A Strategy for a Results-Oriented GEOSS

This document has been prepared by the GEO Secretariat for information

1 Introduction

The wide availability and accessibility of open data, coupled with the design of new technologies related to data processing systems and services, has changed the landscape of Earth observation (EO) applications. Studies that took months can now be done in days. These advances are particularly relevant to low- and middle-income countries, where EO information production now requires minimal infrastructure investment.

As stated in the *GEO Strategic Plan 2016-2025*, a central part of GEO's Mission is to build the Global Earth Observation System of Systems (GEOSS). GEOSS is expected to provide access to a diverse set of EO data and information for a broad range of users by linking EO observation, information and processing systems. This original vision of GEOSS as a "system of systems" continues to be essential to GEO. However, the GEOSS architecture – designed in the early 2000's – no longer matches what is possible and necessary with today's technology.

Given these challenges, the 44th Session of the GEO Executive Committee approved a proposal made by the GEO Secretariat to investigate the status of the current GEOSS and to recommend a strategy for the evolution of GEOSS in line with recent technological advances. EXCOM approved the creation of an Expert Advisory Group (EAG), whose purpose is to provide a proposal for the design of a results-oriented GEOSS. The current document presents the case for the need to evolve GEOSS and the associated timeline, pointing out the actions and experts involved.

2 An Illustrative Example

GEO can help developing nations to increase the benefits they derive from Earth observation and provide support for decision-making. We consider the case where an expert in Cameroon is working for her government to assess tropical forest loss in her country, to support a system that complies with the best practices for Reducing Emissions from Deforestation and Forest Degradation (REDD+), and reports emissions to the United Nations Framework Convention on Climate Change (UNFCCC).

She then enters the GEOSS knowledge hub. The knowledge hub is composed of a set of reproducible documents. These are reports of robust methods that include both their description and an open-source script that can be executed. These scripts have been tested and validated and are organised such that the specialist can include her own in-situ data and chose the space-borne data she needs.

After being recognized by the system, she has access to a large network of resources provided by the GEO community. In her case, the GEO Secretariat has facilitated access to Copernicus service that has put together Sentinel and Landsat data for Africa. She has also access to MODIS data in the African Data Cube, which also hosts a data set of ground-truth data for the African tropical belt. Due to some restrictions by the in-situ providers, the ground-truth data set is not yet public, but GEOSS and the African Data Cube have secured its use by GEOSS-authenticated users.

She then browses the GEOSS knowledge hub and uses a detailed report on best practices for forest monitoring using big EO data done by Brazil's National Institute for Space Research (INPE). INPE has also built a state-of-the-art algorithm that uses deep learning methods for forest monitoring. This algorithm is available on a GEOSS repository of trusted and curated methods. She then uses GEOSS programming environment to combine the ground truth data with the MODIS data set, using INPE's algorithm. The result is a 20-year time series of forest change for Cameroon for the period 2000-2010. Next, she refines the result for the period 2012 onwards using the combined Sentinel-Landsat mosaic. After testing the results, she then uses the tropical biomass map provided by the European Commission (EC) Joint Research Centre to produce an emissions report that the government of Cameroon will submit to the UNFCCC.

3 GEOSS as Trusted Broker

The scenario described above is not futuristic. Rather, it could shortly become reality in different ways. However, we need to consider whether there is still a need for an intergovernmental GEOSS platform, given the expected profusion of

EO data providers. If providers are already doing the work, is there still a need for GEOSS? We maintain that an intergovernmental platform is necessary to ensure fair access to EO data, methods and services to the widest number of decision-makers possible.

It is unlikely that a single data provider will ever be able to store all the satellite images, in-situ data and methods required to produce high quality applications. Data providers cannot foresee all different user needs. New methods and algorithms are developed independently by researchers and are more likely to be available in software repositories than in data providers' archives. GEO member states are particularly sensitive to storage of in-situ data on commercial platfroms. Given the need to combine different sources and the sensitive nature of in situ data, GEO is in the best position to provide an independent perspective in the role of a trusted broker. Thus, when different sources need to be combined, GEOSS will act as a *neutral, trusted platform* to support its Member States and Participating Organisations.

4 Building a Results-Oriented GEOSS

The current design of the GEOSS Portal assumes that users need to find out what kinds of Earth observation data are available, where they can get these data, and what are the associated intellectual property licenses. *This has changed*. Although data and services discovery facilities are still required for many GEO Member states and Participating Organizations, many GEO members are already developing cloud technologies which provide analysis-ready data going beyond the capabilities of the GEOSS platform. Community-based initiatives such as Open Data Cube, coupled with private-sector services such as Copernicus DIAS, Google Earth Engine, and Earth on AWS, are enabling the GEO community to use data in ways not possible before. *Most users no longer need to find satellite data*. The next generation of data providers allows users to interact with analysis-ready data deriving from multiple sensors directly in their cloud services. *Since GEO should focus on what works for our community, GEOSS needs a new design*.

The results-oriented approach will be particularly relevant to GEO Flagships and Initiatives. Much progress on the Flagships and Initiatives will result from finding a trusted and consistent set of methods that can be applied to the big data sets openly available. *Results must be policy-relevant along the three main engagement priorities of GEO*. These applications need to be carried out by Member States, with support from the GEO community.

Consider the Global Forest Monitoring Initiative (GFOI). In its initial phase, researchers were invited to showcase their work. These use cases were typically studies about forest areas in the developing world, carried out by researchers

from developed nations. For example, the University of Wageningen in the Netherlands carried out a series of case studies in small areas in Brazil under the GFOI umbrella without the involvement of Brazilian institutions. This way of working was acceptable in early phases of the program, but brought limited benefits. These case studies did not allow the production of country reports to UNFCCC or Sustainable Development Goal (SDG) indicators. In a results-oriented approach, involvement of the concerned Member state is mandatory. Instead of having a large number of small-sized case studies, the GFOI Flagship needs to build country-relevant results. Instead of answering the question "*what data does forest monitoring need?*", GEO needs to respond to the demand: "*what are the components of a successful forest monitoring application for GEO Member States and how can GEOSS organize the knowledge required to build it?*".

GEO and its collaborators should consider how knowledge about Earth observation is disseminated. This issue is best framed from the perspective of *reproducibility*. All successful EO applications have different components: satellite data, in-situ observations, good quality methods and algorithms, and efficient deployment strategies. We need to be able to organize GEOSS to make sure that these components are visible and accessible, and that others can reproduce relevant work. Doing this, we will capture a significant portion of the knowledge embedded in each application. In so doing, *we will transform the GEOSS Platform from a discovery and access facility to a knowledge hub*.

5 Implementing the Strategy

An important concern is ensuring that the spirit of cooperation which unites the GEO community is enhanced, as the new strategy gets implemented. There are many worthy initiatives that are currently being carried out and that are part of the GEO Work Programme. These activities need to have the continued attention and support of the GEO Secretariat and governance.

Implementing the proposed strategy will require technical decisions on the evolution of the GEOSS Platform. Under the scientific leadership of the Secretariat Director, the Secretariat and the Programme Board will work to reach a consensual view on the required actions. These actions will consider the proposals of the *GEOSSEvolve* Initiative, as well as the technical consensus to be reached in the “Plan for Action”, as described below. The overall aim is that future implementations of the GEOSS Platform will be able to support a results-oriented GEO.

6 Terms of Reference for the Expert Advisory Group

6.1 The Plan for Action

The purpose of the Expert Advisory Group (EAG) is to provide relevant and timely advice with respect to cutting-edge science and technology required for a results-oriented GEOSS that will enable GEO to support its engagement priorities and other global policy conventions and initiatives. The EAG will take, as its starting point, the Plan for Action which has been approved by the GEO Executive Committee in its 44th Session in July 2018. The following questions will be addressed:

1. How best to evolve the GEOSS Platform into a knowledge hub?
2. How can the GEOSS Platform evolve so that the community can use the existing and upcoming analysis-ready data sets?
3. How can the GEOSS Platform bridge across the different public, community-based, and private data providers?
4. How will the future GEOSS Platform interact with the proposed regional GEOSS initiatives?
5. How can GEO support community-based initiatives of sharing infrastructures for processing big EO data, such as Open Data Cube and the proposed African Data Cube?
6. How can GEO best interact with private data providers, such as Copernicus DIAS, Amazon Web Service (AWS), and Google Earth Engine, to help users make the most of them?
7. What are the most promising innovative scientific results produced by the Earth observation research community and how can they be made available to GEO?
8. What are the best practices of EO applications that should be highlighted in the GEOSS Platform, so that they follow the FAIR principles?
9. How can GEO and the GEOSS Platform facilitate access to in-situ observations and analysis methods that are used in cutting-edge and best practice applications?
10. How can development of the GEOSS Platform into a knowledge hub can be made in connection with existing structures?
11. How can these initiatives be financed?

6.2 Deliverables

The principal deliverable of the EAG will be a document outlining a strategy for implementation of the strategy for a results-oriented GEOSS (as per 44th Executive Committee Document 44.6). This document will be discussed by the GEO Executive Committee (EXCOM) during its 47th Session in March 2019. The final version will be submitted for decision of the 48th Session of EXCOM in July 2019. If approved by EXCOM, the GEO Secretariat will work with GEO Programme Board to include the activities required to implement the approved strategy in the GEO Work Programme 2020-2022. The full contents of the Work Programme 2020-2022, which will include these activities will then be submitted for approval to 2019 GEO Plenary.

The timeline for the delivery of the strategy document is setup below.

Task	Expected Completion Date
Initial meeting of expert group	6-7 Sept 2018
First version of Strategy for a Results-Oriented GEOSS to be presented to EXCOM-45 and GEO-XV Plenary for discussion	October 2018
Comments to be received from GEO community	December 31 2018
Second meeting of expert group	Late January 2019
Second version of Strategy presented to EXCOM for discussion	March 2019
Presentation at GEO Symposium and third meeting of expert group	May 2019
Third version of Strategy presented to EXCOM for decision	July 2019
Integration of required activities required in the GEO Work Programme	September 2019
Proposed Strategy presented to GEO Plenary for approval	October 2019

6.3 Composition of the Expert Advisory Group

The composition of the Expert Advisory Group is presented on Annex A.

6.4 Agenda for the first Expert Advisory Group meeting

The first meeting of the EAG took place in Geneva, on 6/7 September 2018. The agenda for the meeting is presented in Annex B.

6.5 Steps forward

For the next meeting of the Expert Advisory Group, two activities are planned. Members of the EAG have offered to develop prototypes to illustrate components of the new GEOSS. The following prototypes and solutions will be demonstrated and discussed in the next EAG meeting:

1. Knowledge generation, knowledge driven and targeted search for SDGs, interaction with datacubes and analysis Ready Data: Joost van Bemmelen (ESA);
2. Executable papers for knowledge sharing and reproducibility: Lubia Vinhas (INPE);
3. Open Earth observation solutions for consistent access to Earth datacubes: Edzer Pebesma (Univ Münster);
4. Cloud computing for weather, climate and oceans: Baudouin Raoult (ECMWF);
5. Integrated global platform for integrated water prediction including floods and droughts, based on GEOGLOWS initiative: Marie-Françoise Voidrot (OGC) and Nuno Catarino (DEIMOS);
6. Strategies for in-situ data storage, management and visualization: the GEO Secretariat is discussing with possible partners to develop this prototype.

In the next EAG meeting, the group will be inviting presentation from relevant GEO initiatives and flagships to express their requirements and needs for the new GEOSS. Activities to be invited for presentation include: GEOGLAM, GEOBON, GOS4M, and GEOGLOWS.

7 Final Remarks

The recent advances in the technologies for storage, analysis, and access to geospatial data have been remarkable. Arguably, there has been more change in the last five years than in the previous 45 years of Earth observation. The GEO community is well aware of the need to use these new technologies for their benefit. The challenge is especially relevant for middle and low income countries.

In a positive scenario, scientists and institutions from these countries could avoid the investments in costly IT infrastructure and concentrate their resources in building their capabilities to use cloud computing services. To support its Member States to achieve such a favorable outcome, GEO needs to change to meet their needs.

There has been widespread support by the GEO community for the initiative of design a new GEOSS. There is a sense that the work of the Expert Advisory Group, combined with later actions by the GEO Executive Committee, the GEO Program Board, and the GEO Secretariat, will lead to a strategy that can implement a new version of GEOSS that meets the needs of our community. All those involved hope that the work of the Expert Advisory Group will prove to be a major support for a results-oriented GEOSS.

ANNEX A

COMPOSITION OF EXPERT ADVISORY GROUP ON THE DESIGN OF A RESULTS-ORIENTED GEOSS

Name	Affiliation
Ariane de Bremmond	Global Land Programme
	University of Bern
Carolin Richter	Global Climate Observing System (GCOS), WMO
	Director
Jessica Espey	UN Sustainable Develop Solutions Network
	TReNDS Project Director
Lubia Vinhas	National Institute for Space Research (INPE), Brazil
	Associate Director for Earth Observation
Marie-Françoise Voidrot	Open Geospatial Consortium
	Innovation Programme, Europe Director
Yana Gevorgyan	National Oceanic and Atmospheric Administration, USA
	Senior International Relations Specialist
Baudouin Raoult	European Centre for Medium-Range Weather Forecasts
	Principal Software Strategist
Christopher Justice	Chair, Dept of Geographical Sciences
	University of Maryland. USA
Edzer Pebesma	University of Münster, Germany
	Institute for Geoinformatics, Co-director
Fernando Ramos	National Institute for Space Research (INPE), Brazil
	Senior Researcher, Lab of Applied Computing
Geoff Sawyer	European Association of Remote Sensing

	Companies (EARSC)
	Secretary General
Guido Schmidt-Traub	UN Sustainable Development Solutions Network
	Executive Director
Gu Xingfa	Institute of Remote Sensing and Digital Earth, CAS, China
	Executive Director General
Imraan Saloojee	South African National Space Agency (SANSA)
	Stakeholder and Business Development Head
Ivan DeLoach	Federal Geospatial Data Committee, USA
	Executive Director
Ivan Petiteville	European Space Agency (ESA)
	ESA Centre for Earth Observation (ESRIN)
Joost van Bemmelen	European Space Agency (ESA)
	ESA Centre for Earth Observation (ESRIN)
Junji Inoue	Executive Management Director
	Remote Sensing Technology Center (RESTEC), JAPAN
Matthew Hansen	University of Maryland, USA
	Global Land Analysis and Discovery Group, co-director
Michael Obersteiner	International Institute for Applied System Analysis (IIASA)
	Head, Ecosystems Services and Management
Mikko Strahlendorff	Finnish Meteorological Institute
	Space Adviser
Noel Gorelick	Google Switzerland
	Software Engineer, Google Earth Engine
Nuno Catarino	Deimos Engenharia, Portugal
	Payload Data Ground Segment Division, Head

Osamu Ochiai	Associate Senior Administrator
	Japan Aerospace Exploration Agency (JAXA)
Paolo Mazetti	Consiglio Nationale di Recherche (CNR), Italy
	Istituto Sull'Inquinamento Atmosferico (IIA)
Patrick Hostert	Geography Department
	Humboldt University Berlin, Germany
Pedro Gonçalves	TerraDue CTL, Italy
	Founder and CTO
Pierre Defourny	Université Catholique de Louvain, Belgium
	Earth and Life Institute
Stefano Nativi	Digital Economy Unit, Big Data Lead Scientist
	Joint Research Centre, European Comission
Steven Brumby	Descartes Labs, USA
	Chief Science Advisor
Wolfgang Wagner	Technische Universität Wien, Austria

ANNEX B

Agenda for Expert Advisory Group Meeting

Geneva, 6/7 September 2018

In the first day, the meeting will start with a presentation of the terms of reference for the EAG. Then, it will consider how GEO and GEOSS should be organized to meet the engagement priorities of GEO (Paris, Sendai, SDGs). Then the EAG will discuss the state of the art on the different components of a proposed GEO (algorithms, in-situ data, and cloud computing for Earth observation).

In the morning of the second day, the EAG will be divided in four subgroups. Each subgroup will discuss in detail the challenges and ways forward on four topics: (a) knowledge production and organization; (b) in-situ data management; (c) reproducible algorithms; (d) cloud computing for Earth observations. The groups will then present their results for discussion.

On the afternoon of the second day, the EAG will consider the technical, organizational and financial challenges on the design of the new GEOSS, and will also agree on ways forward and on possible prototyping efforts to test and validate ideas for to support an informed discussion on the future meetings of the EAG.

Thursday, 6 September

Time	Topic	Presenters
9:00	Tour de table	all
9:20	Current state of GEOSS	Stefano Nativi (JRC) Joost van Bemmelen (ESA)
9:40	Terms of reference for EAG	Gilberto Câmara (GEOSEC)
10:30	Coffee break	
11:00	EO for Paris: Requirements	Caroline Richter (GCOS) André Obregon (GEOSEC)
12:00	EO for Sendai: Requirements	James Norris (GEOSEC)
13:00	Lunch (catered in)	
14:00	EO for SDGs: Requirements	Jessica Espey (UNSDSN)
15:00	State of the art: co-production of interdisciplinary research for EO applications	Michael Obersteiner (IIASA) Fernando Ramos (INPE)
16:00	Coffee break	
16:30	State of the art: cloud computing for EO	Noel Gorelick (Google) Baudouin Raoult (ECMWF)

Friday, 7 September

Time	Topic	
9:00	State of the art: reproducible, robust algorithms for Earth observation analytics	Edzer Pebesma (IFGI) Matt Hansen (GLAD/UMd)
10:00	State of the art: in-situ data for EO	Doug Cripe (GEOSEC)
11:00	Coffee Break	
11:30	Break-out groups:	
	(a) Knowledge production and organisation	Michael Obersteiner (chair) Craig Larlee (rapporteur)
	(b) in-situ data	Yana Gevorgyan (chair) Doug Cripe (rapporteur)
	(c) reproducible algorithms	Lubia Vinhas (chair) M-Françoise Voidrot (rapporteur)
	(d) cloud computing for Earth observations	Wolfgang Wagner (chair) Mikko Strahlendorf (rapporteur)
12:30	Lunch (WMO restaurant)	
14:00	Continuation of WG	
15:00	Presentation of WG reports and discussion	Chairs/ rapporteurs
16:00	Coffee Break	
16:30	Design of the new GEOSS: ways forward, prototyping efforts, action items	Gilberto Camara

QUESTIONS FOR GROUP (A) - Knowledge production and organization

1. How could the GEO activities be organized so as to improve the co-design and co-production of knowledge relevant to GEO Priorities (Paris, Sendai, SDG)?
2. What kind of projects favour the co-design and co-production of knowledge?
3. How can knowledge be shared?
4. What kind of resources should be made available in GEOSS would better support Member States to produce knowledge in response to their international commitments?
5. What kinds of resources should be made available in GEOSS to support knowledge sharing?

QUESTIONS FOR GROUP (B) - In-situ data

1. Can GEO become one of the reference data repositories for in-situ data in support of Member States and POs response to GEO Priorities (Paris, Sendai, SDG)?
2. Can GEO become one of the agencies that supports UN agencies in their mandates?
3. What are the challenges to be addressed for GEO to be an in-situ reference data repository?
4. What other roles can GEO play in supporting in-situ data coordination?

QUESTIONS FOR GROUP (C) - Reproducible algorithms

1. What are possible ways of building reproducible science in Earth observation? What is the criteria we should consider for reproducible Science?
2. How to increase the robustness of EO data analytics? What are the criteria to be applied?
3. How can GEO and GEOSS help to support and promote the use of robust and reproducible methods? In particular, how and where to share in-situ data, space data, algorithms and papers/reports?

QUESTIONS FOR GROUP (D) - Cloud computing for Earth observations

1. How could the GEO activities be organized so as to best use cloud computing services by support production of knowledge relevant to GEO Priorities (Paris, Sendai, SDG)?
2. How can we build on cloud computing to produce reproducible knowledge?
3. How can GEO and GEOSS help cloud computing users? In particular, how and where to share in-situ data, algorithms and papers/reports?
4. How can GEO build partnerships with could computing services to make them be aware of the needs of Member States and POs to respond to international agreeements?
5. Can GEOSS be a place where users could access the different cloud providers, based on a unique API similar to the ideas being developed by the openEO project?