GROUP ON
EARTH OBSERVATIONS

GEOSS Components

This Document is submitted to the GEO-XIII Plenary for information.

GEOSS Components
Opportunities to Help

OVERVIEW

A central part of GEO's mission is to build the Global Earth Observation System of Systems (GEOSS). GEOSS is a set of coordinated, independent Earth observation, information and processing systems that interact and provide access to diverse information for a broad range of users in both public and private sectors. GEOSS links these systems to strengthen the monitoring of the state of the Earth. It facilitates the sharing of environmental data and information collected from the large array of observing systems contributed by countries and organizations within GEO. Further, GEOSS ensures that these data are accessible, of identified quality and provenance, and interoperable to support the development of tools and the delivery of information services.

Thus, GEOSS increases our understanding of Earth processes and enhances predictive capabilities that underpin sound decision-making: it provides access to data, information and knowledge to a wide variety of users. This 'system of systems', through its GEOSS Common Infrastructure (GCI) and GEONETCast, proactively links together existing and planned observing systems around the world and supports the need for the development of new systems where gaps currently exist.

In order for GEO Members and Participating Organizations to better understand where there are gaps, help close the gaps, and ensure a robust GEOSS implementation, a brief status, challenges and opportunities to help will be described for the following four essential elements comprise of GEOSS implementation:

1. Building the space segment of GEOSS;
2. Building the *in situ* segment of GEOSS;
3. Advancing GEO Data Sharing Principles;
4. Contributing to the GEOSS Common Infrastructure (GCI); and
5. GEOSS Knowledge Base Development.

1. Building the Space Segment of GEOSS

Comprehensive Observation of the Earth from Global to Local Scales

1 OVERVIEW

Earth observation satellites have been described as the single richest and most important source of information available about the Earth system and its environment.

Data from Earth observation satellites offers unique value. Satellites orbiting the Earth have a unique vantage point for routine observation of the land, oceans, atmosphere, and sub-surface. They are able to take many different measurements over very large areas, regularly, and over long periods of time, day and night and in all weather conditions.

Data from Earth observation satellites also provides the necessary regional and global context to enable other observational data to be understood. For example, a measurement of the air temperature from a single ground-based observatory tells us certain things; but its value is greatly increased when it can be interpreted in the context of global atmospheric dynamics mapped using satellites.

The costs and complexity of Earth observation satellites are significant. It has long been accepted that international cooperation is critical for comprehensive, sustained, and coordinated observations.

2 CHALLENGES

Through the international Committee on Earth Observation Satellites (CEOS) and the Coordination Group for Meteorological Satellites (CGMS), satellite Earth observation is well coordinated.

CEOS, as the ‘space arm’ of GEO, has made strong links to the GEO community at many levels. CEOS engages directly with specific initiatives to understand how existing and future assets can be optimized to meet specific user needs. CEOS also develops ‘virtual constellations’ that promote continuity of observations for a particular variable (e.g., Sea Surface Temperature) and coordinate mission development and operations across numerous space agencies. In partnership with the Global Climate Observing System (GCOS) and thereby with the United Nations Framework Convention on Climate Change (UNFCCC), CEOS and CGMS are managing a systematic response to the provision of Essential Climate Variables (ECVs). CEOS is also starting to implement cross-cutting ‘thematic’ observing strategies, such as the CEOS strategies for carbon and water observations.

Despite this significant progress, however, challenges remain in ensuring that users have the information derived from satellite data they need, and in ensuring that data plays as full a role as possible in supporting the vision of GEO.

Satellites have a finite life, new user needs emerge, and technologies change. Dealing with these broader challenges does not just require coordination, it ultimately requires investment. Justifying that investment requires:

- Validated and prioritized understanding of the long-term observational requirements;
- Evidence that the data is being used and delivering benefit ‘in the real world’; and
- Strong voices from key parts of the community saying ‘we need this’.

Other challenges exist in ensuring the data that is collected delivers maximum benefit. Key areas where further attention is needed include:

- Crafting initiatives that key stakeholders, like development banks, non-governmental organizations and UN institutions, see as sufficiently ‘concrete’ to engage in and support;

- Proactively building the end-to-end partnerships that ensure users, providers, and other key stakeholders are all involved in defining problems, mobilizing resources, and delivering solutions. An approach predicated on 'first we build the GEOSS, then it gets used' will not work;
- Ensuring the required in-situ observations are captured and made available. Most real world applications benefit when satellite and in-situ observations are integrated. Particularly in the terrestrial domain, there is a lack of coordination of in-situ observation;
- Understanding the role that commercial satellite imagery can play in the future of GEO, and how the complementarity with government satellite programmes can be exploited (see next session); and
- Accelerating efforts to ensure users can reliably 'mash up' data from multiple missions in a way that: enhances the quality of their products; supports reliable large-scale time-series analyses; and mitigates the risks associated with dependence on a specific mission/sensor.

In some domains (such as moderate resolution land imaging) the data availability landscape has shifted significantly. The availability of global scale free and open data is increasing rapidly, and the challenges are increasingly in ensuring the data is available in forms that make it easy for users to exploit it. These challenges affect all users, but are particularly acute for less developed countries.

These challenges make it critical that next generation data architectures are exploited. Technologies likes cloud computing, and improvements in data correction techniques, have great potential to make satellite data more usable. New approaches may also help ensure satellite data can be better integrated with in-situ and socio-economic/statistical data to derive reliable and high quality information. Obstacles to data access and application need to be removed for satellite Earth observations to realise their full potential in an information-rich world.

In addition to these more general challenges, and despite best efforts in space agency coordination, there are still gaps foreseen in the space segment. For example, a recent CEOS study on how to respond to the GEO Water Strategy has flagged potential gaps. Passive microwave for measurement of sea surface temperature at high latitudes is also an area space agencies are watching closely.

3 HOW TO HELP:

- Providing input to the critical User Needs foundational task, which seeks to define observational requirements. This work will guide space agency efforts to provide the observations users need;
- Generating evidence of the value of satellite Earth observations (alone and in combination with other data sources), sharing it, and communicating it;
- Where possible, sharing results and techniques so that others can benefit. Open code and algorithms are highly desirable, and help accelerate progress in the broader community; and
- Engaging with efforts to exploit next generation data products and architectures, and encouraging investment in the infrastructure required to fully utilize them.

It is important that we keep thinking about how to leverage the efforts of specific initiatives to 'build GEOSS', as this means that what we do now can make it easier to do new things in the future.

However, we need to emphasize that our priority is organizing our efforts and communications around how we, through the convening power of GEO, are connecting people together to solve real world challenges that are important to people today. Frameworks like the Global Goals for Sustainable Development, Sendai Framework for Disaster Risk Reduction, and the Paris Climate Agreement have great potential to help us make this shift.

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2. Building the *In Situ* Segment of GEOSS

1 OVERVIEW

Earth observations from diverse sources, including satellite, airborne, *in situ* platforms, and in some cases citizen observatories, when integrated together, provide powerful tools for understanding the past and present conditions of Earth systems, as well as the interplay between them. GEO is a facilitator of policy-level dialogue on the importance and coordination of Earth observation systems (including ground-, air-, water- and space-, airborne- and ground-based sensors). Systems for *in situ* observations (i.e. all ground, water- and airborne observations excluding space-borne observations) are diverse and there is no single global group responsible for their overall coordination. As one of the key findings the GEO Evaluation Report for the first GEO decade recommended the "*Creation of a high-level task force to promote the incorporation of in-situ data into GEOSS.*" Subsequently, the GEO Strategic Plan 2016-2025: Implementing GEOSS underlined the importance of coordination and improvement of *in situ* observation networks. Based on the guidance and recommendations, the GEO *In Situ* Task "GEOSS *In Situ* Earth Observation Resources" was defined in the GEO 2016 Work Programme.

2 CHALLENGES

Cordination of *in situ* Earth observations is not an easy task. Even a simple survey of *In Situ* coordination groups leads to a large, incomplete and very complex system. As an initial activity, the Task Team decided to publish a report in 2016 on the status of global *in situ* observation networks and existing frameworks for their coordination. The report includes options for new *in situ* measurements and coordination scenarios. The Task began with great interest and motivation by a few GEO Members and Participating Organizations and is expected to raise more awareness of the important activity and therefore seek more participants and ideas to contribute to the Task towards 2017 and beyond. The list of the current Task members includes: European Commission (Lead), France, Germany, Spain, EEA, GCOS, GGOS, GOOS, I-BEC, IEEE, and WMO.

3 HOW TO HELP

- In 2016, the Task Team developed a report on "In Situ Observations: Coordination Needs and Benefits". GEO Members and Participating Organizations are encouraged to read it and provide any suggestions and comments in particular on the recommendations;
- It is necessary, however, to work on more specific areas where gaps exist. For example, there is no comprehensive coordination mechanism for terrestrial *in situ* observation networks at this point. GEO could serve as a coordinating mechanism and platform to fill the gap;
- It is also necessary to promote the integration of *in situ* observations with space based observations, and use GEO's convening power to facilitate, link, optimize, and integrate different observation networks;
- *In situ* observation communities include global, regional and national scales, domain specific, and research and operational operations. It is expected that more members will join the Task team representing diverse networks and partially existing coordination mechanisms; and
- Implementation of a global coordination mechanism or framework will require time and effort. A constant dialog with key organizations/stakeholders involved in operating the *in-*

situ observing system at both global and regional scales is required. A specific action may be required in some regions of the world where key players' organizations are not yet well identified. In this overall coordination process, it is important to strive for sustainable solutions, avoid duplication of effort, and rely upon organizations established in the long-term to drive the activities.

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3. Advancing GEOSS Data Sharing Principles

1 OVERVIEW

Data Sharing is a pre-requisite for building an effective Global Earth Observation System of Systems. It is the backbone of the abiding GEO vision “a future wherein decisions and actions for the benefit of humankind are informed by coordinated, comprehensive and sustained Earth observations and information.”

Ever since its inception, GEO has been a strong advocate for broad and open data-sharing policies and practices. The Data Sharing Principles (2005-2015) inspired a few Members and Participating Organizations to evolve from restricted data policies to Open Data approaches. Data sharing was also recognized as one of the greatest successes of the first GEO decade.

Embracing the international trend of Open Data[1], GEO Principals endorsed a new set of Data Sharing Principles, which promote ‘Open Data by Default’, in Mexico City at the dawn of the second decade of GEO (2016-2025). Full implementation of the revised GEOSS Data Sharing Principles continues as an essential step towards maximizing the net societal and economic benefits of the global investment by GEO Members and Participating Organizations in building GEOSS.

2 CHALLENGES

Despite broad recognition and acceptance of the GEOSS Data Sharing Principles, still less than 50 percent of GEO Member governments have established national Open Data regulations/policies to enable agencies to share Earth observation datasets nationally, regionally and internationally.

Various data providers still have the perception that the implementation of the Open Data policy could pose challenges to their development, resulting in limited revenue, in particular as payments for reuse are not consistent with the Principle ‘at no more than the cost of reproduction and distribution’. Many providers cannot see a clear articulation of a new business model linked to the adoption of Data Sharing Principles.

Another challenge is life-cycle data management. Even with a legal framework and social willingness to share data, lack of knowledge about data management schemes and tools leads to unusable or unsustainable datasets from which decision-makers cannot benefit.

3 SUPPORTING RESOURCES:

- The Value of Open Data Sharing: collects evidences for the participants in GEO to adopt the revised GEOSS Data Sharing Principles. More particularly, it identifies and illustrates the economic, societal and educational benefits of Open Data, as well as the value Open Data brings to research, innovation and governance;
- Legal Mechanisms to Share Data as Part of GEOSS Data-CORE: recommends voluntary waivers or standard common-use licenses that enable data providers to share data as part of the GEOSS Data-CORE;
- Interpretation of the “full and open” access to and use of (geographic) data: existing approaches: compares existing data regulations/policies and maps their accordance with Data Sharing Principles;

[1] This international Open Data Trend includes: G8 Open Data Charter by the G8 leaders in July 2013; UN Data Revolution Report: A World that Counts in August 2014; and International Open Data Charter in 2015.

- Draft Data Sharing Principles Implementation Guidelines (2016-2025): Interprets key expressions of revised Data Sharing Principles, and provides guidance for governments, organizations and data managers;
- Draft Data Management Principles Implementation Guidelines: Explains the Data Management Principles, guidance on implementation (with examples) and metrics to measure level of adherence to the Principles.

4 HOW TO HELP

- Develop national or organizational data policies that are in accordance with the GEOSS Data Sharing Principles;
- Explore and enable business model changes for data generation in the public sector; Raise awareness of the technical, organizational, and resource implications of implementing the GEOSS Data Sharing Principles;
- Maximize the number of datasets as Open Data, making them discoverable, accessible and usable and take into account long-term preservation and curation;
- Exert leadership to establish necessary coordinating mechanisms to implement the GEOSS Data Sharing Principles, monitor data sharing progress and provide feedback to GEO. **Countries that have not responded to the Request to Establish National Contact Points for Data Sharing within GEO Member Governments, circulated by GEO Secretariat in August 2016, are requested to provide a nomination; and**
- Promote the benefits of open data sharing within territories or organizations. **Share with the entire GEO community your best practices or lessons learned about transition from restricted data policies to Open Data policies**.

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4. The GEOSS Common Infrastructure (GCI)

1 OVERVIEW

The GEOSS Common Infrastructure (GCI) proactively links together existing and planned observing systems around the world and supports the need for the development of new systems where gaps currently exist. It promotes common technical standards so that data from the thousands of different instruments can be combined into coherent data sets.

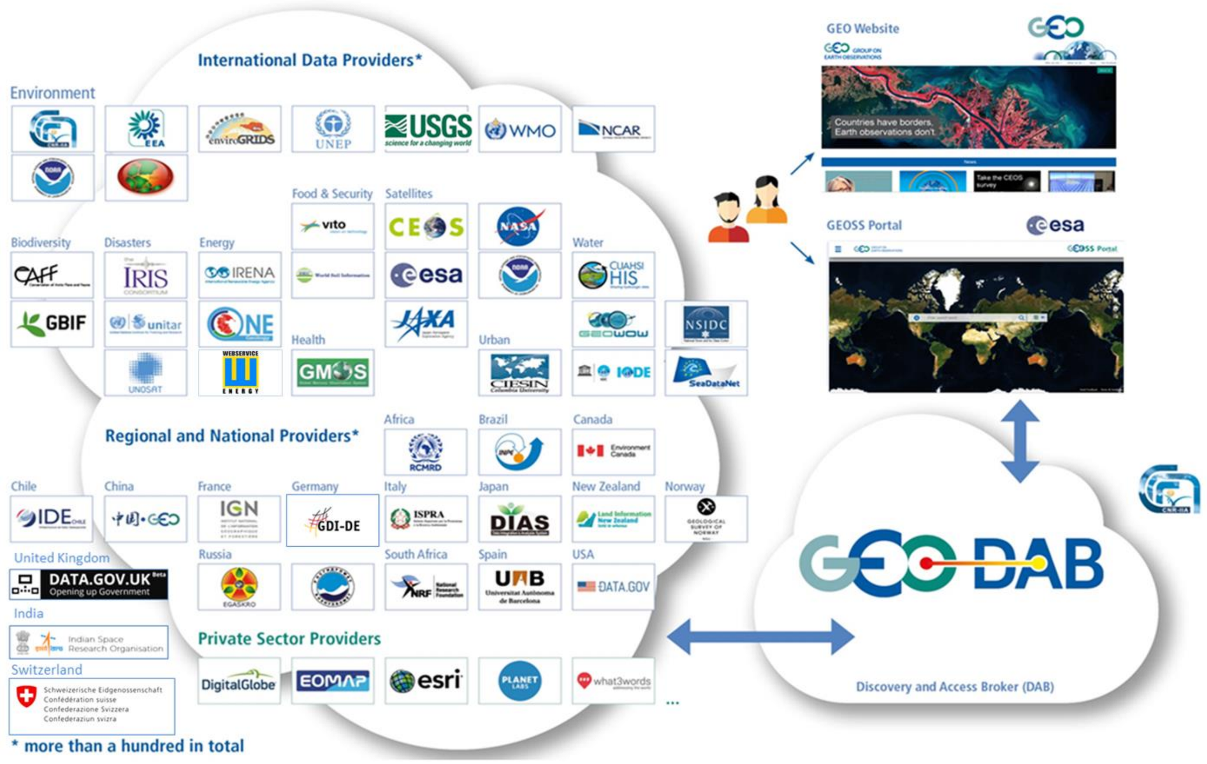
GCI is a brokering infrastructure. This means that through the GEO Discovery and Access broker (GEO DAB) it can connect existing Earth observing systems and data infrastructures without either Data Providers or Users needing to make any change to their technology or standards.

The ‘GEOSS Portal’ offers a single Internet access point for users seeking data, imagery and analytical software packages relevant to all parts of the globe. It connects users to existing data bases and portals and provides reliable, up-to-date and user friendly information – vital for the work of decision makers, planners and emergency managers. For users with limited or no access to the Internet, there are plans to make this information available via ‘GEONETCast’.

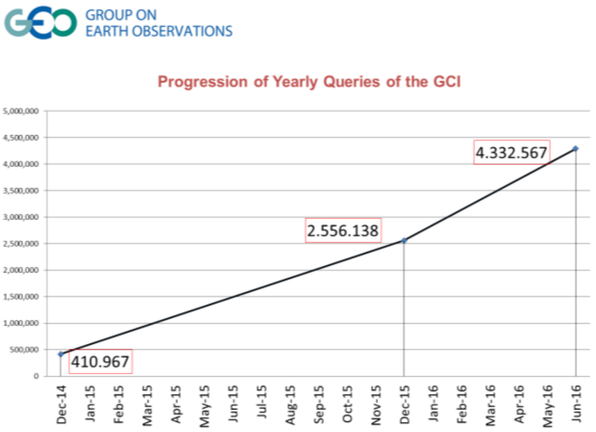
GCI implementation and future developments aligning with user needs can follow the GCI User Requirement Document that constitutes the foundation reference, available at: http://www.earthobservations.org/geoss.php

Presently the GCI brokers more than 140 autonomous data catalogs and information systems.

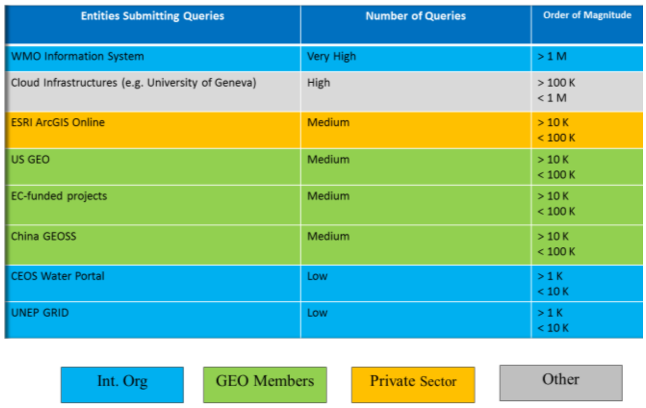
Data providers are constantly and incrementally brokered, paying attention to the needs of the users; thematic and geographic balance of the data; and resources shared.



The GCI has seen a major increase in the machine-to-machine queries of its resources. In fact, the growth has been exponential since 2014. Below is an overview of the number of yearly queries and main users.



Number of yearly queries (machine-to-machine)



GEOSS Main users

Entities Submitting Queries	Number of Queries	Order of Magnitude
WMO Information System	Very High	> 1 M
Cloud Infrastructures (e.g. University of Geneva)	High	> 100 K < 1 M
ESRI ArcGIS Online	Medium	> 10 K < 100 K
US GEO	Medium	> 10 K < 100 K
EC-funded projects	Medium	> 10 K < 100 K
China GEOSS	Medium	> 10 K < 100 K
CEOS Water Portal	Low	> 1 K < 10 K
UNEP GRID	Low	> 1 K < 10 K

Main users (machine-to-machine)

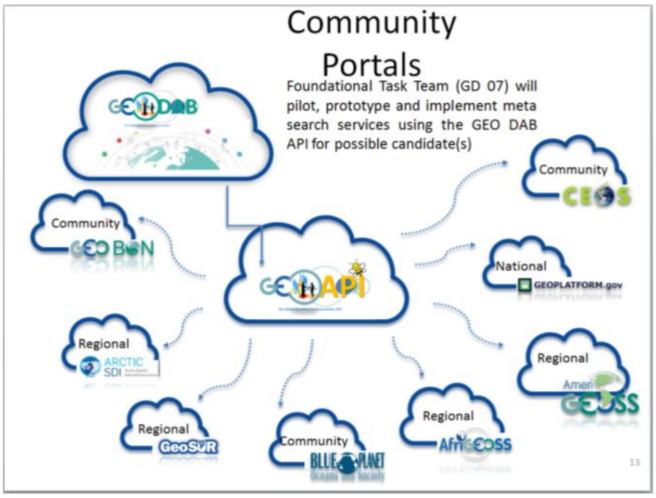
(June 2016)

Source: http://statistics.geodab.eu/gi-stat/stats/

Discovery, Accessibility and Usability are essential Data Management Principles that are being given a high degree of attention in the short term, thereby providing a higher quality experience to users for discovering, accessing and using resources within the GCI for their individual applications.

Through the use of GEO DAB Application Program Interfaces (APIs) more thematic or geographic based community portals will be established to leverage GCI resources; examples of those that have already been implemented are: AmeriGEOSS and Geo Cradle as illustrated below.

To facilitate the access to thematic sets of resources (e.g. agriculture related datasets), thematic views of the GCI resources will also be provided, in the framework of the main Portal.



Example of the Community Portals evolution

Examples of the Regional Community Portals: AmeriGEOSS and GEO CRADLE

2 CHALLENGES

- The GCI should move within the next three years to become an evident user oriented infrastructure with clear examples of the applications and benefits of having such an infrastructure from the User community;
- Lack of resources to ensure the operations and research and development of several GCI components (such as GEOSS Portal and GEO Discovery and Access Broker) over the next three to five years is one of the main challenges;
- Constant human engagement with data providers to ensure quality of good metadata, and implementation of the data management principles, discoverability, accessibility and usability of data shared;
- Attention over the next period will be given to provide visibility for data providers;
- Sustainability of efforts to maintain the GEOSS Portal in an Open source environment; and
- A GEO User Conference will be planned by 2019 to showcase the applications built by User communities leveraging the GCI/GEOSS Resources.

3 HOW TO HELP

- The current estimation of the in-kind contributions is not sufficient to ensure the GCI Operations for the next three Years.
- We need to secure a total amount of 600 K for the next three years (200,000 per year) in cash contributions.
- We propose to create a dedicated line into the GEO Trust Fund to which the Members and Participating Organizations are urgently requested to contribute.

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5. GEOSS Knowledge Base Development

1 OVERVIEW

The development of "a comprehensive interdisciplinary knowledge base defining and documenting observations needed for all disciplines" is central to the goal of GEOSS being user-driven. The knowledge base will document the results of the user needs and gap analysis process and will not only inform about the data needed to meet the observational requirements but also facilitate the sharing of knowledge on how these data can be used to address key policy or scientific question, and also enable linking communities of users addressing similar problems. The knowledge base will document the relations between the data and the processes (models, work-flows, algorithms) needed to develop the indicators, information, and knowledge needed by the users.

The functionality of the knowledge base will also support the GEOSS Common Infrastructure in facilitating availability and accessibility of the observations to user communities. The knowledge base will include the rules for linking the user needs to observational requirements, addressing a wide range of environmental and socio-economic information needs. Of particular interest are those information needs that are linked to indicators supporting the advocacy and monitoring of the Sustainable Development Goals (SDGs) and policy development supporting implementation of the SDGs. The knowledge base will include rules to define the observation needs for these indicators.

The GEOSS Knowledge Base will be developed by leveraging existing knowledge repositories and databases and documenting what is being developed in association with GEO activities. It will include the functionality of user feedback with respect to the fitness for purpose of both data and processes.

2 CHALLENGES

This knowledge base can only be developed and populated with broad participation of the GEO community and, if this is successful, the knowledge base will be a core element of the GEOSS. The main challenge for the Task is currently the engagement of a broader GEO community in the design of the knowledge base and the testing, validation and population of the tool.

The list of the current Task members includes: Co-Leads: IEEE and Italy; Members: ConnectinGEO Project Team.

3 HOW TO HELP

Actions that GEO Members and Participating Organizations can take:

- The current Task Team does not have sufficient global and cross-domain representation. GEO Members and Participating Organizations are asked to consider joining the Task Team both with the intent to contribute to the development and the population of the knowledge base, and to participate in its evaluation and validation;
- In 2016, the Task Team with support from the Horizon 2020 ConnectinGEO project developed the data model and overall functional design of the knowledge base with the report being available before the end of 2016. GEO Members and Participating Organizations are encouraged to comment on this report when available and to provide feedback particularly concerning the functionality of the knowledge base;
- GEO Members and Participating Organizations are encouraged to provide the Task Team with information on existing databases and knowledge bases with relevant

information on user needs, particularly in the frame of their engagement in GEO activities.

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