The GEOSS User Requirement Registry: A Versatile Tool for the Dialog Between Users and Providers

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Abstract - To achieve its goal to be user-driven, building the Global Earth Observation System of Systems (GEOSS) must be guided by a set of explicitly known user needs. At the core of GEOSS is the GEOSS Common Infrastructure (GCI), which includes registries that enable users of Earth observations to search, discover, access, and use the data and services available through GEOSS. Three of these registries focus primarily on the contributors to GEOSS. The fourth registry, the User Requirements Registry (URR) is a place for the collection, sharing, and analysis of user needs and Earth observation requirements, and it provides means for an efficient dialog between users and providers. The URR is a comprehensive database describing User Types, Applications, Requirements, Research Needs, and Technology Needs, and includes a Lexicon and literature References. The novel concept of the URR is in the information captured in the Links form, where links between any pairs of entries in the other forms can be published, including descriptions of the societal benefits of the link and the implementation status. As the URR evolves, the powerful nature of this concept is slowly becoming more obvious as it allows to answer many questions, such as 'who is using my data?'; 'On what applications do I directly or indirectly depend?' or 'What requirements need to be met to make these application work?' A fully populated GCI will allow the identification of gaps between user needs and system performance as a basis for prioritizing of user needs.

1. INTRODUCTION

The 2002 World Summit on Sustainable Development held in Johannesburg, South Africa, underlined the importance of more comprehensive information about the state and trends of the Earth system in support of decision making that could help to ensure a sustainable development of our societies. Taking up this challenge, the Group of Eight (G8) accepted at their annual meeting in 2003 in Evian-les-Bains, France, the G8 Action Plan "Science and Technology for Sustainable Development", and in this plan agreed to "strengthen international co-operation on global observation." The plan identifies increasing inter-operability of existing infrastructure and closing gaps in the observations systems as key steps toward more coordination. To implement this Action Plan, the First Earth Observation Summit (EOS) was held in June 2003 in Washington, D.C. There, representatives of 33 governments established the ad hoc Group on Earth Observations (ad hoc GEO) and tasked this group with the development of an implementation plan for a Global Earth Observing System of Systems (GEOSS). The time frame for the development of this plan was set to only eighteen months, thus recognizing the urgency of having improved knowledge about the Earth system and global change. The Second EOS (EOS-2) held in 2004 in Tokyo identified nine Societal Benefit Areas (SBAs) of Earth observations, covering most societal activities (see Figure 1). EOS-2 asked the ad hoc GEO to address the needs of these nine SBAs as well as cross-cutting needs in the implementation plan. At the Third EOS (EOS-3) held in February 2005 in Brussels, the 10-Year Implementation Plan (10YIP, GEO 2005) was endorsed, after it had been iterated in six international plenary meetings and numerous meetings of working groups. At EOS-3, the ministers establish the GEO with the mandate to implement GEOSS. Since then, GEO has grown continuously and has today 85 Member Countries, and more than 60 Participating Organizations. During the last five years, four Committees, more than 70 Work Plan Task teams, and more than 10 Communities of Practice (CoPs) have worked intensely to build infrastructure to realize the full benefits of Earth observations in the nine SBAs. Annual plenary meetings bringing together high-level representatives of the governments of the Member Countries and the Participating Organizations give guidance and direction to the work of these components of GEO.

"The vision for GEOSS is to realize a future wherein decisions and actions for the benefit of humankind are informed by coordinated, comprehensive and sustained Earth observations and information" (GEO, 2005). Bridging the gap between science and technology on the one side and end users in many societal areas on the other side is crucial for progress towards this vision. This gap between data collected and information available to decision makers had already been identified in the Agenda 21 (UN, 1992). In order to close this gap, the 10YIP requests that GEOSS is implemented as a system driven as far as possible by the needs of end users and decision makers. GEO is asked to establish mechanisms to collect user needs, and to use this information as a driver for the development of GEOSS.

This mandate to develop a user-driven system responding to the vision for GEOSS raises a number of questions concerning the users of GEOSS and their needs, which we address in the next section, taking into account those who initiate and "own" GEOSS. In Section 3, we describe those elements of the GEOSS Common Infrastructure (GCI) that capture and analyze user requirements, including the User Requirement Registry (URR). In Section 4, the structure and functions of the URR are described, and Section 5 discusses different approaches to populating the URR. Section 6 outlines the benefits of the URR for GEO. Finally, Section 7 summarizes the current status and discuss pending extensions and new developments.

2. GEOSS AND ITS USERS

GEOSS is broad in its aim to cover the nine SBAs, and responding to all users in these SBAs appears nearly impossible. Therefore, it is important to ask who are, or should be, the primary users of GEOSS and for whom should GEOSS be tailored? This question is also important considering the original motivation for the formation of GEO and the needs of those who mandated GEO with the implementation of GEOSS.

The "Capetown Declaration" adopted by the Ministerial Summit on Earth Observations in 2007 in Capetown, South Africa, recognizes the importance of Earth observations for

sustainable development and confirms the view of the Member Countries that sustained Earth observations are crucial for sustainable development. The Declaration affirms that GEO is addressing user needs focused on multiple SBAs. The most recent EOS held in November 2010 in Beijing, China, confirmed the needs of the decision makers. These repeated assertions of the link between Earth observations and sustainable development put those users and applications related to sustainable development into the focus of GEO. In its strategic targets for GEOSS (GEO, 2009), GEO acknowledges the need to focus on the 'big' issues. Considering that the number of people without access to sufficient and clean drinking water is increasing (and several agencies and organizations estimate that by 2040, the number will have reached somewhere close to 3.5 Billion); an increasing number of people are without sufficient food, work, and health; global stability is decreasing; and we are getting further away from sustainable development and the Millennium Development Goals, it is of paramount importance that GEO directs it main efforts toward the question of what information about the Earth (including the anthroposphere) is needed in order to help decision makers to make progress towards the declared ethical and political goals. Giving high priority to the needs and requirements of these decision makers therefore appears to be a reasonable guiding principle for the development of the URR.

The challenges to sustainable development in the nine SBAs are many, and, for most of them, coping with the challenges requires more comprehensive, timely, and accessible Earth observations as a basis for the mandatory environmental information. For example, land use planning aiming to reduce the degradation or loss of ecosystems and halt the rapid extinction of species and reduction in biodiversity requires information on the distribution of ecosystems, habitats of species, and changes over time in these, and it depends on detailed information on land use. Likewise, land use planning for sustainable agriculture and reduction of food shortages needs environmental information, including climate and weather conditions. Forests play a vital role ohm regulating climate, storing carbon and providing many other ecosystem services. Policy makers and manager therefore need timely information on changes in the extent and density of the world's forests. For the planning of adaptation to climate change and the reduction of climate change impacts such as sea level rise accurate information about current trends and reliable estimates of future trajectories have to be provided to decision makers. Risk management and disaster reduction for geo-hazards such as earthquakes, volcano eruptions, landslides, and tsunamis depend on the understanding and monitoring of the hazards, for which, for example, accurate observations of the deformations of the solid earth are mandatory. Frequent disasters in the wake of earthquakes, tsunamis, floods and other natural hazards point up the need for national and international emergency response agencies to obtain satellite data to coordinate relief efforts. Mounting water scarcity, particularly of potable water, in many parts of the world necessitates improved water management, which depends on information about water quantity, usage, and quality. Extreme weather events such as hurricanes, tornadoes, floods, and droughts pose a severe and growing threat to society and early warnings are crucial for impact mitigation and loss reduction. Reducing the impacts of many infectious or chronic diseases, such as malaria, meningitis, cholera, dengue, asthma, and rhinitis depends on understanding the relationship between environmental parameters and the occurrence of these diseases, and monitoring of outbreaks and early warnings are crucial steps for meeting these challenges. Mapping the availability of renewable energy sources such as geothermal, wind, wave, and solar energy is a crucial input for the development of reliable and sustainable supplies of energy. Changes in our environment, such as chemicals, dust, and other contaminants in our water and air, also have negative impacts on humans that can only be understood and reduced if these changes are sufficiently monitored and assessed.

The strategic targets for GEOSS underline that GEO is considering all these challenges. With GEOSS, GEO aims to provide Earth observation data and decision-support tools to a wide variety of users particularly in the nine SBAs (Figure 1).

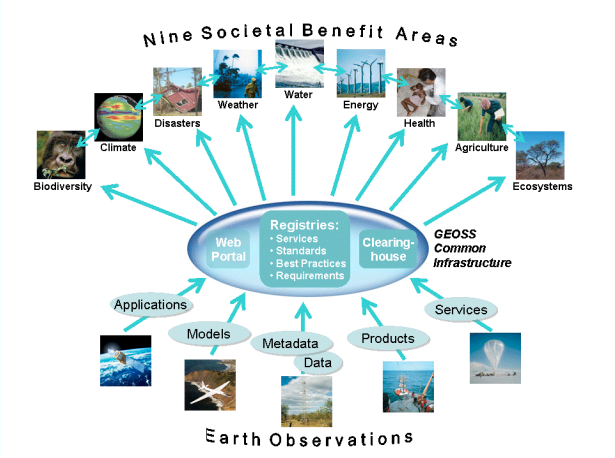

Figure 1. Conceptual diagram of the GEOSS Common Infrastructure (GCI) and its relationship to observations and observation-based products and end-users in the nine SBAs.

3. GEOSS: A USER-DRIVEN INFRASTRUCTURE

At the core of GEOSS is the GEOSS Common Infrastructure (GCI, Figure 2). The GEO Portal provides a unique entrance point to a global network of services, data sets and products. The GCI includes four registries that enable users of Earth observations to search, discover, access, and use the data, information, tools, and services available through GEOSS (Figure 2).

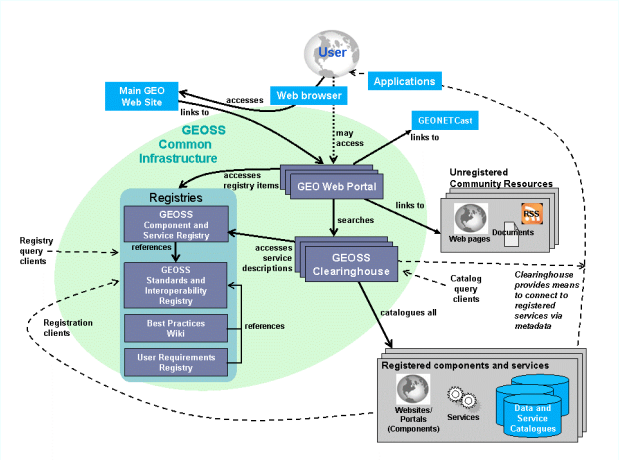

Figure 2. Diagram depicting the major relationships between the GCI component services and selected external resources (courtesy GEO Secretariat).

Three of these four registries, i.e., the GEOSS Components and Services Registry, the GEOSS Standards and Interoperability Registry, and the Best Practices Wiki primarily focus on the

providers and collect information related to the available services and products, as well as information needed to ensure interoperability between all the different services contributing to GEOSS. The Components and Services Registry provides essential details about the components and services contributed to GEOSS by governments and organizations. The Standards and Interoperability Registry is a reference database of interoperability arrangements that enables contributors to GEOSS to configure their systems so that they can share information with other systems. The GEOSS Best Practices Wiki was created for the aggregation and community review of best practices in all fields of Earth observation.

The fourth registry, the URR, is a unique place for users to publisher their needs in terms of Earth observations and derived information. The URR makes available tools for the analysis of value chains and networks from Earth observations to end users and informs both the providers and end users about the connections between observations, applications, and societal benefits.

4. THE USER REQUIREMENT REGISTRY

The 10YIP emphasizes the intention for GEOSS to be user-driven in order to serve the needs of a wide range of users in terms of Earth observations, derived products, and information. To build GEOSS as a truly user-driven system, the development must be guided by a set of explicitly known user needs in the nine SBAs, as well as the observation requirements corresponding to these needs. Therefore, a versatile infrastructure that could answer questions about what users need from GEOSS is a key element of the GCI. This versatile infrastructure is the URR which connects users to GEOSS. The URR provides tools for the collection, sharing, and analysis of user needs and Earth observation requirements. It links to the Components and Services Registry providing information about the available products. A fully populated URR and GEOSS Components and Services Registry will allow the identification of gaps between user requirements and available products and thus provides a basis for the prioritizing of user needs.

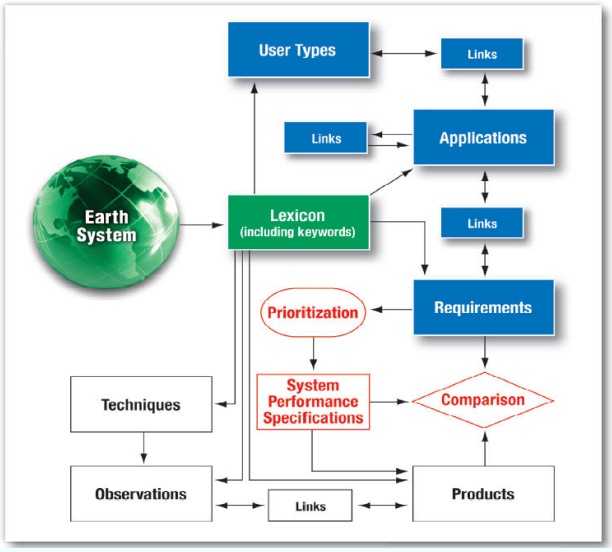

Figure 3. The URR provides forms to publish user-related information (blue boxes) and a vocabulary (green). System-related information (black boxes) is to be extracted from the GEOSS Component and Services registry. Comparison of system performance to specifications helps identifying gaps, and prioritize requirements (red boxes).

At the core of the URR is a comprehensive database (Figure 3) describing the User Types in the nine SBAs; the Applications that depend on Earth observations and products or information derived from Earth observations; and the qualitative and quantitative Requirements in terms of Earth observations and derived information. The database includes an extendable Lexicon with the vocabulary used and Reference to literature with more background information. A new addition also allows the publishing of Research Needs, and the addition of a form for Technology Needs is under consideration.

The novel concept, which distinguishes the URR from many, if not all, other registries of user requirements is the information captured in the Links form. Here, links between any pairs of individual entries for User Types, Applications, Requirements, Research Needs, and Lexicon can be published. Beside the source and target entries, information on the societal benefits associated with the link and the implementation status can be provided. As the URR evolves, the powerful nature of this concept is slowly becoming more obvious as it allows to answer many questions, such as 'who is using my data?'; 'On what applications do I directly or indirectly depend and what requirements need to be met in order to make these application work?'

For a practical illustration of how the URR links user types, applications, and Earth observation requirements, we consider the example of a public health officials (i.e., the user type), who may be interested in numerical weather prediction (i.e., the application) to provide wind forecasts every 3 hours (i.e., the requirement) to help prevent or reduce airborne diseases (Figure 4). In this regard, the GEO meningitis vaccination and control effort in Africa (the Meningitis Environmental Risk Information Technologies [MERIT] Project) is helping African health officials link forecasts of drought and dry spells (i.e., a link between an application and requirements) in the Sahel zone with disease outbreaks in central Africa. GEO is facilitating efforts to combine Earth observations with public health data and information systems to improve strategies for prevention and control of meningitis epidemics in Africa. The GEO data are helping to map the population at risk for meningitis, provide earlier and timelier warning of the occurrence of epidemics, monitor the efficacy of the vaccines, and predict changes in the distribution that may result from environmental or climate changes.

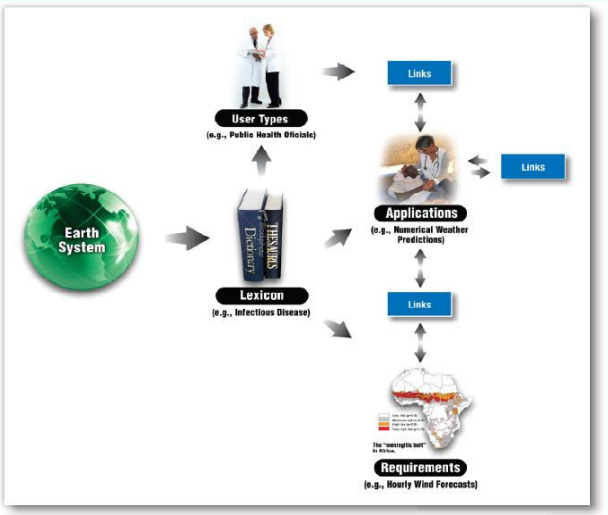

Figure 4. Links between user types, applications, and requirements for the example of infectious diseases.

5. POPULATING THE URR

There are three main approaches for populating the URR:
(1) Ask experts to assess user needs and publish the result of the assessment in the URR;
(2) Harvest information from the available user requirement registries compiled by other groups;
(3) Use a Wikipedia-like approach opening the URR for input from any user interested in publishing information in the URR.

Each of these approaches has particular advantages and shortcomings. Approach (1) is the one taken in the GEO Task US-09-01a. Its main advantage a high recognition of the value of the information collected (expert knowledge). However, the experts may be detached from users; they may depend on what has been published; and they may be biased towards their own needs. Expert assessments are resource-demanding and frequent updates are difficult. Approach (2) can be implemented relatively easily and is not as demanding as other approaches. It is, however, hindered by the fact that information in existing registries may not be complete and structured appropriately, which complicates the interpretation. Updates depend on decisions made by those operating the other registries. Approach (3) is the only approach that is based on a direct link to end users. Through this link, the URR is capable of rapidly capturing new needs, and it has the potential to be comprehensive. However, peer-contribution based open systems tend to have a certain amount of unreliable, incorrect, or unqualified information, which may require editing. Moreover, in order to capture a significant amount of user requirements in all SBAs, this approach necessitates focus on user engagement and education.

Initially, the URR is being populated using a combination of approaches (1) and (3). During the development phase in 2010, the URR was populated with the information extracted from US-09-01a reports for the two SBAs Disasters (landslides, earthquakes, and floods) and Health (air quality and health, aeroallergens, and infectious diseases). During this initial population process, feedback was collected from experts and workshop participant. After the first population phase was completed, the URR was launched for testing by a broader audience during several major events (approach 3). In this stage, users can assist in the further development of the URR in two ways: (1) by publishing information in the various URR forms; and (2) by providing comments on the overall URR design and logic flow. A comments field is available on each URR form to provide feedback on individual entries and a questionnaire is available online to provide more overall comments. Feedback from expert users revealed the necessity of extensive tutorials in support of those who want to publish their needs, applications and requirements. These tutorials are designed to walk users through the various work flows and to explain the underlying concepts. Furthermore, user feedback confirmed considerable interest in a fully populated URR, and indicated a wide range of questions users would like to ask the URR. Several suggestions from users led to significant changes, and they also indicated that additional forms would greatly enhance the versatility of the URR.

6. BENEFITS OF THE URR FOR USERS AND GEOSS

As mentioned before, the key innovative element of the URR is the ability to link the different entities in the URR, and all of these to system components. By introducing this simple but very flexible data model of “knots” and “links,” the construction and analysis of value chains, networks of value chains, dependency networks, and so on, are possible. The URR helps connect the processes, individuals, and dependencies that support decision making through Earth observations.

In the next URR development stage ,algorithms for gap analysis will be added, and the output of these algorithms provides a basis for informed decisions on GEOSS development priorities. System performance specifications, which define what data, products and services GEOSS is expected to provide, allow the matching of the user- and system-related components against each other to facilitate a gap analysis.

As a user-driven system GEOSS needs to engage users. The URR is designed to be one of the key entry points for user engagement. GEO is discussing a registration system for users of GEOSS. Most likely, the registration will be global and scalable, so that a user can register in any of the GEOSS components and is then known globally in GEOSS. Combining this registration system with the URR will open many new opportunities for social and expert networking, which will further in-crease the versatility of the URR.

7. FUTURE EXTENSIONS: IMPROVING THE DIALOG BETWEEN GEOSS AND ITS USERS

Based on user feedback, the original design of the URR will be extended with four new forms: (1) a Research Needs form for the publication of research that would increase the societal benefits of Earth observations; (2) a Technology Needs form to capture gaps in the available technology that hinder societal applications in need of currently not available information; (3) a Infrastructure Needs form in which infrastructure gaps can be described; and (4) a Capacity Needs form for the publication of needs related to the building and retention of capacity in applying Earth observations for the benefit of society.

Analysis algorithms to explore the connectivity created through the links published in the URR have been developed and will be further extended to increase the types of questions that can be answered based on the information published in the URR. Pairing these analysis tools with graphical tools will further enhance the versatility of the URR.

In order to enable a through gap analysis, the URR also needs to be fully integrated into the GCI and linked to the other three registries mentioned in Section 3. There is a development towards well-defined ontologies in several SBAs. These ontologies will have to be mapped into the lexicon of the URR in order to ensure maximum interoperability between the different GCI registries.

REFERENCES

GEO, 2005. The Global Earth Observing System of Systems (GEOSS) - 10-Year
Implementation Plan. Available at http://www.earthobservations.org.

GEO, 2009. GEOSS Strategic Target. Available at http://www.earthobservations.org.

United Nations, 1992. Agenda 21. The United Nations Program of Action from Rio. Available at http://www.un.org/esa/dsd/agenda21/.