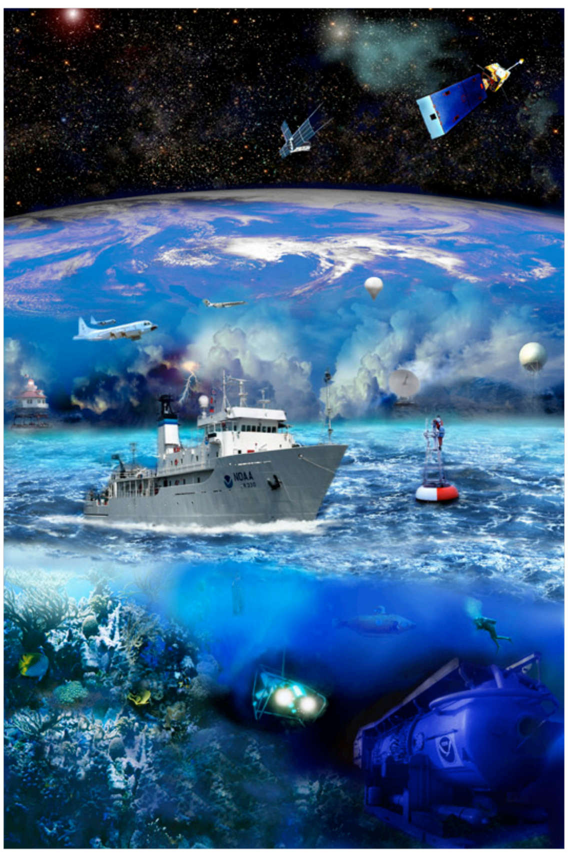
GROUP ON EARTH OBSERVATIONS

GEOSS Future Products Workshop

Workshop Dates: 26-28 March 2013

Summary and Recommendations Report



Content developed by GEO Task IN-05

Executive Summary

The GEOSS Future Products Workshop was held March 26-28, 2013 at NOAA Science Center, Silver Spring, MD, USA with participation of more than 50 people from different sectors in the private industry, academia, government agencies. Organizations were from USA, Europe, Africa and Brazil.

This workshop provided a unique opportunity to learn how GEOSS as a platform makes all sorts of sensor and model data available in an interoperable manner. Data streaming from in-situ and remote sensing sensors (Sensor Web), models (Model Web) offers a huge potential to generate a wide portfolio of on-demand and near real time products. This multi-day workshop will feature: invited speakers and contributed positions; breakout sessions to exchange views and provide proposed approaches; with summaries posted on the web.

Recommendations from the workshop are provided in the following categories:

- Use methods of science to guide use of observations and predictions.
- The utility of Sensor Web has been shown; development is needed to meet remaining challenges.
- The Model Web vision should be advanced with a short-term plan.
- Interaction of Sensor Web and Model Web brings benefits beyond their individual use.
- Further develop the understanding of the diversity of GEOSS Users
- Authentication and Interoperability issues can be advanced with support by SIF and AIP
- Go beyond the current state of GCI to meet expectations
- Capacity Building activities can improve how GEOSS is used
- Improve public messaging about GEO

The workshop committee is pleased to report the success of this workshop. We collectively offer the workshop content and recommendations for consideration by GEO,

Steven Browdy, OMS Tech and IEEE
Kathleen Fontaine, NASA
Karen Moe, NASA
Stefano Nativi, CNR
George Percivall, OGC
Ingo Simonis, OGC-E
Martin Yapur, NOAA

Recommendations from the GEOSS Future Product Workshop

Development of GEOSS should **use the methods of science** to guide use of observations and predictions.

- The GEOSS information system should be designed using an approach that considers the epistemological methods of science - deduction and observation - to utilize observations and predictions in support of decision-making.
- The GEOSS objective to link observations with models to provide decision support should be developed based on sound scientific principles of observations and deduction.

The **utility of Sensor Web** has been shown with further development to meet remaining challenges.

- Based on presentations in the workshop and references, the Sensor Web approach has begun to deliver results for operational systems but requires additional areas of development in order to achieve its full vision.
- Additional developments of Sensor Web should be undertaken in the areas of accuracy and timeliness in providing data products (e.g., to support decision support, early warning, model calibration); distributed computing (caching, brokering, user of cloud computing), improving robust services, diverse data models and metadata using standards, e.g., OGC Sensor Web Enablement.
- Further steps are needed to improve perspective of some scientists regarding the Sensor Web, e.g., data sharing and web services
- Detailed recommendations include: That every service come with a client; That every service is self-explanatory and shows how to add to it; and there are guides on how to get GEOSS service providers established
- To make products directly usable it is recommended that Sensor Web services be made invisible to end users perhaps by defining a "GeoSocial API" enabling people to express their product needs, and to supplement low-level services producing those products. The challenge for sensor webs (and associated information technologies) is how to match the user's mental model of their need, using credible sources of data matched to appropriate analysis, modeling and visualization services.
- Further deployment of Sensor Web be undertaken in order that bringing sensor data together will increase inter-comparisons and improve the quality of observations

Based on the **Model Web vision**, the short-term plan developed in the workshop should be implemented in GEOSS and beyond in order to utilize models as our best understanding of physical systems.

- Models are the codification of the best understanding we have about physical phenomena and process and should be further applied
- The vision of Model Web should be a basis for development: *A dynamic web of models, integrated with databases and websites, to form a* consultative infrastructure *where researchers, managers, policy makers, and the general public can go to gain insight into "what if" questions.*
- A short-term road map for the Model Web should be developed, including effective showcases. Adopt a step-wise approach, considering low hanging fruits and integrating existing components. Start a forum to discuss model integration challenges (e.g. in OGC). Involve Users, adopting social approaches to progress business models. Lower entry barriers: e.g. filling the gap between the Business Processes Design (Abstract) and Executable workflows. Link with analogous initiatives stemming from different areas (e.g. medicine, biology, etc.).

- Develop an Integrated Model Web based on the existing technologies, e.g., OpenMI and ESMF. Further testing of OpenMI and ESMF together should be encouraged to increase the community understanding of concepts that are in common and implementations approaches that differ to meet different operating environments.
- Specific recommendations implementing Model Web for the GEOSS include are listed in the report.

Increasing the effectiveness of **interaction between Sensor Web and Model Web** will bring benefits beyond their individual use.

- Improving sensor web – model web interactions will lead to improved accuracy of both the observations, as models help sensor systems target most relevant observations, and the predictions where the most current and relevant observations provide the initial inputs to the models.
- There is little integration or coupling between sensor web data and modeling, limiting the benefits of feedback mechanisms between measured observations and predictive systems. A key challenge is to harmonize traditional models with simple client-server or compile-time integration with the sensor web's service-oriented architecture. This will entail achieving more compatibility based on open standards for data and model sharing.
- Science Goal Monitoring system to determine the plans for sensor planning; scientific workflows differ from business process workflows in that they are less predetermined and must support exploration, cataloguing of experiments, portability, and linkages to domain-specific tools
- Develop "Events" as an element of interactions in systems, e.g., define Preparedness Plans in advance in the form of "when you see a type of event, take specific actions."
- Continue development of the methods for workflow. In science the workflow may not be clear from the start: issues to be addressed include how do you facilitate exploration, provenance, enable repeatability, portability, domain specific tool-sets. With time, scientific workflows can become the basis for hypothesis development and peer review of new theories.

Further develop the understanding of the **diversity of GEOSS Users**.

- For GEOSS to be fully defined different types of users that build and interact with it need to be defined. Users are involved in so many steps of data generation, upload, modification and manipulation, data consumption and development that it is not possible to talk about *the* GEOSS user.
- The recommended approach is to define different types of users, seen from different angles with different motivations. Talking of "the GEOSS user" is very ambiguous and should be avoided.
- The first class of users is data publishers. To identify two extremes, we have data publishers with very little resources that probably need some sort of GEOSS data cloud with semi-automated indexing, tagging, and metadata generation – and - we have large data set publishers with dedicated systems publishing their data at a distinct set of interfaces with their data made available via GEOSS with minimum additional effort.
- On the data consumer side, we have to differentiate a similar broad range: From casual users that access GEOSS without much experience, to scientific users that make regularly use of GEOSS, understand metadata models, query languages and various access services.
- The third group is the rather heterogeneous group data integrators that make use of the data portfolio made available by GEOSS, develop richer information by applying processes to it, and publish the results either directly to their clients or make it available via GEOSS again.

- The fourth group is the GEOSS operators that develop and maintains GEOSS. As the group handles a system of systems the group does not have direct influence of or control over, requirements from the contributing systems and so addresses interface definitions, metadata models, commitment to standards and application of GEOSS approaches.

Several recommendations regarding **Authentication and other Interoperability Issues** should be advanced supported by the SIF and AIP activities of GEO.

- Authentication and SSO should be initially focused on OpenID and SAML-2.
- Authorization should be added to the authentication and SSO federation as soon as possible, but no later than AIP-7.
- Use metrics for the GEOSS should include some location information to gauge how widespread the reach of GEOSS is.
- The Semantics Registry/Component needs to be deployed into the GCI as soon as possible.
- Linked data and crawling should be investigated as a means to solve the registration issues of GEOSS.
- Broker interoperability should be investigated and developed as a way to serve communities and to handle the existence of different types of brokers.
- Create a tutorial for the Best Practices Wiki focused on the adoption and use of a consistent schema for unique and persistent identifiers for GEOSS resources

Recommendations about the **current state of GCI and what is needed** to achieve expectations

- With the existing GEOSS Common Infrastructure (GCI) elements in place, it appears the current functionality is not matching all the needs of the user communities.
- Refinement of GCI should focus on the core need of seamless discovery and access to data that is not currently being met. Automated machine-to-machine methods, phasing out any manual operations and utilizing the broker approach, should be emphasized.
- Using the methods of Linked Open Data should continue to increase incorporation of semantics and linkages of data with CEOS SEO vocabulary. Using the W3C linked data cookbook for Government the path forward for GEOSS should aim towards “5 star” data.
- Use of Digital object Identifiers (DoIs) should be considered for GEOSS in part based on NOAA and NASA experiences with the use of DoIs that offer best practices and lessons learned for handling Identifiers.
- Brokering in GEOSS has become a necessity, the sociotechnical nature of the common infrastructure has enabled data providers to develop and enhance individual interfaces.
- The current architecture is already anticipating challenges ahead related to general coordination with licenses and user management, types of semantic information, independent community portals from SBAs, mobility, tracking of content quality, etc.
- In order to help facilitate the realization of the GCI vision, we recommend an introspective assessment. The main goal of this assessment will include the formulation of a plan to inform GEO on how to move GCI forward, through an analysis of lessons learned, inputs from stakeholders, and assessment of current architecture. A final report with recommendations for potential changes and potential new initiatives for the next 3-5 years will be the end product.
- There was discussion about “What is the current architecture?” There are several different definitions for the GCI. Some of the definitions are still referring to the “old” GCI architecture that was modified as of the Plenary of 2011.

GEOSS Capacity Building recommendations based on the workshop discussions include:

- The GEO Infrastructure Implementation Board (IIB) through task IN-05 should continue to work toward: Technical documentation of the GCI and the greater GEOSS architecture; and Expanded set of tutorials for GEOSS providers and GEOSS users.
- The GEOWOW project should continue tasks that support capacity building including: Improve data discovery and provide easier data access; Provide new data registration mechanisms, including support for the GEOSS Data CORE
- The GEO Institutions and Development Board (IDB), through ID-02 Task, could help GEOSS users to understand better what GEOSS is and what can do to improve their lives.
- The workshop attendees supported a greater and more effective distribution of information regarding what GEOSS is through social media of different types
- Some attendees suggested to develop deliverables for GEOSS users who are interested to use and exploit immediately the functionalities provided by GEOSS

The GEO Secretariat should undertake to **improve the public messages for GEO**

- There was much agreement that few people outside of those working with the GCI had a clear understanding of what the GEOSS is. Even those that had some idea about the GEOSS seemed to not have an understanding of how it can benefit society and policy formulation.
- GEO should establish a brand, tag line, and easy to understand statement about GEOSS. The recommendation is that the GEO Secretariat takes on the responsibility of engaging a professional organization to properly brand GEOSS so that the public can easily appreciate its value to society.

Revision History

Version	Date	Editor	Comments
0.1	2013/05/01	George Percivall	Draft for Workshop Committee and Task Review
0.8	2013/05/27	George Percivall	Final Review by Workshop Organizers
0.9	2013/06/20	George Percivall	Draft for GEO IN-Board Review
1.0	2013/07/08	George Percivall	Public release

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GEOSS Future Products Workshop

1. Introduction – the Workshop overall

This workshop provided a unique opportunity to learn how GEOSS as a platform makes all sorts of sensor and model data available in an interoperable manner. Data streaming from in-situ and remote sensing sensors (Sensor Web), models (Model Web) offers a huge potential to generate a wide portfolio of on-demand and near real time products. This multi-day workshop will feature: invited speakers and contributed positions; breakout sessions to exchange views and provide proposed approaches; with summaries posted on the web.

To meet the GEO aim of achieving interoperability of existing and new systems that provide essential environmental observations and information, this workshop builds on prior GEO activities including: the GCI Architecture Workshop in 2008, SIF Interoperability Workshops, GEO Sensor Web Workshops; and initiates similar discussions for the GEOSS Model Web. In the GEO Work Plan these activities are elements of GEO Task IN-05 "GEOSS Design and Interoperability".

The workshop was held March 26-28, 2013 at NOAA Science Center, Silver Spring, MD, USA with participation of more than 50 people from different sectors in the private industry, academia, government agencies. Organizations were from USA, Europe, Africa and Brazil.

Table 1. GEOSS Future Products Workshop Sessions

1. Overview and Introduction Policy and Science Vision for GEOSS	George Percivall
2. Current GEOSS Architectures: What exists and what is hindering progress	Martin Yapur
3. Sensor Web: Observations for forecasts, on-demand	Karen Moe
Keynote: **Dr. M. Frielich, NASA**	
4. Model Web: Vision and current frameworks	Stefano Nativi
5. Interoperability and Resource Discovery: Linked data, brokers, unique identifiers	Steve Browdy
Demonstrations	
6. Discussion on the Way forward	Ingo Simonis
7. Wrap-up and planning	George Percivall

All presentations are posted on line http://www.ogcnetwork.net/node/1872

The Workshop was conducted in the framework of the Global Earth Observing System of Systems. (GEOSS). GEOSS is about connecting observations, models and decision support for policy decisions and societal benefits. The scope and focus of GEOSS, as implemented by its component systems, is illustrated in Figure 1.

GEOSS, collectively, has several functional components:

- To address identified common user requirements
- To acquire observational data
- To process data into useful products
- To exchange, disseminate, and archive shared data, metadata and products; and
- To monitor performance against the defined requirements and intended benefits.

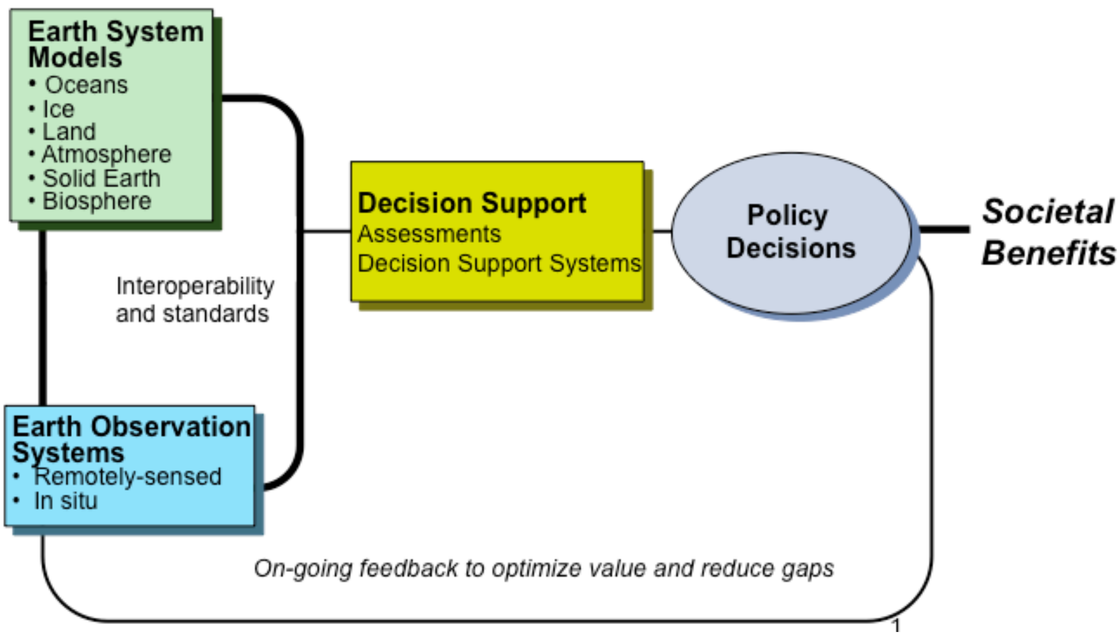


Figure 1. GEOSS Observations and Models linked to Societal Benefits[1]

Figure 1 provided a basic structure for the GEOSS Future Products Workshop. Sensor Webs are a method to increase accessibility to products from Earth Observation Systems. Model Web is a concept for improving the access to and interoperable use of Earth System Models. Additionally observation systems and models need to efficient and accurate coupling. The results of observations and models are decision support for societal benefits.

[1] GEOSS 10-Year Implementation Plan: Reference Document, GEO Document 1000R, February 2005

2. Workshop Sessions

2.1 Session 1: Workshop Vision and Overview

This session will address the overall objectives of the workshop. It is the aim of the workshop to define how GEOSS as a platform can make data from Sensor Webs and Model Webs available in an interoperable manner to generate a wide portfolio of on-demand and near real time products.

This workshop of experts is organized under the auspices of the GEO Infrastructure Implementation Board (IN-Board) with leadership from GEO Task IN-05 "GEOSS Design and Interoperability". The workshop builds on prior events of the GEOSS Architecture and Data Committee in particular the successful series on Sensor Web and the GEOSS Common Infrastructure. An outcome of the workshop is to provide recommendations to IIB and GEO about how to make future products more readily available and useful to GEOSS Users.

Table 2. Workshop Session 1 Agenda

Presentation Title	Presenter
Welcome from NOAA	Zdenka Willis, NOAA representative to US GEO
GEOSS Policy Vision (See section 2.1.1)	Peter Colohan US OSTP
GEOSS Vision for Water Science	Professor David Maidment, Univ. Texas - Austin
Workshop Objectives	George Percivall, OGC and GEO IN-05 Task
Discussion • Is GEOSS vision achievable • What are your expectations of GEOSS • What are your expectations of workshop	Moderator: George Percivall Rapporteur Curt Tilmes, NASA

References

- Group on Earth Observations home page:
  - http://www.earthobservations.org/geoss.shtml
- GEOSS Strategic Targets
  - http://www.earthobservations.org/geoss_stta.shtml
- GEOSS Key Documents
  - http://www.earthobservations.org/docs_key.shtml
- GEOSS Design and Interoperability (GEO Task IN-05)
  - http://www.earthobservations.org/ts.php?id=141
- GEO Architecture Implementation Pilot
  - www.ogcnetwork.net/AIpilot

2.1.1 GEOSS Policy Vision

Peter Colohan, OSTP - Summary of Remarks

Peter Colohan of the Office of Science and Technology Policy in the Executive Office of the President provided remarks on the "GEOSS Policy Vision" in the context of the Obama Administration's broader policy initiatives. He noted that the vision for the Global Earth Observation System of Systems (GEOSS)—to enable comprehensive, coordinated, and sustained observations of the Earth for societal benefit, and to inform decision-making based on those observations—remains as valid today as it was in 2005 when the Group on Earth Observations (GEO) and the concept of GEOSS was created. Colohan noted that the GEOSS vision also reflects the Obama Administration's broader policy priorities relating evidence-based policy making and information sharing. As articulated in 2009 by Dr. John P. Holdren—President Obama's science and technology advisor—in his address to the GEO-VI Plenary in Washington:

> *The Obama Administration believes in the vision of GEOSS. It represents a commitment to three important principles this government intends to champion both at home and abroad: science-based decision making, open access to data and information, and increased international cooperation on science and technology to help address the great global challenges of our time.*

The United States considers data from civil Earth observations to be a global public good. Consequently, the United States has promoted policies and initiatives that facilitate full, open, and timely access to these data. Colohan applauded the workshop organizers and participants for exploring how the framework of GEOSS might be used to develop specific new information products. Colohan raised as examples several challenges that the GEOSS framework could help resolve, including the need to quantify and regionally disaggregate carbon emissions, absorption, and retention; the need to monitor changes in the frequency, geography, and intensity of extreme events; and the need to make agriculture more productive and resilient and enhance global food security.

Mr. Colohan concluded by reiterating the Obama Administration's commitment to GEO and to GEOSS going forward.

2.2 Session 2: Current GEOSS Architectures

This session focuses on current architectures and functionality of GEOSS based on System of Systems Principles. Throughout this session, we will seek to gain a broader understanding of what is hindering progress. We will explore architectures being developed and will try to answer if the architecture/functionality we are currently using is realistically matching the needs of the user communities.

Table 3. Workshop Session 2 Agenda

Presentation Title	Presenter
GEOSS Common Infrastructure (GCI)	Doug Nebert USGS (webex)
GEO Global Agricultural Monitoring (GEO GLAM)	Kathy Fontaine for Chris Justice & I. Becker-Reshef
GEO Biodiversity Observation Network (GEO BON)	Gary Geller NASA-JPL (webex)
GEOSS Disaster Management Sensor Web architecture - CEOS	John Evans, NASA/GST
Discussion topics: • **What is the status of current GEOSS** • **Where should GEOSS develop** • **System of System approach**	Moderator: Martin Yapur Rapporteur Ken McDonald

References for Session

- GEOSS Common Infrastructure
    - http://www.earthobservations.org/gci_gci.shtml
- GEO Portal
    - http://www.geoportal.org/web/guest/geo_home
- GEO Global Agricultural Monitoring (GEO GLAM)
    - TBD
- GEO Biodiversity Observation Network (GEO BON)
    - GEO BON - Implementation Overview from GEO-V Plenary http://www.earthobservations.org/documents/cop/bi_geobon/200811_geobon_implementation_overview.pdf
    - "Toward a Global Biodiversity Observing System" Science 2008 http://www.earthobservations.org/documents/cop/bi_geobon/200808_science_toward_a_global_biodiversity_observing_system.pdf
    - "Essential Biodiversity Variables", Science 18 January 2013: Vol. 339 no. 6117 pp. 277-278 http://www.sciencemag.org/content/339/6117/277.summary
    - CEOS project GEOSS Architecture for Disasters (GA4D)
        - http://tinyurl.com/GA4Disasters

2.3 Session 3: Sensor Web

This session builds on previous GEOSS Sensor Web workshops, bringing together research, commercial and government perspectives. Having been established and built over the last decade, sensor webs are still expert systems for experts. Broadening the scope to make it easier for end users to participate is one direction for growth. The goals of this session are:

1) To explore techniques to integrate in situ and satellite observations, and model forecasts in a sensor web architecture, and

2) To look at ways to enable users to leverage sensor webs to develop 'on-demand' products.

The expected session outcomes include recommendations to GEOSS on how to to incorporate techniques or components that would enable new future products with sensor webs.

Table 4. Workshop Session 3 Agenda

Theme 1: Integrating in situ, satellite and model forecasts in sensor webs	
Presentation Title	Presenter
Crowdsourcing, Open Street Map and the Namibia Flood SensorWeb	Dan Mandl NASA - GSFC
Use of open standards to share ocean observing and model data in U.S. IOOS	Eoin Howlett, ASA Science
Sensor-Web-technology based Sensor-model integration for supporting the GEOSS societal benefit areas	Liping Di, GMU CSISS
Incorporating models into the sensor webs	Sergii Skakun, NASU (webex)
Discussion topics: • What products are available? • Are observations relevant to user needs? • On demand products	Moderator: Karen Moe Rapporteur Brian Wee, NEON

Workshop Session 3: Sensor Web – Continued

Theme 2: Enabling on-demand products

Presentation Title	Presenter
Scientific Workflows on the Sensor Web	Derek Hohls CSIR
Integration of data and on-demand data products generation	Ingo Simonis OGC-E
Data Preparedness for Disaster and Events	Ken Keiser UAH
User-centered goals driving system workflows	Pat Cappelaere, NASA - GSFC
Discussion topics: • How are sensor products made available in a GEOSS System of System Context? • How do users access the products? • What do users need to work with sensor webs? • Integration/fusion of remote sensing and in-situ observations • How are sensor products presented to users, e.g., near-real time for disasters? • Next steps for GEOSS to make sensor web reality	Moderator: Karen Moe Rapporteur Brian Wee

References for Session

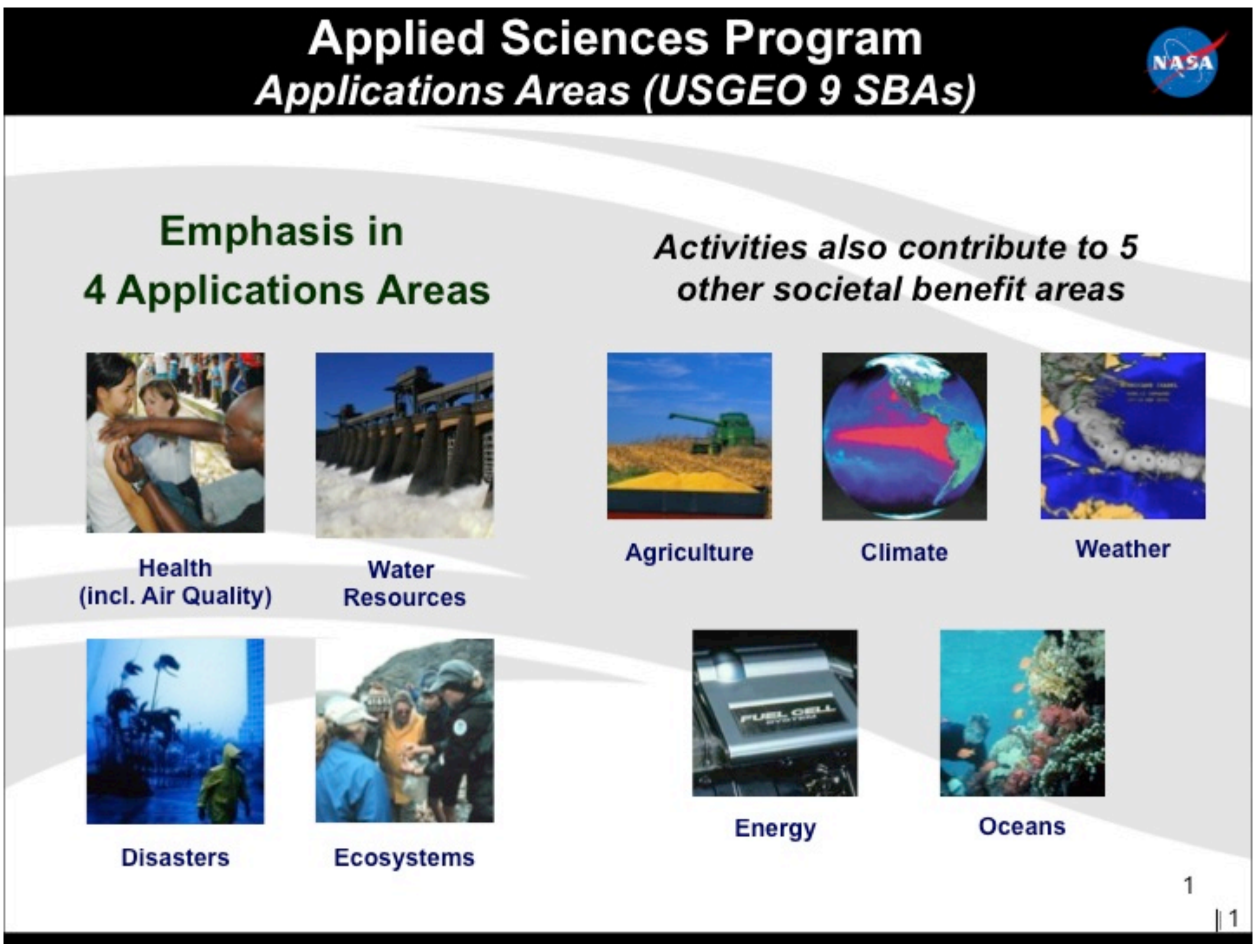
- GEOSS Sensor Web Workshop Report 2011
  - http://www.ogcnetwork.net/system/files/Sensor%20Web%20Final%20Report_0.pdf
- GEOSS Sensor Web Workshop Report 2010
  - http://www.ogcnetwork.net/system/files/GEOSS_Sensor_Web_Workshop_2010_Report.pdf
- Sensor Web Workshop Report 2008
  - http://www.ogcnetwork.net/system/files/_FinalReport_2.pdf
- EO-1 flood sensor web project
  - http://eo1.gsfc.nasa.gov/new/sensorWebExp/index.html
- OGC Sensor Web Enablement open standards
  - http://www.opengeospatial.org/projects/groups/sensorwebdwg
- Sensor-model integration for supporting the GEOSS societal benefit areas
- Incorporating models into the sensor webs
- Scientific Workflows on the Sensor Web
- Integration of data and on-demand data products generation
- Automated Data Delivery and Processing for Disaster Events, S. Graves, U. Nair, K. Keiser, poster presented at the ESIP 2013 Winter Meeting, Jan 2013, http://commons.esipfed.org/node/1054http://commons.esipfed.org/node/1054
- "User-center goals driving system workflows"

2.4 Keynote: Dr. Michael Frielich, NASA

Dr. Michael Freilich, Earth Science Division Director

Presentation: NASA Earth Science Division Update

- NASA Earth Science Overview and Status
- Future Mission Plans
- CEOS and GEO Leadership and Engagement
- ESD Budget Outlook
    - Sequester Gyrations
    - Details of FY14 President's Budget Proposal (time permitting)



2.5 Session 4: Model Web

This session addressed the "Model Web" action (and Vision) as part of GEOSS IN-05 component: GEOSS Design and Interoperability.

The Model Web is a generic concept for increasing access to models and their outputs and to facilitate greater model-model interaction, resulting in webs of interacting models, databases, and websites. Integrating models into more complex, tightly coupled model systems has been done for decades and has led to great progress in predictive capabilities.

The topics addressed by this session included but were not limited to:

- The Model Web overview/vision
- User-perspective of the Model Web concept
    - Social approach to business model specification
    - Current tools and technological solutions
    - Existing model frameworks
    - Integrated Environmental Modeling
- Challenges and future products to implement the Model Web vision
    - Documenting models (simulation and processing) – model outcomes.
    - Models notation languages
    - Tools for prototyping new models
    - Brokering services
- Relevant on-going projects

Table 5. Workshop Session 4 Agenda

Theme 1: Model Web Vision	
Presentation Title	Presenter
The GEO Model Web vision and action overview	Stefano Nativi CNR
The Model Web and the Biodiversity and Ecosystems benefit areas	Gary Geller, NASA-JPL
Developing and Validating Model Web Business Processes with the GEOSS User Requirements Registry	Hans Peter Plag, Nevada Bureau of Mines and Geology, Univ Nevada
Discussion topics: • Why the Model Web? • A user-driven approach to the Model Web • Model Web as a social instrument for Scientists?	Moderator: Stefano Nativi Rapporteur David Arctur

Session 4: Model Web – Continued

Theme 2: Model Web Implementation

Presentation Title	Presenter
The ESMF framework	Fei Liu NOAA
The OpenMI and Integrated Environmental Modelling - achieving the vision	Roger Moore OpenMI Association
The Business Model Broker	Mattia Santoro CNR
Discussion topics: • Do we need (new) Metadata Models ? • Local open APIs vs. open web interfaces • A future brokering infrastructure for model frameworks? • How to engage industry to advance GEOSS Model Web?	Moderator: Stefano Nativi Rapporteur David Arctur

References for Model Web Session

- Stefano Nativi, Paolo Mazzetti, and Gary N. Geller, "Environmental model access and interoperability: The GEO ModelWeb initiative," Environmental Modelling & Software, 39 (2013), pp. 214-228
- Energy prediction modeling by Mine PARIS Tech. Lionel Menard, et. al., Environmental Impacts Assessment life cycle analysis. http://www.ogcnetwork.net/pub/ogcnetwork/GEOSS/AIP3/pages/AIP-3_ER.html#energy
- Jump to the 4 minute mark in this video to see this model in use including WPS interface http://www.ogcnetwork.net/pub/ogcnetwork/GEOSS/AIP3/pages/Demo.html?movie=4
- OGC and iEMSs have an MoU to coordinate on interoperable model access. http://www.iemss.org/society/
- Press Release: http://www.reuters.com/article/2010/01/19/idUS191848+19-Jan-2010+BW20100119
- Earth System Modeling Framework (ESMF), http://www.earthsystemmodeling.org/
- For general information on OpenMI: http://www.openmi.org/ For detailed documentation on the OpenMI: https://sites.google.com/a/openmi.org/home/learning-more
- G. Geller, S. Nativi, K. Iwao, 2009, The Model Web, presentation available at: http://www.earthobservations.org/documents/committees/adc/200909_11thADC/AR-09-02d_ModelWeb_Geller.pdf
- Gary N. Geller and Forrest Melton, “Looking forward: Applying an ecological model web to assess impacts of climate change,” Biodiversity (3 & 4) 2008

2.6 Session 5: Interoperability and Resource Discovery

This session will look into areas of promise with respect to multidisciplinary interoperability of, discovery of, and access to Earth observation resources. Linked data will be examined from the point of view of what the U.S. is doing. Unique identifiers and brokering will be discussed generally, and with regards to Model Web and Sensor Web efforts. Semantics will be included, as appropriate. A discussion of authentication and single sign-on as it applies to accessing data will take place, and examples of operational networks, such as Polar Data Network and GEOWOW will show advances in interoperability and simpler access to data. The GEO Standards and Interoperability Forum (SIF) organized this session.

Table 6. Workshop Session 5 Agenda

Theme 1: Interoperability I	
Introduction and Agenda	Steve Browdy IEEE, OMS Tech
Vision on GEOSS Evolution: Towards a GEOSS for all stakeholders Discussion: • Do the usage patterns reflect the SBA needs? • What additional component types should be identified in the GEOSS architecture? • How can GEOWOW results be made operational?	Roberto Cossu, ESA and GEOWOW
Linked Data: Another strategy for discovery and access Discussion: • How can GEO/GEOSS best track developments in linked data initiatives? • How, specifically, would GEOSS adopt linked data and educate the data users and data providers? • How could semantics play a role when using linked data for GEOSS? • Can the use of linked data help resolve the GEOSS resource registration issues?	William Sonntag, US EPA
Unique Identifiers within Systems of Systems Discussion: • What is the difference between URLs and unique identifiers? • Are different identifiers needed for data and the associated metadata? • How do unique identifiers support linked data? • How are duplication and persistence handled?	Joan Maso GeoViQua (CREAF)

Workshop Session 5 Agenda - Continued

Theme 2: Interoperability II

Presentation Title	Presenter
Brokering for Multi-Disciplinary Interoperability: An EarthCube perspective Discussion: • Are all brokers the same? • How are brokers managed in a system of systems? • How can brokers assist with semantic interoperability? • "Lost in brokering": what is the downside to using brokers?	Siri Jodha Singh Khalsa, Univ. Colorado
Authentication, Single Sign-On, and User Management for GEOSS Discussion: • What if a data provider wishes not to engage with authentication, as recommended? • Can "GEOSS" users be differentiated from others? • How can GEOSS enable secure programmatic authentication?	Steve Browdy IEEE, OMS Tech
Session Summary	Steve Browdy IEEE, OMS Tech

References for Session

- GEOWOW Project
  - http://www.geowow.eu/project.html
- "Linked Data" by Tom Heath, Christian Bizer
  - http://linkeddatabook.com/editions/1.0/
- Linked Data Cookbook
  - http://www.w3.org/2011/gld/wiki/Linked_Data_Cookbook
- Government Linked Data Working Group
  - http://www.w3.org/2011/gld/wiki/Main_Page
- Data.gov site - http://www.data.gov/
- Tetherless World Constellation - http://tw.rpi.edu/
- EarthCube Brokering Concept Award site
  - http://earthcube.ning.com/group/brokering
- EarthCube Brokering Road Map
  - https://docs.google.com/file/d/0B_VW4kvIBAzQZEUxSjJkV1JaakE/edit
- EarthCube Brokering Reference Material
  - http://earthcube.ning.com/group/brokering/page/reference-material
- OpenID site - http://openid.net/
- SAML 2 specification
  - http://saml.xml.org/saml-specifications
- COBWEB project http://cobwebproject.eu/

2.7 Demonstrations

Demonstrations during break. Running concurrently at tables around the room.

- GEO DAB – Mattia Santoro, CNR and EC-JRC
- Arctic Data Explorer – Siri Jodha Singh Khalsa,
- ENVISION Platform – Titi Roman, SINTEF
- GEOSS Architecture Progress – George Percivall
- Video - Ben Burford, Steve Browdy

2.8 Session 6: Discussion on the Way forward

This session included reports from the Rapporteurs for each of the previous session. Then an integrative discussion of the entire workshop was undertaken to answer questions such as: Based on the discussions of previous sessions, what can we do now to get more use out of GEOSS? How can GEOSS be supportive of the broad community?

Table 7.Workshop Session 6 Agenda

Presentation Title	Presenter
Introduction	Ingo Simonis OGC-E
Eye on Earth and Coopeus	Steve Browdy IEEE, OMS Tech
Reports from Rapporteurs • **Session 1 – Curt Tilmes, NASA** • **Session 2 – Ken McDonald, NOAA** • **Session 3 – Brian Wee, NEON** • **Session 4 – David Arctur, UT-A/OGC** • **Session 5 – David Arctur, UT-A/OGC**	Rapporteurs
“Summary of the Summary”	Ingo Simonis OGC-E

2.9 Session 7: Actions and Outreach planning

Planning for results of workshop

- Workshop Report to be developed by Planning Committee
- Report results to GEO events in June in Geneva
  - GEO Work Plan symposium
  - IN-Board
- Other Reports
  - Capacity Building Report perspective on the workshop – Karine Ferreira, INPE
  - Article in "Environmental Modelling & Software" journal, Andrea Emilio Rizzoli, editor; Stefano to author the report
- Summit input:
  - Sprint to Summit –
  - AIP-6 – Bart
  - GEO Ministerial Working Group
- IN-05 Documenting the architecture
  - George Percivall, Task Coordinator IN-05
  - Steve Browdy, Task Lead IN-05a
  - GEOWOW, Roberto Cossu

Table 8. Workshop Session 7 Agenda

Presentation Title	Presenter
Introduction	George Percivall IN-05 Task Coordinator Steve Browdy, IN-05-1 Component Lead
GEO Work Plan	Espen Volden GEO Secretariat
EO Ministerial Summit Planning	Kathy Fontaine, NASA and US GEO
AIP-6 Update	Bart de Lathouwer, OGC
GEOSS European projects workshop (GEPW7)	Joan Maso GeoViQua (CREAF)
Workshop Publication Planning	Several

3. Recommendations

3.1 Science-based approach needs observations and predictions

RECOMMENDATION: The GEOSS information system should be designed using an approach that considers the scientific methods of deduction and observation to utilize observations and predictions in support of decision-making.

GEOSS and many other Earth information systems connect observations, models and decision support for policy decisions and societal benefits. To design such information systems, a science-driven approach is needed to connect observations and predictions. P. Colohan's talk in the workshop recalled a speech given at the 2009 GEO Plenary by Dr. John Holdren, then Director of the White House Office of Science and Technology Policy. Dr. Holdren emphasized three principles for GEOSS success: 1. Science based decision making, 2. Open access to data, and 3. International activity.

Professor David Maidment's presentation to the workshop developed the science based approach to defining GEOSS by considering the main epistemological methods of science: deduction, experiments and observation. He identified a quintessential exemplar for each method: Deduction by Newton, Experiments by Louis Pasteur, and Observations by Charles Darwin. Relating this to GEOSS, he identified the Model Web with deduction and the Sensors Web with Observation - the heart of GEOSS (Figure 2). Model as a Service needs now to be defined.

RECOMMENDATION: The GEOSS objective to link observations with models to provide decision support should be developed based on sound scientific principles of observations and deduction.

Much has been done to advance observation as the heart of GEOSS. What is now needed is for models to advance to a similar level of maturity. Defining a Model as a Service will produce such an advance. Figure 3 shows how observations and predictions with a model as a service have been deployed for studying river flows. In later presentations GeoBON was presented as another example of how Observation systems relate to Product Generation for users.

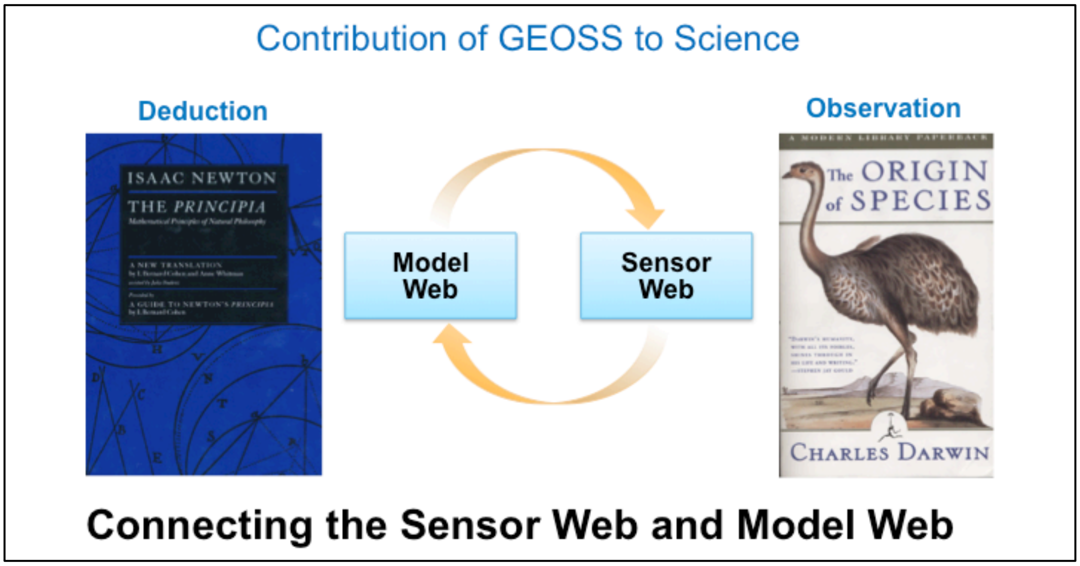


Figure 2. GEOSS based on a Science Driven Approach (Source: D. Maidment)

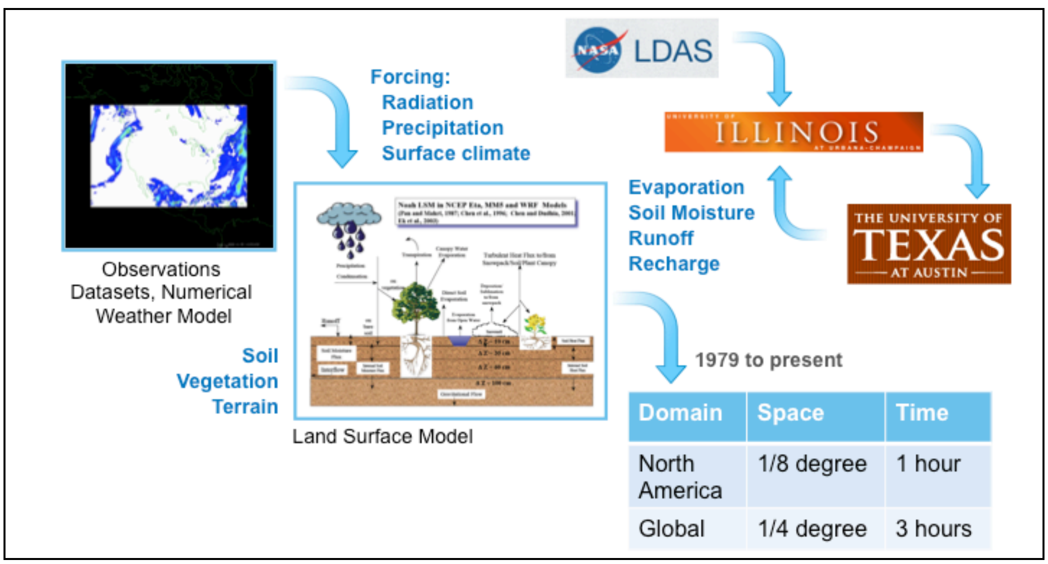


Figure 3. Model as a Service: River Flow (Source: D. Maidment)

3.2 Sensor Web: state of the art and challenges

Major topics identified in the workshop regarding the Sensor Web:

- Experience with sensor webs (EO-1, IOOS) highlights challenges for accuracy and timeliness in providing data products (e.g., to support decision support, early warning, model calibration)
  - EO-1 experience highlights the challenge of extracting accurate regional flood products from satellite observations (see Figure)
  - The IOOS data and model sharing concept leverages OGC web services, NetCDF and DAP (Hyrax, TDS), WaterML, and ISO 19115 standards; challenges in distributed computing (caching, brokering, user of cloud computing), robust services (alternatives to complex GetCapabilities) and diverse data models and metadata
- Architecture's perspective
  - Sensor Web Enablement, SWE has been applied and is useful
  - Need stress-testing (GetCapabilities, XML)
  - Sensor web technology based on service-oriented architecture is not directly compatible with traditional modeling environments.
- Scientist Perspective
  - The migration to data sharing is slow; my data is my competitive advantage
  - Scientists question what are web services, a foreign concept for scientists
- What if?
  - Every service comes with a client
  - Every service is self-explanatory and shows how to add to it
  - The GEOSS consumer are identified, and their needs are well understood
  - These steps guide how to get GEOSS service providers established
- It remains difficult for users to get what they need
  - Users want directly usable products, not services; need clients that make Sensor Web infrastructure invisible to end users; challenge is to define a “GeoSocial API” enabling people to express their product needs, and to supplement low-level services producing those products
  - Model builders are great client users
- Bringing sensor data together allows for comparison and improving quality of data
- Challenges
  - Sensor discovery, sensor access, transformation remain as barriers to expanded use
  - Automating sensor data handling in the cloud to support calibration/ validation, annotation and processing
  - Feature creation, data scrubbing, integration to transform raw data into useful information
  - Processing: exploration/visualization, workload distribution, provenance

Figure 4. Sensor Web Session - Focus on the User

Figure 4 depicts the sensor web presentations' Focus on the User and raises the question: How do you deliver to the user the required products and services with the requisite level of customization? The challenge for sensor webs (and associated information technologies) is how to match the user's mental model of their need, using credible sources of data matched to appropriate analysis, modeling and visualization services.

Figure 5. Namibia Flood Pilot Sensor Web Concept (Source NASA)

The Namibia Flood Sensor Web pilot operationally tasks EO-1 sensors to automatically acquire and process imagery. The challenge for remote sensing data is extracting accurate flood extent measurements.

The team conducted a crowd-sourcing exercise in Namibia to acquire in situ GPS data used to compare with EO-1 and Radarsat2 flood map products. Noting that Radarsat does not detect floods within grassy areas, local in situ readings helped determine relative accuracy to aid sensor data calibration. OpenStreetMaps provided an easily accessible open standard for data exchange.

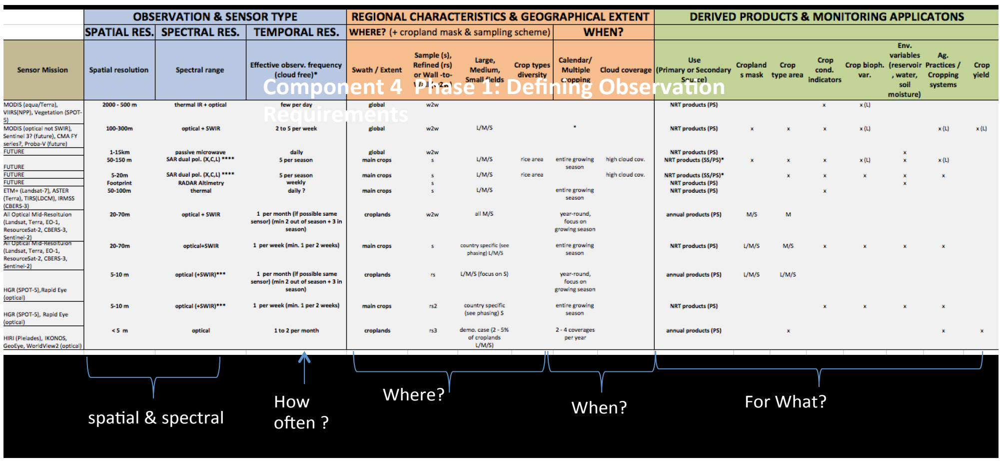


Figure 6. EO Data Requirements Table (Source: GEOGLAM)

3.3 Model Web: defining the concept and ways it could develop

Major topics identified in the workshop regarding Model Web:

- Models are the codification of the best understanding we have about physical phenomena and process –see Figure 6 and 7..
    - There is a clear need to ***connect:*** (a) data (including sensor measurements and products) to models, (b) disciplinary models to other models, (c) models across other across different across different disciplines.
    - GeoBON is a good example of a framework developing models accessibility and interoperability.
- Vision statement of Model Web
    - Vision: *A dynamic web of models, integrated with databases and websites, to form a* consultative infrastructure *where researchers, managers, policy makers, and the general public can go to gain insight into "what if" questions* –see Figure 6.
    - Model Web is not a dedicated tool, model framework, or workflow framework
    - It is a facilitation and intermediation framework.
- Technological Challenges
    - Manage heterogeneity of resources
    - Agreed definition of "model" representation and description –see Figure 11.
    - High-performance computing
    - Long-term access; standardization vs. virtualization
- Non-technological Challenges
    - Model-Related challenges.
    - Cultural, and Social, challenges.

  - Organizational and Institutional challenges
- Elements:
  - Model Web needs to consider elements such as: data, model, link/interface, Business Process -see Figure 8.
    - There is the clear need to (unambiguously) identify these resources in GEOSS – see Figure 12.
    - This seems to be possible by using the GEO DAB functionalities to supplement the remote provides capabilities.
  - The evolutionary process of models accessibility and interoperability –see Figure 9:
    - Tightly coupled model systems have been done for decades –e.g. model frameworks and tools
    - Loosely coupled model systems development needed —-—e.g. Component-Based Architectures (CBAs), and SOA solutions ((Models as a Service)
    - ESMF and OpenMI as examples –see Figure 10. They address different needs. CAM/OpenMI Integration diagram in Web Services Pilot:
    - Simple , small set of standards: Model component descriptions, interface definitions, semantics - especially for variables.
  - There exists a significant gap between Business Processes Design (Abstract) and Executable workflows
  -
    -
- Integrated Environmental Modeling
  - More emphasis on 'integrated modeling' than 'environmental' domain
  - 1) Work out a short-term road map for the Model Web, including effective showcases
    - Considering low hanging fruits, Integrating existing components
    - OSM is successful today because the end uses contribute now
    - Can we use crowd-sourcing to progress business models?
  - 2) IEM development like digital mapping, Comparison to weather
    - model marts for model components/apps and services
    - A way forward: a committed group, a program
    - Need this first process of getting all the little things before going after quick wins that
    - Roadmaps are available in these areas.
  - Important barriers to progress (several are cultural): lack of awareness, lack of confidence, not ready, no skills based, few tools, little up take, few resources.

<u>Recommendations</u>

- General Recommendations
  - Work out a short-term road map for the Model Web, including effective showcases
    - Adopt a step-wise approach, considering low hanging fruits and integrating existing components.
  - Recognize that GEOSS has different User types and Model Web addresses some of them
  - Start a forum to discuss model integration challenges (e.g. in OGC).
  - Involve Users, adopting social approaches to progress business models.
  - Lower entry barriers: e.g. filling the gap between the Business Processes Design (Abstract) and Executable workflows.
  - Link with analogous initiatives stemming from different areas (e.g. medicine, biology,

etc.).

- Specific Recommendations
  - Include modeling/process capabilities as discoverable and usable GEOSS resources
  - Provide the necessary intermediary services (e.g. brokering services) to address multi-disciplinary heterogeneity
    - Leverage and extend the GEO DAB capabilities adding new resource types: Models represented as either *Business Process* or *Workflow* artifacts.
  - Encourage accessibility and interoperability across existing model frameworks.
  - Leverage existing solutions and technology for High Throughput Computing (HTC) and High Performance Computing (HPC) either stand-alone (e.g. General Purpose Graphical Processing Units) or distributed (e.g. Cloud Computing).
  - Use Standardization (e.g. OAIS) and Virtualization (e.g. Cloud Computing) for Long Term Access.

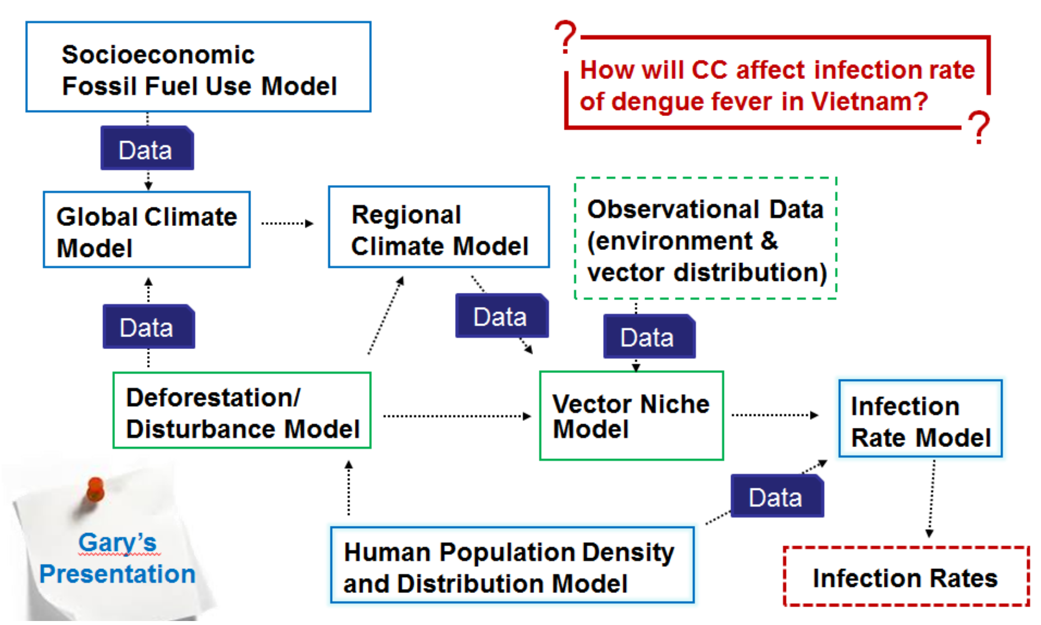


Figure 7. "What if?" model for Dengue Fever prediction (Source: Geller)

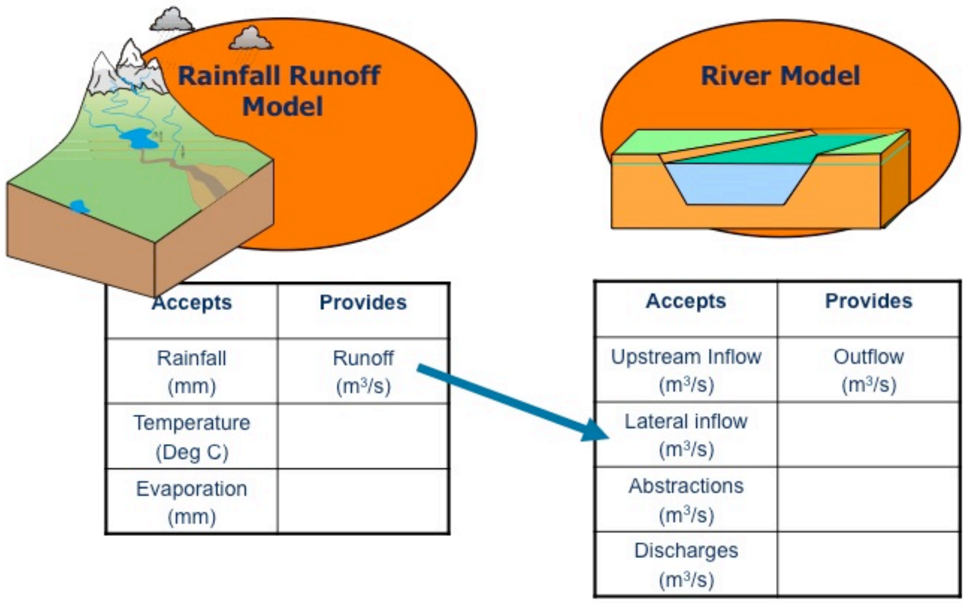


Figure 8. Linking modeled quantities (Source: Moore)

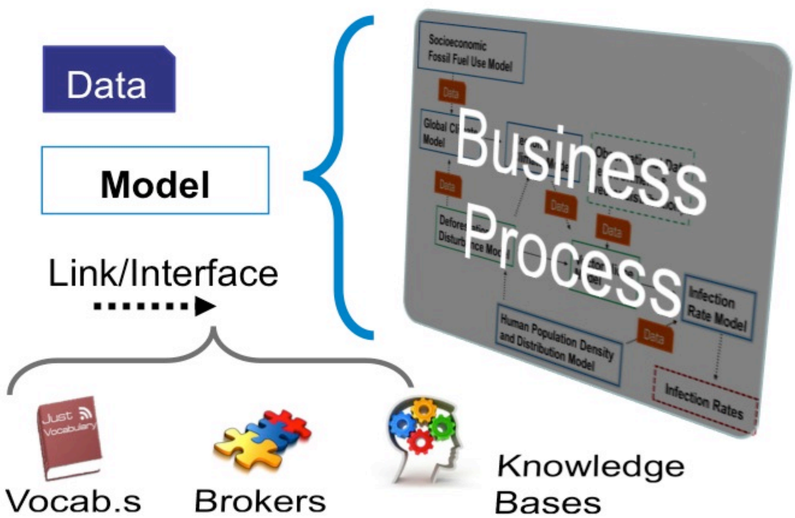


Figure 9. Elements of Model Web (Source: Nativi)

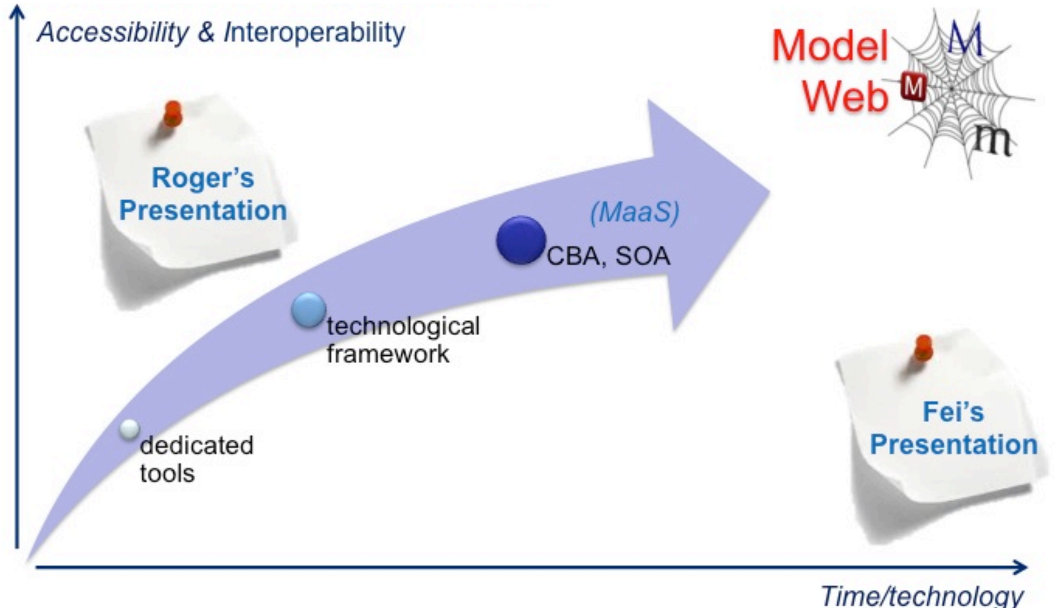


Figure 10. Model Interoperability - An Evolution (Source: Nativi)

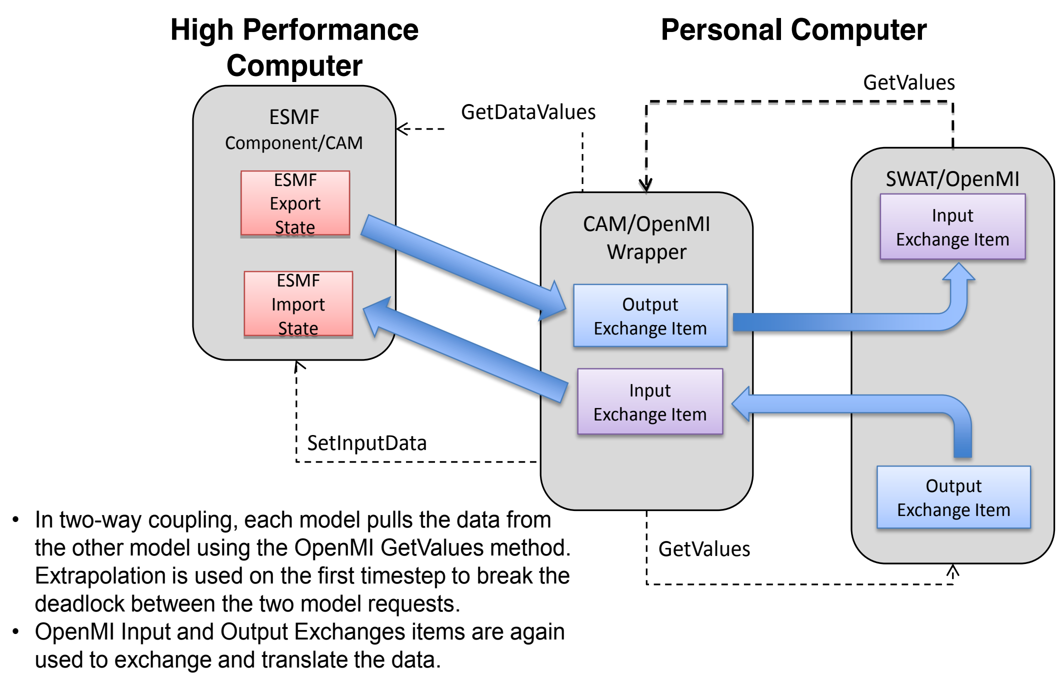


Figure 11. ESMF and OpenMI coupling (Source: F. Liu)

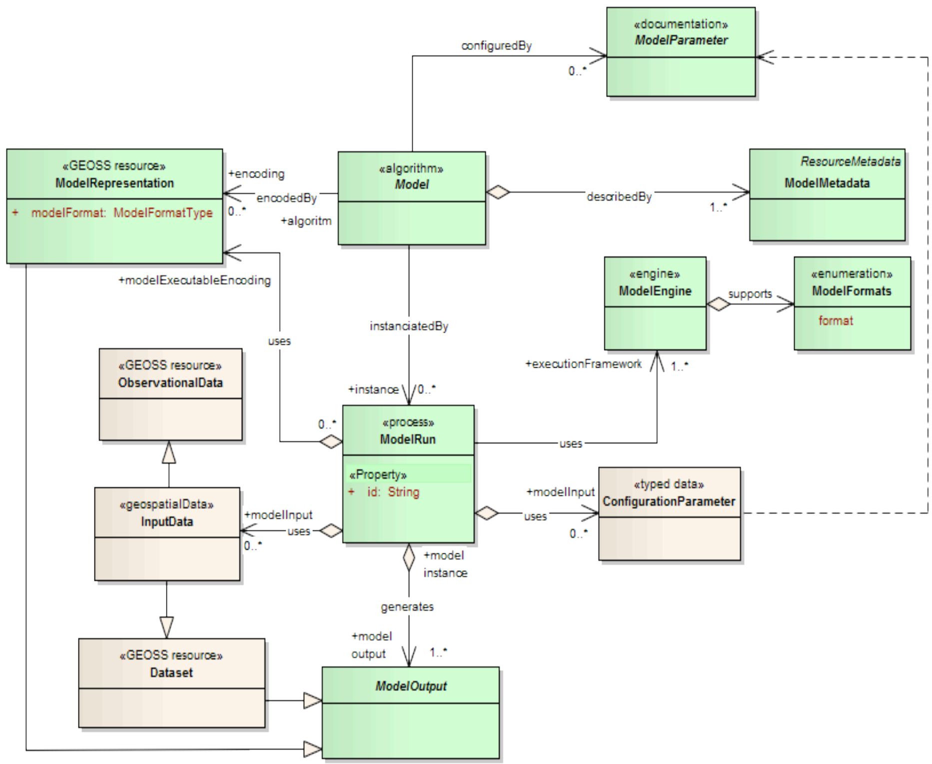


Figure 12. Environmental Model Resources (Source Nativi)

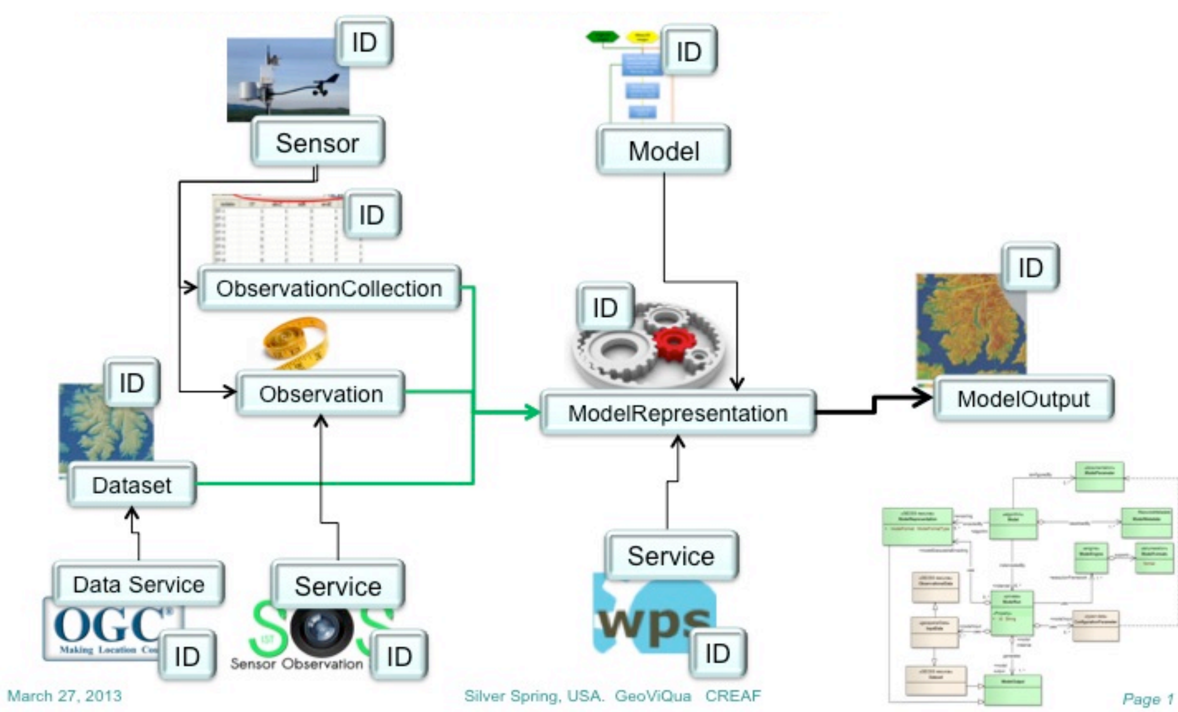


Figure 13. Identifiable Resources in GEOSS (Source: Maso)

3.4 Sensor Web – Model Web interactions

Major topics identified in the workshop regarding Sensor Web-Model Web interactions:

- Improving sensor web – model web interactions will lead to improved accuracy of both the observations, as models help sensor systems target most relevant observations, and the predictions where the most current and relevant observations provide the initial inputs to the models.
- There is little integration or coupling between sensor web data and modeling, limiting the benefits of feedback mechanisms between measured observations and predictive systems. A key challenge is to harmonize traditional models with simple client-server or compile-time integration with the sensor web's service-oriented architecture. This will entail achieving more compatibility based on open standards for data and model sharing.
- The evolutionary path is for sensor web – model web to share common APIs however they are currently using different standards
- OGC SWE and other standards cover many current needs but exceptions include feature creation, data scrubbing and integration (especially into machine-learning frameworks) and provenance capture needed for repeatability required to enable scientific workflow reuse
- Science Goal Monitoring system to determine the plans for sensor planning; scientific workflows differ from business process workflows in that they are less predetermined and must support exploration, cataloguing of experiments, portability, and linkages to domain-specific tools
- Need pre-processing between observations in sensor web and inputs to model web.
    - GMU Self-adaptive Earth Prediction Systems (SEPS)
        - Data Pre-processing, Integration, and Assimilation Services (PIAS)
        - Figure showing the architecture
        - ESMF and WPS implementation
    - Applications:
        - Community Atmosphere Model
        - Severe weather Event
        - Flood and drought monitoring
        - Agriculture
- Events as an element of interface
    - Event-Driven Data Delivery (ED3) - NASA applied science project
    - **Preparedness Plan**: When you see this type of event, take these actions/processing
- Solutions 2: Workflow - in science the workflow may not be clear from the start, how do you facilitate exploration, provenance, enable repeatability, portability, domain specific tool-sets
- Solutions 3: Sensor Web and Scientific workflows
    - EO4VizTrails: built on python, spreadsheet output, allows bespoke and ad-hoc components, embedded provenance framework, supported.
    - Python: scientific algorithms
    - Core OGC services: SOS, WCS, WFS, WMS; Plus PostGIS, QGIS, OPeNDAP

Figure 14 shows the Sensor-Model Integration themes in the Sensor Web session, raising the question of how to better enable discovery of workflows that match a given suite of user requirements, i.e., to pattern match between sensor observation characteristics and decision support requirements.

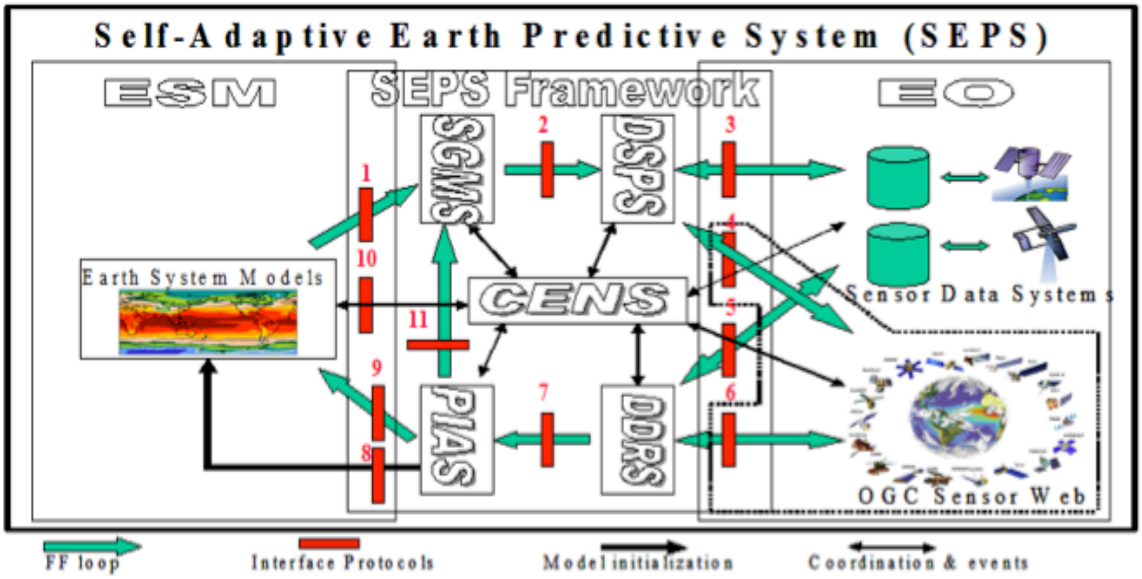


Figure 14. Framework for Model and Sensor Web Interaction (Source: L. Di)

Workflow was a consistent topic during the workshop. It affects several of the recommendations and is included here as this recommendation is the most integrative. The following references relate to workflow:

- Bigagli, L., Santoro, M., Angelini, V., Mazzetti, P., Nativi, S., (2011), "UncertWeb D 2.2 - Service frameworks for modelling resources"
- Santoro, M., Bogagli, L., Roncella, R., Mazzetti, P., Nativi, S., (2012), "A Brokering Solution for Business Process Execution", AGU Fall Meeting 2012
- Bastin, L., Cornford, D., Jones, R., Heuvelink, G.B.M., Pebesma, E., Stasch, C., Nativi, S., Mazzetti, P., Williams, M., (2013) "Managing Uncertainty in Integrated Environmental Modelling: The UncertWeb framework", Environmental Modelling and Software, Volume 39, pp. 116-134
- Santoro, M., (2012), "Environmental Model Composition in the GEO Model Web", Ph.D. Thesis, University of Basilicata: Italy
- OWS-6 Geoprocessing Workflow Architecture http://portal.opengeospatial.org/files/?artifact_id=34968.
- OGC Web Processing Service http://www.opengeospatial.org/standards/wps
- Exposing the Kepler Scientific Workflow System as an OGC Web Processing Service http://www.iemss.org/iemss2010/papers/S17/S.17.02.Exposing%20the%20Kepler%20Scientific%20Workflow%20System%20as%20an%20OGC%20Web%20Processing%20Service%20-%20BRADLEY%20LEE.pdf
- WPS orchestration using the Taverna workbench: The eScience approach, Computers & Geosciences, J. de Jesus, P. Walker, M. Grant, S. Groom, Available online 15 November 2011, ISSN 0098-3004, 10.1016/j.cageo.2011.11.011. (http://www.sciencedirect.com/science/article/pii/S0098300411003906)

3.5 GEOSS Users: diversity is key as there is so such thing as *the* GEOSS user

GEOSS cannot be fully defined without identifying the different types of users that build and interact with it. Users are involved in so many steps of data generation, upload, modification and manipulation, data consumption and development that it is not possible to talk about *the* GEOSS user per se. In fact, referencing *the* GEOSS user as if there would be a single type of user only has been the nucleus of endless unfruitful discussions about the GEOSS architecture, GEOSS products, or GEOSS information models that have led nowhere. Figure 15 shows a perspective on the range of GEOSS Users.

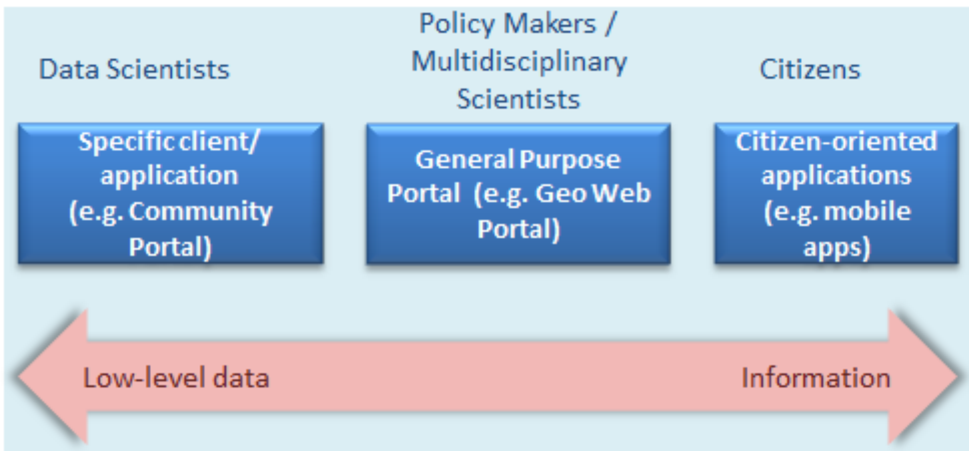


Figure 15. Range of GEOSS Users (Source: GEOWOW)

Defining the different types of GEOSS users is a challenging task that again could result in endless discussions, simply because of the manifoldness of GEOSS as a complex system of systems. As each integrated system serves a different purpose, has been built for different user communities with different requirements and framework conditions, it is not meaningful to define a single list of roles and declare them as ultimo ratio. Instead, the following paragraphs can be used as part of an ongoing conversation to help mutual understanding of the different types of users, seen from different angles with different motivations. The crucial aspect is to be always aware of the fact that talking about "the GEOSS user" is a very ambiguous, i.e. dangerous endeavor and should be avoided. Instead, aclear definition should be given prior toto any discussion about GEOSS in general and in particular.

It is possible to think of users in four general groups. The first group of users is data publishers. Data publishers have data at hand that they either want to or have to publish due some set of rules or laws. The amount of data, the experience how to handle the data or what can be done with the data, varies. Mass data providers probably have the resources available to establish a largely automated system to make their data available at their own set of interfaces. The metadata gets registered at catalogue systems from where is could be harvested by brokers or aggregators. Other publishers have only a very limited set of data, little experience with data publishing and no dedicated system at hand. Nevertheless, they want to make their data available to specific communities without investing substantial resources. To identify the two extremes, we have data publishers with very little resources that probably need some sort of GEOSS data cloud with semi-automated indexing, tagging, and metadata generation. Simplicity and ease of use is key for those users, as they cannot invest substantial resources into getting familiar with GEOSS and new technologies just for the sake of data publication. On the other side of the continuous spectrum, we have large data set publishers with dedicated systems publishing their data at a distinct set of interfaces. Those users like to see their data made available via GEOSS with minimum additional efforts, e.g. by automatically harvested catalogues, metadata model conversion, internationalization etc.

On the data consumer side, we have to differentiate a similar broad range: From casual users that access GEOSS without much experience, to scientific users that make regularly use of GEOSS, understand metadata models, query languages and various access services. The casual user on the other hand would be more interested in an as simple an access approach as possible. GEOSS as a social platform would be an example, where GEOSS users highlight information and data found on GEOSS in a way directly exploitable for other community members. The casual user requires an API that allows rapid exploration of GEOSS without understanding every single aspect and component. Rapid access and success are crucial.

The third group is the rather heterogeneous group of data integrators. To some extent, this group is both data publisher and data consumer, but has specific requirements in addition. Data integrators make use of the data portfolio made accessible through GEOSS, develop richer information by applying processes such as statistical analysis, data mining techniques, simulation models, etc. to it, and publish the results either directly to their clients or make it available via GEOSS again. As integrators tend to play a mediating role between data providers and data consumers, we often see a portfolio of requirements being stated that address alerting, monitoring, and rapid delivery aspects of data management.

The fourth group is the organizations that develop and maintain the components that constitute the GEOSS Information Systems. This includes the data center operators for the components operated that operate independently and primarily for purposes other than GEOSS; as well as the operators of components specifically supporting GEOSS, e.g., the GCI. Collectively this abstract group maintains the system of system components that constitute GEOSS.

Several presentations in the workshop addressed approaches to meeting the needs of the diverse groups of GEOSS Users. Figure 16 shows how information needs to be tailored to target different users. Figure 17 from the workshop proposed a "GeoSocial API" that would encapsulate existing service interfaces making them more accessible to users with simpler client tools.

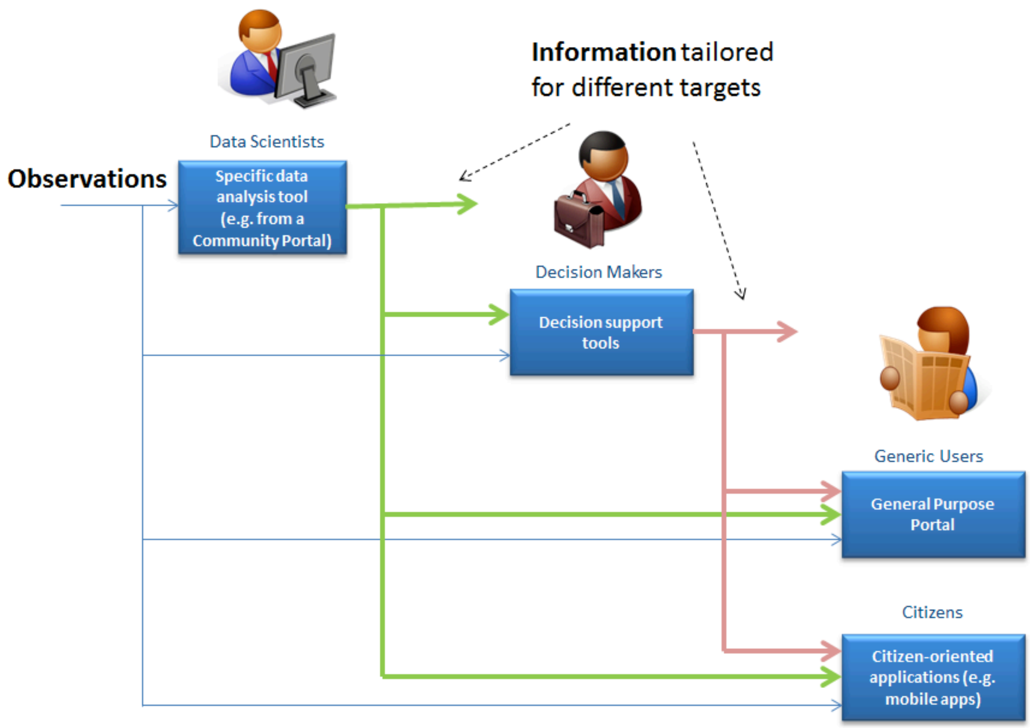


Figure 16. Information tailoring for GEOSS Users (Source GEOWOW)

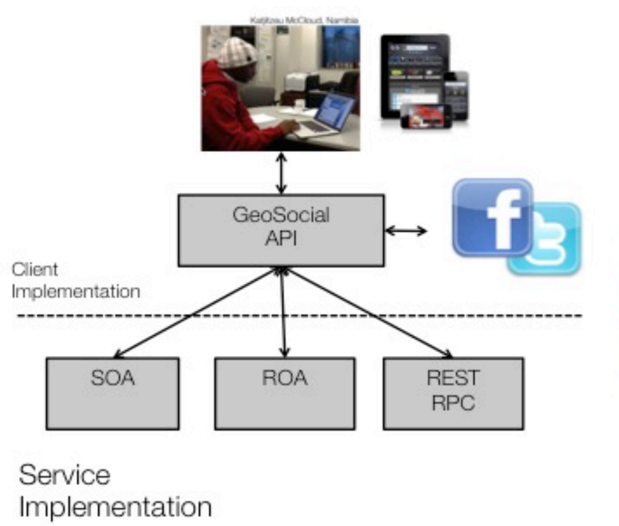


Figure 17.GeoSocial API to encapsulate service interfaces (Source Cappaleare)

3.6 Authentication and other Interoperability Issues

These recommendations pertain to Authentication and other Interoperability Issues

Recommendation 1: Authentication and SSO should be initially focused on OpenID and SAML-2. This approach leaves open the possibility of inclusion of more authentication opportunities to evolve the SSO federation for GEOSS. (SSO = Single Sign On)

Recommendation 2: Authorization should be added to the authentication and SSO federation as soon as possible, but no later than AIP-7. The addition of authorization will allow data providers, if necessary, to easily organize which resources are available to GEOSS users and which are not, and to modify that organization easily, as well.

Recommendation 3: Use metrics for the GEOSS should include some location information to gauge how widespread the reach of GEOSS is. The use metrics will give GEO and data providers a means to discover how the GEOSS is being used and with what frequency. Although it has been decided that no personal information will be collected or stored, it is recommended that some level of location information be collected, so that there is a way to determine which parts of the world use the GEOSS, and when.

Recommendation 4: The Semantics Registry/Component needs to be deployed into the GCI as soon as possible. The semantics registry or component is vital to the further evolution of the GEOSS. Although this has been worked on in the past, it has not been deployed yet, leaving various alternative solutions to be implemented by the GCI. There needs to be a uniform and consistent way to handle semantics within the GCI and for the benefit of the broader GEOSS.

Recommendation 5: Linked data and crawling should be investigated as a means to solve the registration issues of GEOSS. The registration process for GEOSS has received many complaints over many years due to the process that needs to be followed, plus the personnel that typically have the responsibility for performing the registration tasks. Solutions need to be investigated that take the burden of registration away from those that are being invited to participate and contribute to the GEOSS.

Recommendation 6: Broker interoperability should be investigated and developed as a way to serve communities and to handle the existence of different types of brokers. It seems fairly clear that one instance of one broker cannot be scaled and managed enough to deal with the population of GEOSS users that is envisioned will exist in the years ahead. There are also communities that have deployed brokers different than the GEOSS Discovery and Access Broker (DAB) that would benefit from being able to work with the DAB. Broker interoperability is recommended.

Recommendation 7: Create a tutorial for the Best Practices Wiki focused on the adoption and use of a consistent schema for unique and persistent identifiers for GEOSS resources. The use of unique and persistent identifiers will enhance the validity and trust of the GEOSS. A schema for these identifiers needs to be developed and published in the Best Practice Wiki, so that the GEOSS data providers can begin to adopt it.

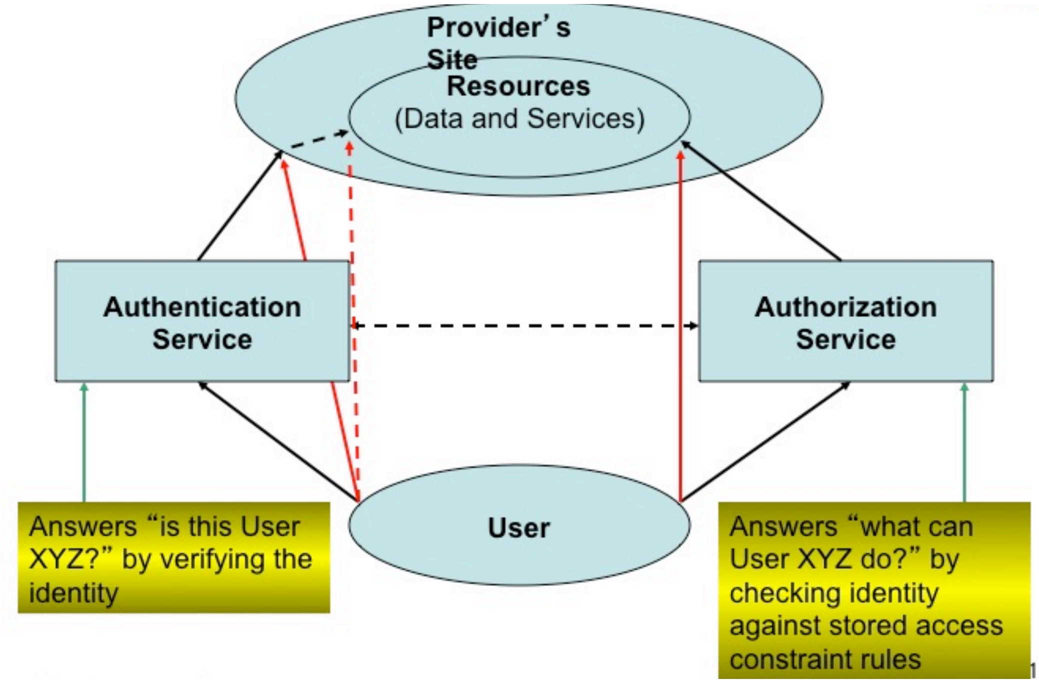


Figure 18. Authentication Framework (Source: Browdy)

3.7 Continue to improve the GCI to meet expectations

Recommendation:

The GEOSS Common Infrastructure (GCI) fundamental principle is to allow users of Earth observations to access, search and use the data, information, tools and services available through the Global Earth Observation System of Systems. The infrastructure and its four main elements: The GEO Portal, The GEOSS Clearinghouse, The GEOSS Components and Services Registry and The GEOSS Standards and Interoperability Registry constitute the current GCI architecture which has proven to be a logical and valid architecture. With all the right elements in place, a question emerges and rises above all: what is hindering progress? It appears the current functionality is not matching the needs of the user communities and GCI is not living up to its expectations.

There is consensus throughout the community that the evolving process of GCI has not been optimal, as it hasn't touched the nerve of a fundamental unresolved issue that is the seamless discovery and access to data. With the proliferation of data brokerage and the access of external clients to GCI in addition to the advent of new registration mechanisms perhaps in response to user's frustrations, the community has seen a shift in practices that opted for creating their own solutions tailored to their needs. Another known concern has been the process of manual registration required by GCI which in the opinion of many experts should be completely eliminated; a machine to machine process that obtains information not available through online services could represent the practical solution sought by many.

On a similar note, subject matter experts at this workshop agreed to suggest the incorporation of semantics and linkages of data with CEOS SEO vocabulary, and already established and stable resource.

CEOS and GEO leadership with the proper engagement can allow the incorporation of Essential Climate Variable (ECVs) inventories with a controlled population. GCI as it was reminded by one of the participants supports already 8 different semantic assets. No less important was the discussion and debate during the workshop pointing out the need to link open data, much has been discussed about the W3C linked data cookbook for Government and the path forward for GEOSS aiming towards 5 star data.

Digital object Identifiers (DoIs) were also part of the conversation, there is NOAA and NASA experiences with the use of DoIs that offer best practices and lessons learned for handling Identifiers. The "Page not found" problem has been persistent and is clearly looking for solutions; URLs in GCI have changed and will continue to change as the demand for practical solutions becomes more evident.

Brokering in GEOSS has become a necessity, the sociotechnical nature of the common infrastructure has enabled data providers to develop and enhance individual interfaces that reach much further than an individual one stop shop as shown in Stefano Nativi's diagram in Figure 23. Brokering is a community practice that GCI needs to leverage from.

Overall, The GEOSS Future Products Workshop generated a healthy and important debate that reflected the divided positions of data users and data providers. Clearly not all the parties are satisfied nor convinced with the evidence of progress of GCI. The current architecture recognizes a number of issues related to data content, registration, service quality, consistency of inventory search, search and access and is already anticipating challenges ahead related to general coordination with licenses and user management, types of semantic information, independent community portals from SBAs, mobility, tracking of content quality, etc.

In order to help facilitate the realization of the GCI vision, we recommend an introspective assessment, similar to the one CEOS underwent with its self- study. This assessment will include the identification of past successes, strengths, opportunities, and areas of challenge. The main goal of this assessment will include the formulation of a plan to inform GEO on how to move GCI forward, through an analysis of lessons learned, inputs from stakeholders, and assessment of current architecture. A final report with recommendations for potential changes and potential new initiatives for the next 3-5 years will be the end product. Who, how and when is not specified and delineated in this recommendation, clearly a task for GEO coordination and all the voluntary organizations that support the idea.

There was discussion about "What is the current architecture?" There are several different definitions for the GCI. Some of the definitions are still referring to the "old" GCI architecture, which was modified as of the Plenary of 2011.

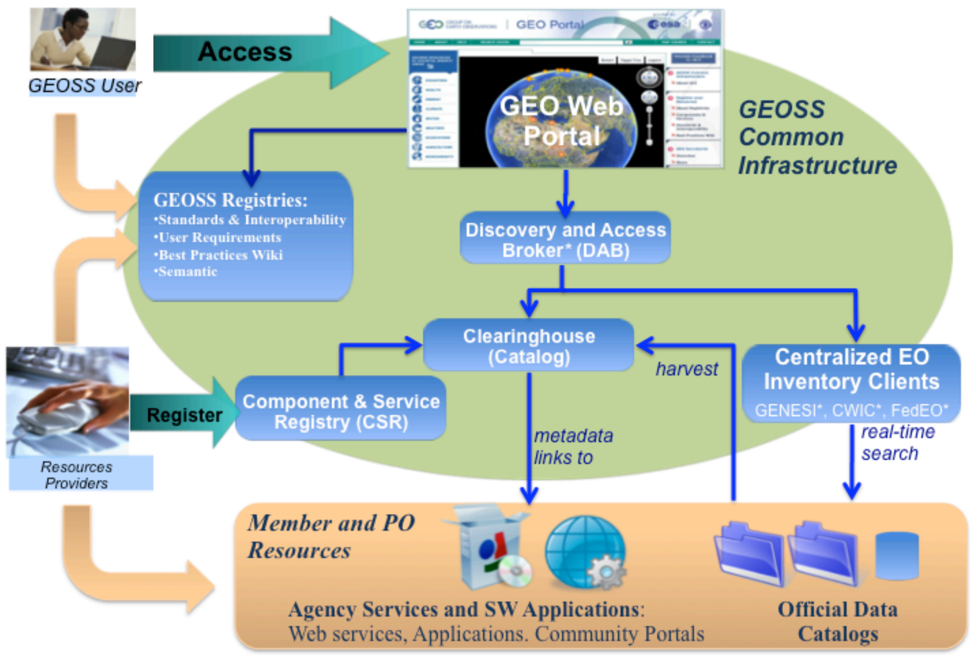


Figure 19. GEOSS Common Infrastructure (Source: D. Nebert)

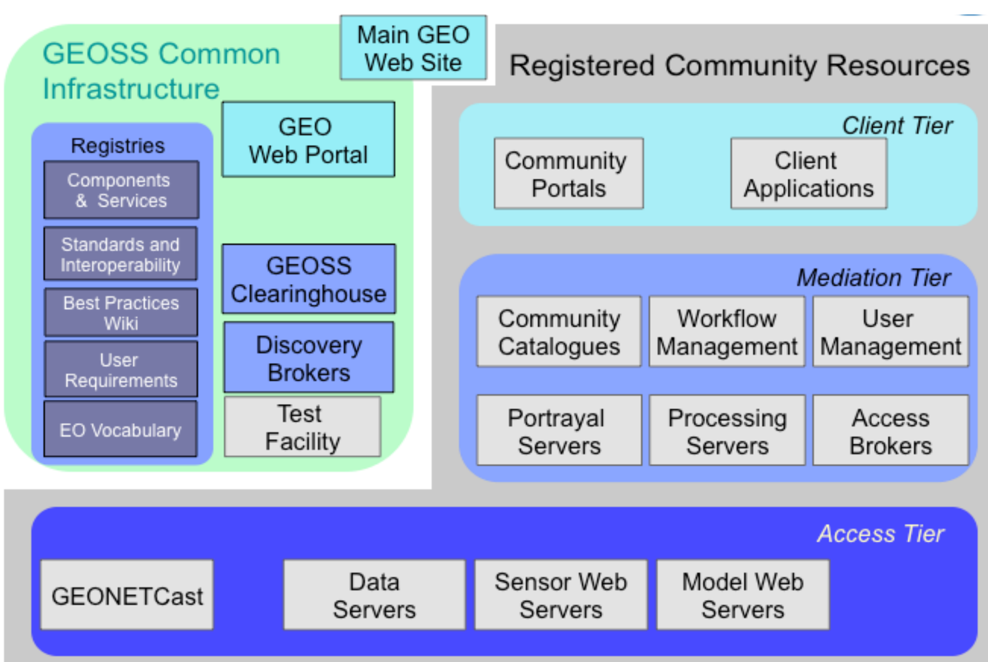


Figure 20. GEOSS Architecture – AIP Engineering Viewpoint (Source: AIP)

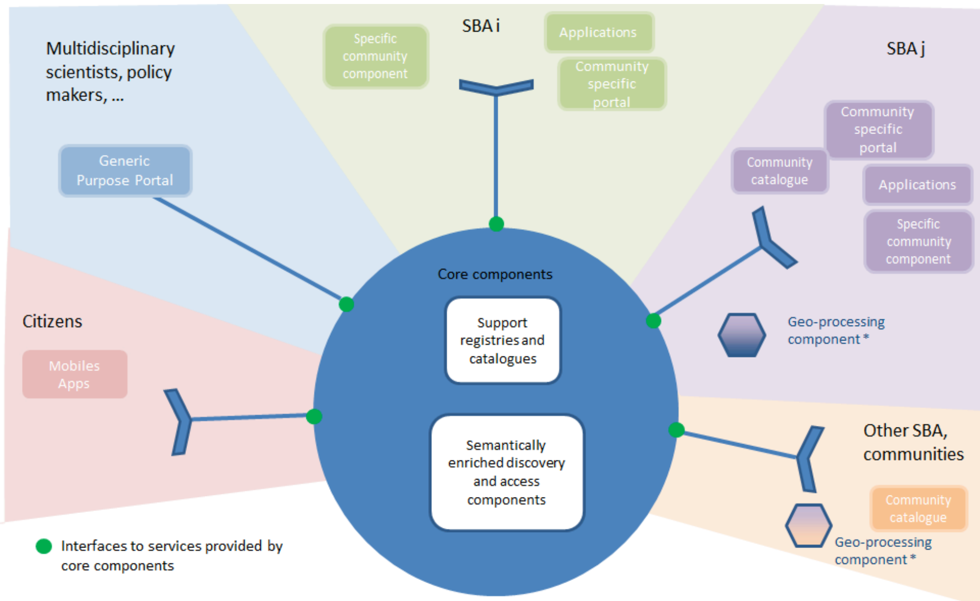


Figure 21. GEOSS serving many communities (Source GEOWOW)

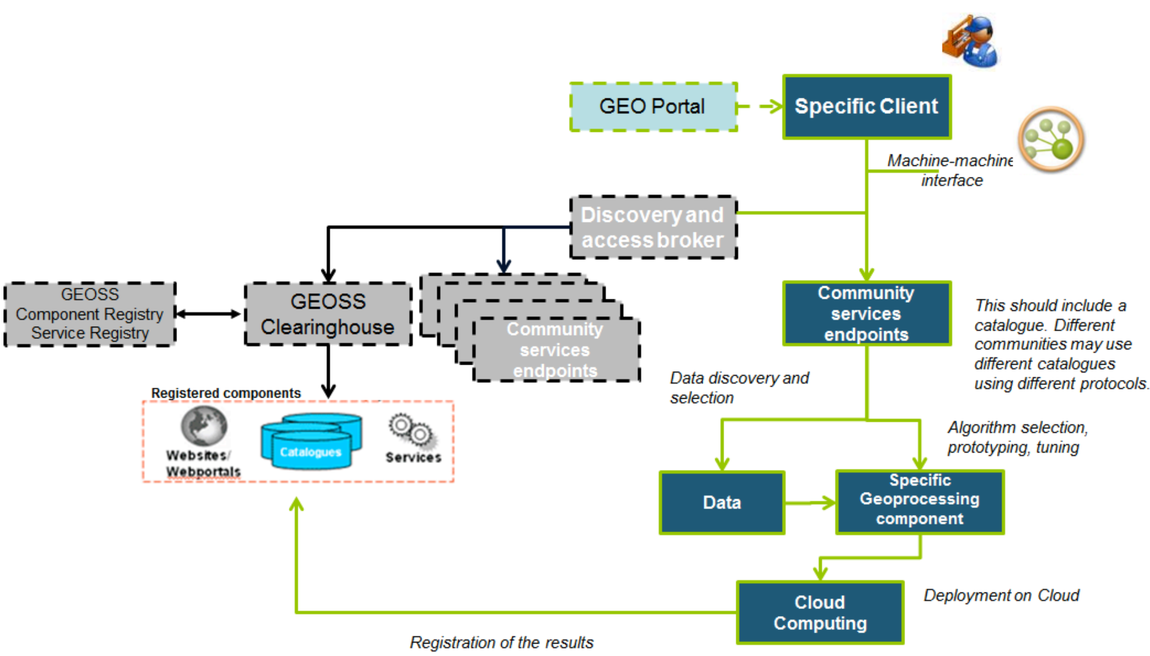


Figure 22. GEOSS Community Components (Source GEOWOW)

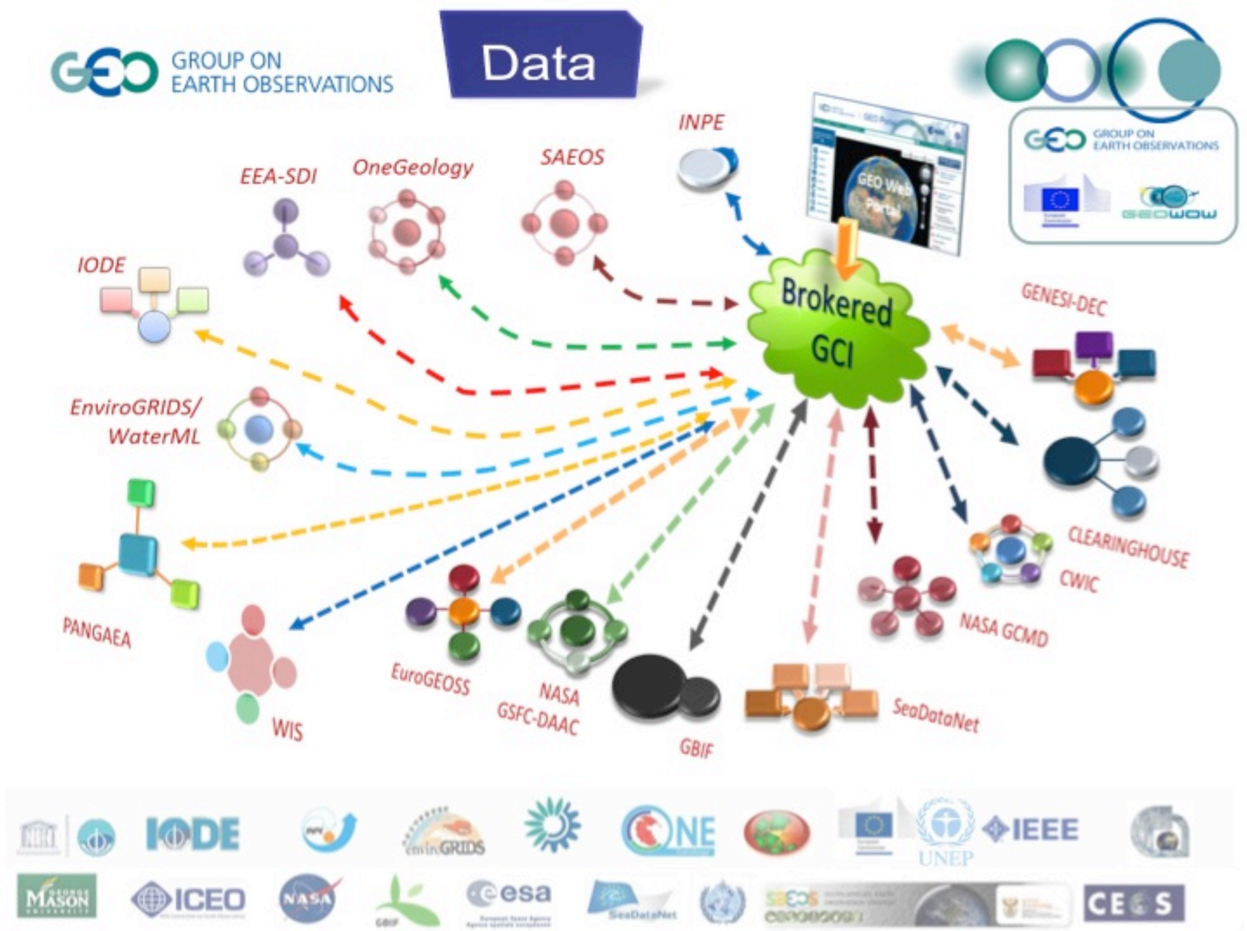


Figure 23. The GCI Brokering approach (Source Nativi)

3.8 Capacity Building activities can improve how GEOSS is used

The Capacity Building Report (Annex A) suggests that GEO IDB (ID-02 Task Coordinator) prepares these tutorials together with or following/observing the activities/tasks of two other groups:

1) GEO Infrastructure Implementation Board (IN-Board) => IN-05 Component: GEOSS Design and Interoperability. In this component, two of their expected achievements by 2015 are:
   a. "*Technical documentation of the GCI and the greater GEOSS architecture*".
   b. "*Expanded set of tutorials for GEOSS providers and GEOSS users*".

   See: http://www.earthobservations.org/ts.php?id=141

2) GEOWOW project whose priority tasks include:
   a. "*Improve data discovery and provide easier data access*".
   b. "*Provide new data registration mechanisms, including support for the GEOSS Data CORE*".

The report also suggests that GEO Institutions and Development Board (IDB), through ID-02 Task, could help GEOSS users to understand better what GEOSS is and what can do to improve their lives. The workshop attendees supported a greater and more effective distribution of information regarding what GEOSS is through social media of different types (for example, the Capacity Building AIP-6 leader has started tweeting about GEOSS https://twitter.com/luxavatar but more could be done through other mediums). Furthermore, some attendees suggested to develop deliverables for GEOSS users who are interested to use and exploit immediately the functionalities provided by GEOSS (for example, by developing easy to download through different devices, focused GEOSS applications, such as Flood Maps in the Namibia region)

3.9 Improve the public messages for GEO

The workshop uncovered a repeating theme regarding the public relations aspects of GEO and GEOSS. There was much agreement that few people outside of those working with the GCI had a clear understanding of what the GEOSS is. Even those that had some idea about the GEOSS seemed to not have an understanding of how it can benefit society and policy formulation. GEO should establish a brand, tag line, and easy to understand statement about GEOSS

The GEO Secretariat is currently working with an organization to develop a Communications Strategy for GEO and the GEOSS, which includes issues of branding, messaging, and engagement. This group is eager to see the results of this work.

4. Additional Activities

4.1 GEO Task Reporting

This report is a major deliverable from the workshop. This Report will be provided to the GEO community for consideration in GEO Work Plan. The report will be presented by the IN-05 Task Coordinator and the IN-05-01 Task Lead to the GEO Work Plan Symposium, June 2013.

The Workshop closed with a discussion of the role of the workshop in GEO including an overview of GEO Work Plan management provided by Espen Volden (Figure 24) and a discussion of Ministerial Planning by Kathy Fontaine.

While GEO (at heart) is a diplomatic group doing a project, its voluntary, non-legally binding, intergovernmental nature allows for

- High flexibility (response to meetings like this)
- Common discussion and action platform (spins up GEO BON, GEOGLAM, GFOI, expands SERVIR…..)
- Leveraging existing agreements, missions, funding, etc. to address 'stuff'
- Visibility to work in the international arena

Each of those elements has its drawbacks (cosmetic, real, imagined….), including

- Setting expectations that GEO work moves faster than it does
- Setting up perceptions that GEO is about and for high-technology, space-based, large data volume providers
- 'Our' experience is the entirety of the universe of needs and capabilities

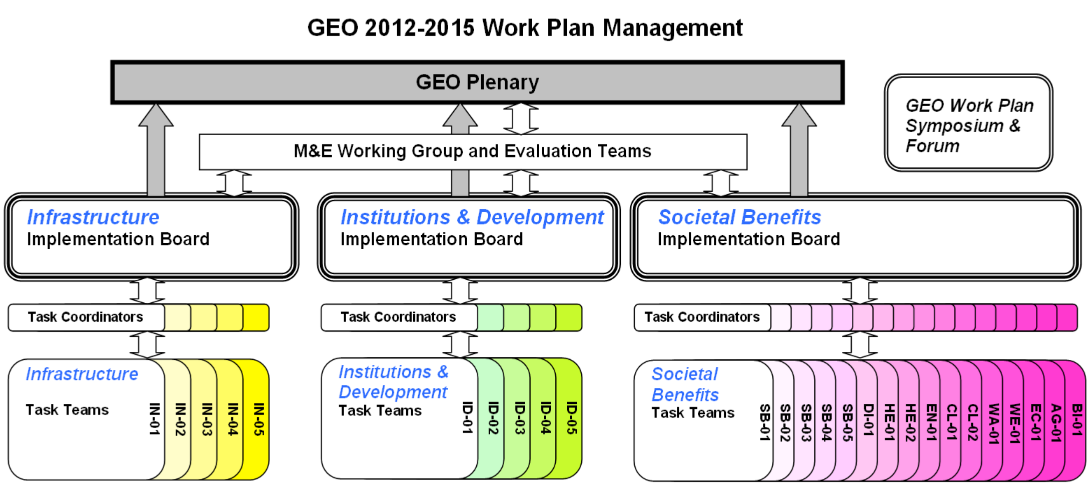


Figure 24. GEO Work Plan Management (Source: GEO Secretariat)

4.2 Activities as a result of the workshop

Additional Reports are planned or are complete:

- Capacity Building Report (See Annex)
- GEOSS European projects workshop (GEPW7)[2]
  - Joan Maso GeoViQua (CREAF) presented a summary of this Future Products Workshop to the GEPW7
- Environmental Modelling & Software" journal
  - Stefano Nativi plans to author an article in this journal and has initial discussions with Andrea Emilio Rizzoli, editor of the Journal
- Eye-on-Earth – Steve to distribute report
- CEOS – WGISS will send an executive summary to CEOS SIT.

Presentation to GEO IIB

Environmental Model workshop – Roger Moore, Stefano Nativi.

[2] http://gepw7.creaf.cat/Program.htm

Annex: Capacity Building Report for the Workshop

Capacity Building Report: Perspective on the workshop "GEOSS Future Products"

By: Karine Reis Ferreira (INPE-Brazil), revision by Hilcea Ferreira (INPE-Brazil) and Lucia Lovison (Capacity Building- AIP6)

Date: April 03, 2013

A.1. Goal

This report aims at identifying Capacity Building (CB) activities in the workshop context. It focuses on CB activities that can help GEOSS users better understand and use the GEOSS products.

A.2 Summary of the Workshop

The workshop addressed interesting topics:

- The current GEOSS Common Infrastructure (GCI) and its ongoing evolution and improvements through the GEOWOW (GEOSS Interoperability for Weather Ocean and Water) project;

- Initiatives that are/will be implemented in the GEO framework: (1) GEO Global Agricultural Monitoring (GEO GLAM), (2) GEO Biodiversity Observation Network (GEO BON) and GEOSS Disaster Management Sensor Web architecture – CEOS and NASA.

- Sensor Web: examples of use, technologies to integrate and handle observations from different kinds of sensors and scientific workflows. Interesting use cases were presented, such as Namibia Flood SensorWeb (NASA) and Ocean Observations and Model Data in U.S. IOOS.

- Model Web: researches and implementations of Model Web, such as OpenMI, Business Model Broker and ESMF.

A.3. Conclusions

During the workshop, some presenters pointed out an existing gap between the GEOSS architecture and the GEOSS users, especially scientists and public data consumers who need different type of GEOSS deliverable-products. Two examples are:

1) In the presentation of Gary Geller (NASA-JPL) about GEO BON, he pointed out that: "*Most GEO BON people do not understand the GCI*" and "*Intent to use it is unclear*".

2) Ingo Simonis (OGC-Europe) talked about the need of "*Integration of data and on-demand data products generation*" and pointed out the difficulties faced by scientists when they want to share their data and web services. Figure 1 is from his presentation and illustrates this gap.

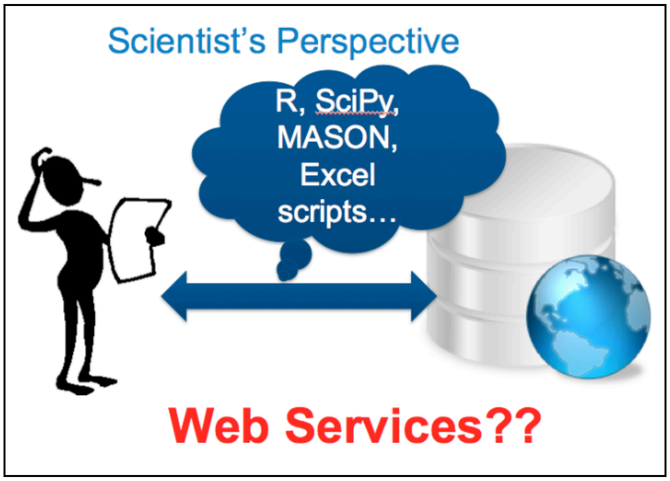


Figure 1: Gap between scientists and technology. (Source: Ingo Simonis's presentation, 2013)

3) Pat Cappelaere emphasized that "*current OGC API's are too hard for GEOSS users (too low-level, too hard to learn, develop or use)*" and that "*GEOSS users are no professional software developers*". He pointed out that "*to generate a simple flood map, GEOSS users such as McCloud in Namibia need to master 60+ standards with API's from 400+ organizations at different revision levels and binding types (RPC, SOA, ROA).* " Figure 2 is from his presentation and illustrates this scenario.

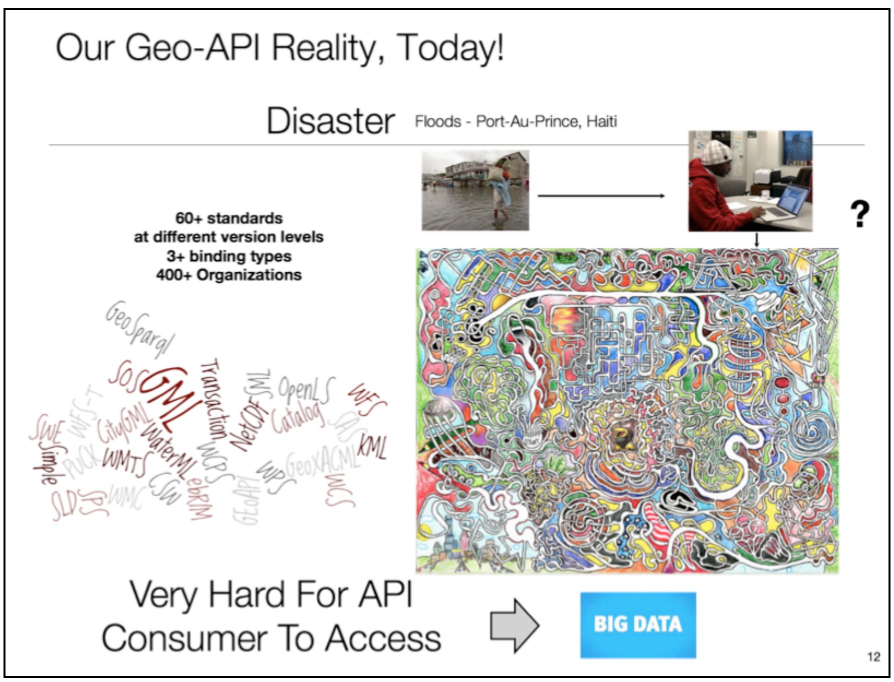


Figure 2: Gap between GEOSS data consumer and technology. (Source: Pat Cappelaere's presentation, 2013)

Considering this current scenario, we believe that GEO Institutions and Development Board (IDB), through ID-02 Task (Developing Institutional and Individual Capacity), could help GEOSS users better understand and use the GEOSS architecture by providing "hands-on" tutorials that address the following topics:

1) How to **share** different kinds of **data** (in different formats such as XLS, CSV, Shapefile, Geotiff, …) using GCI and the GEO Portal? (For example: What software can I use to serve my set of shapefiles as WFS files?).

2) How to **get data** using the GEO Portal and how to **use** it? (for example: What software can I use to access a WFS server? How can I convert XML file that comes from WFS into a shapefile? How can I access a WFS server in the R package?)

The main idea is to provide step-by-step and hands-on tutorials using existing data and existing free and open source software tools. Nowadays, there are many free and open source software tools able to access web services (for example Quantum GIS, TerraView and R packages) and to serve data through web services (for example GeoServer).

We suggest that GEO IDB (ID-02 Task Coordinator) prepares these tutorials together with or following/observing the activities/tasks of two other groups:

3) GEO Infrastructure Implementation Board (IN-Board) => IN-05 Component: GEOSS Design and Interoperability. In this component, two of their expected achievements by 2015 are:

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4) GEOWOW project whose priority tasks include:

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We also believe that GEO Institutions and Development Board (IDB), through ID-02 Task, could help GEOSS users to understand better what GEOSS is and what can do to improve their lives. The workshop attendees supported a greater and more effective distribution of information regarding what GEOSS is through social media of different types (for example, the Capacity Building AIP-6 leader has started twitting about GEOSS https://twitter.com/luxavatar but more could be done through other mediums). Furthermore, some attendees suggested to develop deliverables for GEOSS users who are interested to use and exploit immediately the functionalities provided by GEOSS (for example, by developing easy to download through different devices, focused GEOSS applications, such as Flood Maps in the Namibia region)