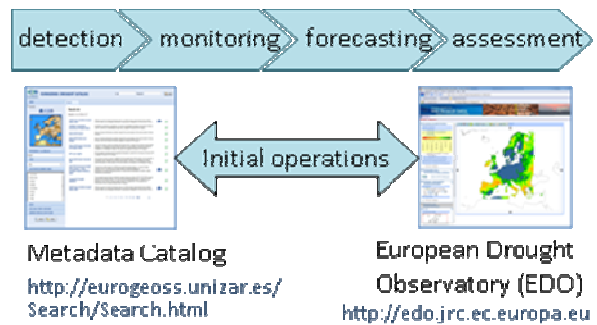


Figure 6 European Drought Observatory

2.4 Inter-Disciplinary Interoperability with the EuroGEOSS Broker

These important thematic developments have been supported by development of the EuroGEOSS broker. The broker embodies the pragmatic approach of building inter-disciplinary interoperability by reaching out to the different communities, their standards and professional practices, and building mediating services that connect them to the broker, rather than assuming that different communities will all adopt a centrally imposed set of standards.

A key function of the Broker is to facilitate the implementation of robust metadata. The European Open Source Metadata Editor (EUOSME) is a web application written in Java and based on Google Web Toolkit (GWT) libraries. This implementation allows the description of a spatial data set, a spatial data set series or a spatial data service in 22 languages that is compliant with the standards ISO 19115:2003 (corrigendum 2003/Cor.1:2006) and ISO 19119:2005. This editor builds on the experience acquired in the development of the INSPIRE Metadata Implementing Rules, and is available from the INSPIRE EU Geo-portal (<http://www.inspire-geoportal.eu/EUOSME>). The source code for the editor can also be downloaded from the Open Source repository (<http://www.osor.eu/projects/euosme.so>) so that it can be extended for use by different communities.

Another key development is the evolution toward integrated thesauri. Currently, the prototype application, developed within the GENESIS EU project, is based on the Simple Knowledge Organisation System and manages the following thesauri:

- The General Multilingual Environmental Thesaurus (GEMET);
- The GEOSS Societal Benefit Areas (SBA) categorization;
- The multilingual INSPIRE Feature Concept Dictionary.

A semantic manual mapping of the GEOSS SBAs to the GEMET utilizing the SKOS-Matcher tool was achieved (with contributions from the thematic experts). EuroGEOSS is extending this work with development of a Multi-Natural Language query interface (MNL WPS) and web application (WPS profile) for the discovery of Geospatial resources and a *Demonstrator on natural language Discover and Query Interface*. The Demonstrator objectives are: design and test a set of instructions and a protocol to demonstrate the usability of the first phase of the Natural Language Query Interface application.

The EuroGEOSS/GENESIS FP7 projects aim to contribute to the definition/refinement of existing standards. Interoperability solutions for providing comprehensive drought indices through standard services will be investigated, as well as their

integration with a WPS for potential drought hazards recognition. This will be achieved according to the model web paradigm [Geller & Turner, 2007]. In fact, the EuroGEOSS/GENESIS FP7 projects aim to provide a demonstration framework for the GEOSS Model Web Development in order to experiment with model components interoperability.

To better understand the impacts of multi-disciplinary information, a methodology for assessment of the social and economic benefits and value-added of enhanced interoperability across disciplines and systems is being developed as part of the EuroGEOSS project. The lack of accepted theoretical frameworks and agreed methodologies to measure such impacts in field of digital information are well known. The GEO-BENE project (www.geo-bene.eu) addressed these issues in the context of GEOSS. EuroGEOSS extends this work for applications in the domains of biodiversity, drought and forestry. More importantly, it addresses, and quantifies where possible, the increased benefits that are derived from cross-domain information integration.

A demonstration of impacts of EuroGEOSS was done in the GEOSS Architecture Implementation Pilot. (AIP-3) The main objective was to illustrate the interoperability benefit of coupling the EDO (i.e. a drought specific system) with a discovery and access-brokering framework advanced with ontology capabilities for selecting useful resources to assess potential drought hazards. In fact, the heterogeneity of the resources involved requires the use of a brokering and mediation framework to harmonize the discovery and access functionalities. Another AIP-3 pilot developed the e-Habitat scenario discussed earlier and demonstrated the possibility of turning models into geo-processing services of wider applicability. Both pilots extended the IT interoperability framework developed in the context of GEOSS IP3 [Nativi et al., 2007; Khalsa et al., 2009] and AIP-2 [GEOSS AIP-2, 2009a, 2009b] for multi-disciplinary resources management.

3. CONCLUSIONS

EuroGEOSS has demonstrated significant advancements in multi-disciplinary research: the Initial Operating Capability (IOC) in the fields of biodiversity, drought, and forestry has been established: a meta-data editor has been created for cross-discipline work. The EuroGEOSS broker is a registered component in GEOSS giving access to over 400 datasets and 26 services, including multiple catalogue services in the three thematic areas, and a multi-layered framework of surveys and models to assess the longitudinal impact of the project and the benefits of GEOSS have been put in place.

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REFERENCES

- European Commission, Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE), Official Journal of the European Union, L 108/1-14, 2007.
- European Commission, "Towards a Shared Environmental Information System (SEIS)" COM (2008) 46 final [<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:52008DC0046:EN:NOT>]
- G. Dubois, J. Skøien, J. de Jesus, S. Peedell, A. Hartley, S. Nativi, M. Santoro, G. Geller (2011). "eHabitat: a contribution to the model web for habitat assessments and ecological forecasting."
- G.N. Geller and W. Turner, "The model web: a concept for ecological forecasting", Geo-science and Remote Sensing Symposium, IGARSS 2007, IEEE International, 2007, pp. 2469 – 2472.
- GEOSS AIP-3 Engineering Report (2011), "eHabitat", available at <http://www.ogcnetwork.net/system/files/CCBio-eHabitat-ER-v2.0-FINAL.pdf>
- ICSU, "Grand Challenges in Global Sustainability Research" 2010, available at http://www.icsu-visioning.org/wp-content/uploads/GrandChallenges_Pre-publication.pdf
- S.J. Khalsa, S. Nativi, G. Geller, "The GEOSS Interoperability Process Pilot Project (IP3)", *IEEE Transactions on Geoscience and Remote Sensing*, 47(1), 2009
- S. Nativi, P. Mazzetti, H. Saarenmaa, J. Kerr, H. Kharouba, E. Ó Tuama and S. J. Singh Khalsa, "Predicting the Impact of Climate Change on Biodiversity – A GEOSS Scenario", The Full Picture, pp. 262-264; edited by the Group of earth Observation (GEO) secretariat, published by Tudor Rose, ISBN 978-92-990047-0-8, copyright © GEO 2007.
- J. Skøien, P. Truong, G. Dubois, D. Cornford, G.B.M. Heuvelink, G. Geller (2011), "Uncertainty Propagation in the Model Web. A Case Study with eHabitat"