2019 Work Programme Progress Reporting

This document is submitted to the Programme Board for discussion.

1 INTRODUCTION

This document was prepared by the Secretariat based on the information in the Implementation Plans that have been submitted to the Work Programme 2020-2022. The progress reports cover the period from 2017 to 2019 to summarize the overall progress of the 3-year Work Programme.

2 SCOPE AND CONTENT OF REPORTING

Flagships and Initiatives were asked to report on the following aspects:

- Status of implementation of planned activities and outputs for the 2017-2019 period.
- Evidence of use of the outputs of the Initiative, particularly by end users.
- Examples or evidence of outcomes and/or impacts based on use of outputs (e.g. policy decisions taken, behaviour changes by users, risks mitigated).
- Reflection on the effectiveness of the Initiative's governance structure and resourcing strategy.
- Summary of the results of any internal or external reviews or evaluations of the Initiative.
- Lessons learned from (or challenges experienced in) the previous implementation period and proposed actions for amendments or improvements.

Community Activities were only asked to provide on the first aspect listed above.

Foundational Tasks are not included in this report as they were not requested to submit Implementation Plans.

3 SUBMISSION OF REPORTS

A summary of the numbers of activities that submitted information on previous achievements in the Implementation Plans 2020-2022 is provided below in Table 1.

Table 1 - Status of GWP Activity Progress Report 2019 Submission

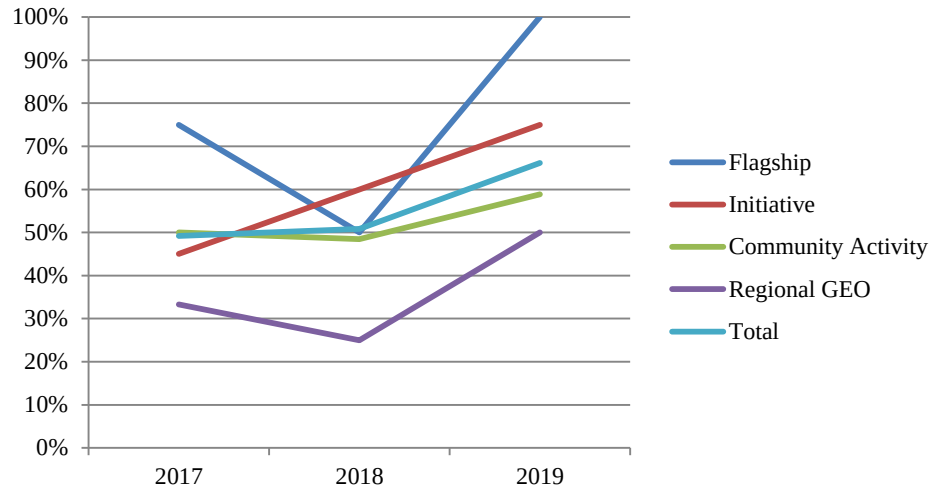
	Total	Reporting Expected	Received	Not Received	% Received of Reports expected
Flagship	4	4	4	0	100%
Initiative	21	20	15	5	75%
Community Activity	38	34	20	14	59%
Regional GEO	4	4	2	2	50%
Total	67	62	41	21	66%

A multiple-year combined reporting status is provided in Table 2.

Table 2 – 2017-2019 Combined Reporting Status					
	Total	Three Submissions	Two Submissions	One Submission	No Submission
Flagship	4	2	1	1	0
Initiative	20	4	10	5	1
Community Activity	33	8	10	6	9
Regional GEO	3	0	1	2	0
Total	60	14	22	14	10

The trend of reporting rates is plotted in Figure 1 below.

Figure 1 - Trend of Reporting Rates



Flagships and Initiatives were required to provide more details, as listed in the previous section, than Community Activities and Regional GEOs. Table 3 provides information on the various reporting rates of different content aspects.

Table 3 – Flagships and Initiatives Reporting Status by Contents 2019				
	Status of Implementation	Evidence of Use and Impact	Effectiveness of Governance and Resources	Lessons and Solutions for Improvements
Reported	19	10	4	5
Not Reported	5	14	20	19
Reporting Rate	79%	42%	17%	21%

The status of individual activity reports of 2019 as well as of 2017 and 2018 is provided in Annex A.

Reports of individual activities of 2019 are provided in Annex B.

4 OBSERVATIONS

From the statistics above and reported contents included in Annex B, several observations can be drawn:

- Comparing to 2017 and 2018, 2019 has seen higher reporting rate with an anticipation of further increase in the rate. The main driver is applying for renew of activities in GEO Work Programme 2020-2022. The interaction the GEO Secretariat did with the Initiatives and Flagships may also motivate a few activities that did not provide reports for either of 2017 and 2018.
- Most activities provided information on status of implementation, while less than half of activities gave evidences on use of products and services, with even less responses on effectiveness of governance and resourcing, and lessons learned.
- Most activities did not follow the reporting template, and did not report against the objectives, tasks and deliverables established in the Implementation Plans 2017-2019. This makes reports not as structural, traceable and comparable throughout the implementation period.
- For information that of most concern, such as users and actual use of products and services, only a few reports provided the level of details that can form a storyline.
- The activity reporting is not a sufficient source for monitoring data collection. Other information sources have to be combined.

5 RECOMMENDATIONS

- This year, the Secretariat will explore combine this report, the GEO Initiative Status Report produced earlier this year and the impact stories being collected for the GEO Report on Impact to generate more useful information on how the GEO Work Programme has achieved the objectives.
- For the term of 2020-2022, more structured templates have been provided to plan the objectives, tasks and deliverables. The PB Review Teams are recommended to pay attention to the measurability of deliverables and provide advice to proposers to strengthen the plans.
- The Secretariat will develop a database to capture the progress of Work Programme activities in a more systematic way.

ANNEX A

STATUS OF SUBMISSION OF 2019 PROGRESS REPORTS

Short Name	Full Name	IM Category	2019 Report	2018 Report	2017 Report
GEO BON	GEO Biodiversity Observation Network	Flagship	Y	N	N
GEOGLAM	GEO Global Agricultural Monitoring	Flagship	Y	Y	Y
GFOI	Global Forest Observation Initiative	Flagship	Y	N	Y
GOS4M	Global Observation System for Mercury	Flagship	Y	Y	Y
AQUAWATCH	Aquawatch	Initiative	Y	N	Y
GEO CCIOACZ	Climate Change Impact Observation on Africa's Coastal Zones	Initiative	N	N	N
GEO DARMA	Data Access for Risk Management	Initiative	N	N	Y
EO4EA	Earth Observations for Ecosystem Accounting	Initiative	Y	N	N
EO4SDG	Earth Observations in Service of the 2030 Agenda for Sustainable Development	Initiative	Y	N	N
GEO CARBON	GEO Carbon and Greenhouse Gas Initiative	Initiative	N	Y	Y
GEO CRI	GEO Cold Regions Initiative	Initiative	N	Y	Y
GSNL	GEO Geohazard Supersites and Natural Laboratories	Initiative	Y	Y	Y
GEO ECO	GEO Global Ecosystem Initiative	Initiative	N	Y	N
GEO GNOME	GEO Global Network for Observation and Information in Mountain Environments	Initiative	Y	Y	Y
GEOGLOWS	GEO Global Water Sustainability	Initiative	Y	Y	Y
HUMAN PLANET	GEO Human Planet Initiative: Spatial Modeling of Impact, Exposure and Access to Resources	Initiative	Y	Y	N
GEO LDN	GEO Land Degradation Neutrality	Initiative	ner		
GEO VENER	GEO Vision for Energy	Initiative	Y	Y	N
GEO WETLANDS	GEO Wetlands Initiative	Initiative	Y	Y	N
GEO-CRADLE	GEO-CRADLE	Initiative	Y	Y	N
GDIS	Global Drought Information System	Initiative	Y	N	N
GOS4POPS	Global Observation System for Persistent Organic Pollutants	Initiative	Y	N	Y
GUOI	Global Urban Observation and Information	Initiative	Y	N	N
GWIS	Global Wildfire Information System	Initiative	Y	Y	Y
BLUE PLANET	Oceans and Society: Blue Planet	Initiative	Y	Y	N
CLIMDATA ACCESS	Access to Climate Data in GEOSS	CA	N	N	N
COMM NETWORKS	Advancing Communications Networks	CA	Y	Y	N
AFRICA GEOCHEM	African Geochemical Baselines	CA	N	N	Y
AIRNOW	Airnow International: Expanding Networks and Integrating Methods for	CA	N	N	Y

Short Name	Full Name	IM Category	2019 Report	2018 Report	2017 Report
	Air Quality and Health Data				
Arctic GEOSS	Arctic GEOSS	CA	ner		
CTMS	Chinese Tsunami Mitigation System	CA	N	N	N
CAMS	Copernicus Atmospheric Monitoring Service	CA	Y	Y	Y
C3S	Copernicus Climate Change Service	CA	Y	Y	Y
DIAS	Data Integration and Analysis System	CA	Y	N	N
GEOMUSEUM	Digital Geomuseum	CA	N	N	N
CITIZEN SCIENCE	Earth Observations and Citizen Science	CA	Y	N	Y
GEO HERITAGE	Earth Observations for Cultural Heritage Documentation	CA	N	Y	Y
EO4DRM	Earth Observations for Disaster Risk Management	CA	N	Y	N
EO4GEOHAZ	Earth Observations for Geohazards, Land Degradation and Environmental Monitoring	CA	N	Y	Y
EO4HEALTH	Earth Observations for Health	CA	Y	Y	N
EO4MINERALS	Earth Observations for Managing Mineral Resources	CA	Y	N	Y
EO4WEF	Earth Observations for the Water-Energy-Food Nexus	CA	Y	Y	N
EARTH2OBSERVE	EartH2Observe	CA	ner	Terminated	Y
FORESTBIODIV	Forest Biodiversity in Asia and the Pacific Region: Capacity Building Phase	CA	N	N	N
G4AW	Geodata for Agriculture and Water	CA	ner		
GLOBAL AGRIDROUGHT	Global Agricultural Drought Monitoring	CA	Y	N	Y
GEOARC	Global Ecosystems and Environment Observation Analysis Report Cooperation	CA	Y	Y	Y
GLOFAS	Global Flood Awareness System	CA	Y	Y	Y
GLOBAL FLOODRISK	Global Flood Risk Monitoring	CA	Y	N	N
GFCS-GEO	Global Framework for Climate Services - GEO Collaboration	CA	N	N	N
GLOBAL MANGROVE	Global Mangrove Monitoring	CA	Y	N	N
GMEM	Global Marine Ecosystem Monitoring	CA	ner		
WHEAT PEST	Global Wheat Pest and Disease Habitat Monitoring and Risk Forecasting	CA	Y		
HARMFUL ALGAE	Harmful Algal Bloom Early Warning System	CA	N	N	N
HIMALAYAN GEOSS	Himalayan GEOSS	CA	Y	Y	N
IN-SITU WATER	In-situ Observations and Practices for the Water Cycle	CA	Y	Y	Y
RESILIENCE-IO	Integrated City-Region Systems Modelling	CA	N	Y	N
LANDCOVER	Land Cover and Land Cover Change	CA	Y	N	Y
GEO MUSYQ	Mult-Source Synergized Remote Sensing Products and Services	CA	Y	Y	Y
DATA SCIENCE SCHOOLS	Research Data Science Summer Schools	CA	N	N	N
SOCIOECO BENEFITS	Socio-Economic Benefits of Earth Observations	CA	N	N	N

Short Name	Full Name	IM Category	2019 Report	2018 Report	2017 Report
SPACE & SECURITY	Space and Security	CA	Y	Y	Y
TIGGE	Thorpex Interactive Grand Global Ensemble Evolution into a Global Interactive Forecast System	CA	Y	Y	Y
AFRIGEOSS	AfriGEOSS: Reinforcing Regional African Engagement	RG	N	N	Y
AMERIGEOSS	AmeriGEOSS	RG	Y	N	N
AOGEOSS	Asia-Oceania GEOSS	RG	Y	Y	N
EUROGEOSS	EuroGEOSS	RG	N	N	N

ner = not expected to report (due to the activity being discontinued or recently launched).

ANNEX B

2019 PROGRESS REPORTS RECEIVED AS OF 17 May 2018

1 GEO BIODIVERSITY OBSERVATION NETWORK (GEO BON)

1.1 Status of implementation for the 2017-2019 period

EBV Development

- All EBV classes are represented in a working group (achieved)
- Connection made between EBVs and EOVs (achieved)
- Pilots for EBV operationalization with national BONs (delayed but ongoing)
- Framework for the Essential Ecosystem Services Variables published (delayed but ongoing)
- One or two EBVs per class with available datasets on the EBV portal (on track)
- Recommendations for metadata standards and on line EBV catalogue (on track)

Since 2017, the structure of GEO BON is complete, with each of the 6 EBV classes (Genetic Composition, Species Populations, Species Traits, Community Composition, Ecosystem Structure and Ecosystem Functions) as well as Ecosystem Services being represented by a dedicated working group. Those groups are more specifically tasked with providing lists of EBVs for each class, later to be aggregated into a final EBV list endorsed by the network, and with the development of the EBV data products per se. Meanwhile, the GEO BON Secretariat has developed an EBV Data portal (in partnership with the University of Marburg) where the data products will be made available to the public, while allowing the calculation (on the fly) of temporal trends per countries and globally. The secretariat, together with the Data Task Force, is developing a set of metadata standards for the EBV products, as well as an online EBV catalogue, both implemented to facilitate the integration of new datasets in the portal.

BON Development

- BON in a Box Version 2 fully operational (delayed but ongoing)
- Existing and currently developing national BONs endorsed by GEO BON (achieved)
- Assessment and web mapping of existing biodiversity observatories (delayed but ongoing)
- Marine and Freshwater BONs operational (on track)
- New national, regional and thematic BONs developed or enhanced (on track)
- BON Development manual with online decision matrix available (on track)

Since 2017, two new thematic BONs have been endorsed by the network, the Freshwater BON in 2017, and the soil BON in 2018. Discussions are on-going for the establishment of BONs in the Americas, Australia, South Africa, Quebec and Switzerland. The GEO BON Secretariat (via Martin Luther University) will also start a project funded by the ERANet LAC program in 2019, to establish a BON in the Tropical Andes. In collaboration with the Instituto von Humboldt (Colombia), the BON Development WG and the Secretariat are working on version 2.0 of BON in a Box. The WG continues its work on the development of a BON development manual which will be linked to BON in a Box. Finally, GEO BON participated in the Global Audit of Biodiversity Monitoring led by the Cambridge Conservation Initiative, which will inform on gaps and priorities for future BON Development.

Policy Relevant outputs

- Brochure promoting the value of long term monitoring for decision making (delayed but ongoing)
- Establishment of a hub for communicating requirements to CEOS (on track)
- Position paper linking the IPBES conceptual framework and BONs (delayed but ongoing)

- Three Global Biodiversity Change Indicators produced and available (on track)
- IPBES Socio-ecological indicators for Ecosystem Services developed (on track)

Since 2017, GEO BON has continued its engagement with various policy bodies and was represented by official delegations in the annual IPBES Plenaries, as well as in the SBSTTA and COP meetings of the CBD. And information document on the relevant activities of the network for the parties of the CBD was prepared for SBSTTA 21 (Dec. 2017), and a side-event presenting the value of biodiversity monitoring for decision making was organized at COP 14 (Dec. 2018). On the occasion of the GEO BON All Hands meeting organized in Beijing in July 2018, participants produced the *Beijing call on biodiversity observations for post-2020 decision-making*. This document was presented at the CBD COP14 and is part of the wider strategy and contribution of GEO BON for the post 2020 biodiversity framework of the CBD that is currently being discussed. The GEO BON Policy Task Force is also working with the teams developing the Global Biodiversity Change Indicators, to ensure that the final products are communicated to the CBD parties for their reporting on the current biodiversity framework, and to a wider audience via the GEO BON portal. Meanwhile, the Task Force will continue its work on mapping the EBVs and EESVs to global targets and goals (e.g. Aichi targets, SDGs). Finally, the Remote Sensing Task Force has formally approached CEOS to discuss the requirement for biodiversity monitoring using satellite remote sensing.

1.2 Evidence of use of the outputs and their impacts

Since it was first brought up to the scientific community and to other users in 2013, the Essential Biodiversity Framework has been gaining momentum and is being used and applied more widely. On the policy side, the UN CBD recognized the value of the framework and invited GEO BON and members to continue their work on developing the EBVs (Decision XI/3 in UNEP/CBD/COP/11/35). The EBV framework is also being used in IPBES Assessments. In parallel, the number of scientific publications using the EBV concept and framework has steadily increased since 2013.

Concretely, a set of Indicators of Global Biodiversity Change, derived from EBVs, has being endorsed by both the CBD and IPBES. Some of those indicators have been also endorsed by the Biodiversity Indicator Partnership (BIP) and are being used for the Global Assessment of IPBES. The EBV framework is also used at the national scale by the French BON to document existing biodiversity observatories and infrastructure in the country. Similarly, in Finland, the EBVs were used to assess the national indicators used for reporting and the biodiversity monitoring programs underlying them.

The flexible approach for BON Development developed and promoted by the network has been used and adapted for Australia's New South Wales, Colombia, and will be applied in the Tropical Andes in the context of an ERANet-LAC funded project. GEO BON also supported the development of the China BON, which is today a remarkable example of a systematic, country-wide monitoring design with broad spatial and taxonomic extent: 441 sites are part of an observation system of over 9000 transects and point counts for birds, amphibians, mammals, butterflies, and vascular plants with the participation of volunteer citizen scientists at each site.

1.3 Effectiveness of the governance structure and resourcing strategy

The current structure of GEO BON was designed to better reflect the two pillars of the network: the development of both the EBVs and the BONs. Having all EBV classes and ecosystem services represented by dedicated WGs is meant to greatly facilitate the parallel development of the EBV lists, workflows, and data products. The BON Development WG acts as a bridge between the different WG and BONs to allow good communication on activities and outcomes between them. Giving equal weight, within the structure, to the BONs allows those groups to continue their activities semi-independently, while actively participating in the decisions making process and implementation the network. Finally, the establishment of task forces, in close collaboration with the Secretariat, allows to delegate some of the short term and urgent cross cutting activities (e.g. metadata development, policy support) to a smaller group of individuals representative of the different WGs and BONs. In terms of financial resourcing, the Secretariat tries to the best extent possible to allocate funds to organize

workshops for the different WGs, while encouraging WGs and BONs to apply for separate funding to support their activities. As an example, NASA is currently funding 8 projects[1] led by GEO BON members and targeted at both BON and EBV development.

1.4 Lessons learned and proposed actions for amendments or improvements

The next implementation phase will benefit from putting more emphasis on potential synergies between the different activities of the WGs, BONs and Task Forces and allow for more cross-cutting activities. More sources of funding will have to be found to support the work of the network, also considering the limitations (person/months and funding) of the Secretariat.

2 GEO GLOBAL AGRICULTURAL MONITORING (GEOGLAM)

2.1 Status of implementation for the 2017-2019 period

Crop Monitor for the Agricultural Market Information System (CM4AMIS) (Complete and continuing)

Published monthly reports of near real time global crop conditions for the 4 major AMIS crops in G20 and other major producing nations (http://www.amis-outlook.org/index.php?id=48514). Since September 2013, over 60 monthly CM4AMIS bulletins have been generated for inclusion in the AMIS Market Monitor.

Crop Monitor for Early Warning (CM4EW) (Complete and continuing)

Published monthly crop condition reports for food insecure nations of the world. In contrast to the CM4AMIS, the Crop Monitor for Early Warning (CM4EW) focuses on a range of 14 crops that have regional food security implications. Over 35 monthly CM4EWs have been published since 2016 (https://cropmonitor.org/).

In recent years, the early warning focus has moved to engaging national organizations in the development of national instances of the Crop Monitor bulletins. These monitors are run by mandated agencies within nations to support policy and program decision-makers and have resulted in rapid deployment of proactive policies and programs to mitigate disasters and mobilization of resources in response to emerging food emergencies.

Joint Experiments for Crop Assessment and Monitoring (JECAM) (Complete and continuing)

Any operational system, particularly one based on a quickly evolving technology like Earth observation, must be underpinned by strong R&D. The operational R&D foundation of GEOGLAM is the Joint Experiments for Crop Assessment and Monitoring (JECAM http://jecam.org/). The JECAM network is focused on R&D towards the development of operational crop type, area, and condition analysis. Within projects funded by G20 nations, JECAM conducts method inter-comparison research on a network of more than 40 data-rich test sites around the world (figure 5). Its goal is to reach a convergence of analytical approaches, developing monitoring and reporting protocols and best practices for a variety of global agricultural systems. Past cross-site experiments have resulted in the development of tools to utilize free and open data from Europe's Sentinel satellite constellations and USGS/NASA Landsat data. More recent cross-site experiments include the use of synthetic aperture radar (SAR) data for crop type mapping and biomass estimation in cooperation with AsiaRiCE crop team.

Capacity Development - National and Regional Crop Monitoring (Implemented and operated by mandated agencies, supported by GEOGLAM) (Complete and continuing)

[1] https://geobon.org/about/projects/

Implementation of National Crop Monitors: Uganda; Kenya; Tanzania; Vietnam. Development of Regional Crop Monitors: Horn of Africa (10 nations). Training of quantitative yield forecasting with several tools including the Crop Statistics Tool (JRC). Operational in Algeria, still in testing for: Senegal, Burkina, Ethiopia, Somalia, South Africa.

Implementation and customization of CropWatch Cloud: Mozambique.

Development of customized CropWatch Cloud: Egypt, Mongolia, Russia, and Lower Mekong Basin (5 countries).

Implementation of rice crop outlook using Japan's agromet information system (JASMIN) in ASEAN member states using Japan ASEAN trust fund as new ASEAN project during 2019-2020 proponed by LAPAN and MOA, Indonesia (https://suzaku.eorc.jaxa.jp/JASMIN/index.html).

Participatory CropWatch Cloud Platform (Complete and continuing)

CropWatch migrated to a cloud service platform including CropWatch Processing, Explore, Analysis, and Bulletin sub systems. Providing service to the public through quarterly bulletins and monthly updates. Partners can have access to agro-climatic, agronomic, and PAY information, and make use of CropWatch analytics to independently analyze crop conditions for a region of interest. (https://cloud.cropwatch.com.cn/)

Review of Data and Systems Requirements for Operational Agricultural Monitoring (Complete)

Workshop held. (http://www.grainwatch.cn/geoglam/index.html)

Study on the Value of Earth Observations and GEOGLAM to Commodity Markets (On track and continuing)

Progress on track, preliminary results presented to the AMIS Rapid Response Forum, 26 February 2019

Increased Emphasis on Regional Networks (On track)

New GEOGLAM networks established in Asia+ (Belt and Road) and Agricultural Monitoring in the Americas; strengthening of Asia-RiCE with ASEAN project (AFSIS) as well as Mekong Basin rice monitoring initiative with CEOS2019 priority and ESA GEORice project and expand to South Asia in cooperation with South Asia countries under Asia Pacific Regional Space Agency Forum (APRSAF) Space Application for Environment (SAFE) project.

ASAP - Anomaly Hotspots of Agricultural Production (Complete and continuing)

Online decision support system for early warning of agricultural production anomalies (crop and rangeland), developed by the JRC for food security crises prevention and response. Monthly assessments for hotspot countries published on the ASAP platform, a direct JRC contribution to the CM4EW. (https://mars.jrc.ec.europa.eu/asap/)

MARS – Neighborhood Bulletins (Complete and continuing)

The JRC MARS crop monitoring bulletins have been complemented by a series of neighborhood bulletins that are now published twice a year. Countries covered are North Africa, Ukraine, Turkey, Russia and Kazakhstan (https://ec.europa.eu/jrc/en/mars/bulletins)

Essential Agricultural Variables (EAVs) for GEOGLAM (New activity initiated)

White paper written to support development of EAVs, towards the development of quantitative metrics to support markets and food security, and new policy drivers around the UN Sustainable Development Goals; Paris Accord and the Sendai Framework for Disaster Risk Reduction.

Development of a Forward Community Research Agenda for GEOGLAM 8 New activity continuing)

First draft completed.

RaPP – Rangeland and Pasture Productivity (Complete and continuing)

Extension of GEOGLAM goals into the rangeland and pasture systems sustaining livestock production. Aims at enhancing the community of practice of EO in rangelands

RaPP Map – Rangeland and Pasture Productivity Map (Complete and continuing)

Online tool for monitoring rangeland and pasture condition. Developed by CSIRO initially for the Australian rangelands, it has been expanded to have global coverage. (https://map.geo-rapp.org/)

GEOGLAM Observation Requirements (Complete)

An articulation of spectral, spatial, and temporal resolution requirements for satellite-based observations to create Essential Agricultural Variables and Core Information Products for GEOGLAM. Results presented to CEOS, who are now preparing their strategic response.

2.2 Evidence of use of the outputs and their impacts

Since September 2013, over 60 monthly CM4AMIS bulletins have been generated for inclusion in the AMIS Market Monitor

The CM4EW reports are used by food security organizations, including the United Nations Office for the Coordination of Humanitarian Affairs (OCHA). In 2018 the OCHA referenced the CM4EW in a food security alert for Southern Africa. In the alert they also indicated a need for more frequent information in areas of emerging concern. Based on this requirement GEOGLAM responded, and in March 2019 released a special interim report in response to the South African drought, and the early impact assessment from cyclone Idai.

Both global GEOGLAM Crop Monitor publications are internationally recognized as a reliable source of information on global crop conditions, and are used by a range of ministries, multi-national, governmental, and non-governmental organizations to inform agricultural decisions.

GEOGLAM as a GEO flagship represents the very best example of how the convening power of GEO was able to bring a community together to operationally deliver EO based services that are making a difference for commodity market stability and food security and early warning. GEOGLAM is a program and as such, with sufficient support, the community intends to continue delivering timely accurate and relevant information to support food commodity markets and early warning for food security.

3 GLOBAL FOREST OBSERVATION INITIATIVE (GFOI)

3.1 Status of implementation for the 2017-2019 period

The GFOI was founded in 2011 under GEO and follows the pilot of GEO-Forest Carbon Track tasks (GEO-FCT), which was founded in 2008. In facilitating global coordination on forest monitoring, GFOI partners have achieved the following:

- Built technical capacity in developing countries and provided operational guidance to support countries to meet their international reporting requirements, including to the UNFCCC and under multilateral initiatives such as the World Bank's Forest Carbon Partnership Facility (FCPF)
- Published methods and guidance on MRV for REDD+ which is IPCC compliant and supports countries to design and develop systems and procedures that meet their national reporting requirements, in particular to the UNFCCC
- Worked with the broader community of space-data providers to assure the availability of annual wall-to-wall coverage for all the world's forested regions with multiple remote sensing data sources in support of reporting by countries

- Contributed to the development of scientific best practices, and enabled scientific institutions to address necessary scientific advancements identified by developing countries and capacity developers.

4 GLOBAL OBSERVATION SYSTEM FOR MERCURY (GOS4M)

4.1 Status of implementation for the 2017-2019 period

GOS4M is in force since 2017 and its implementation is proceeding following the established timeline.

Following the GOS4M implementation plan, the main activities along these two years were completely oriented to establish the Governance. Along the two years of activities, a survey was done to list worldwide monitoring network as well repositories of monitoring datasets. For such information metadata where prepared, each one reporting data source, intellectual property, term of use and consistency among others. This information is published by means of the GEOSS mirror site http://www.geoportal.org/community/gos4m.

Major outcome is related with the Report of the ad hoc group of experts on effectiveness evaluation (UNEP/MC/COP.2/INF/8) a document prepared for the Conference of Parties of the Minamata Convention on Mercury, which includes the GOS4M as global Observatory Network for mercury in air.

Meanwhile the GOS4M Knowledge Hub (G-KH) was planned. The G-KH is an integrated solution of high quality observational data, model outputs and digital tools to respond closely to the needs of Minamata Convention on Mercury assessment, addressing major knowledge gaps. It brings end-users into a decision on policy implementation and cost-benefit evaluation in the light UN agenda 2030.

The G-KH is based on five knowledge elements:

- Collection/Elicitation
- Formalization/Encoding
- Sharing
- Use
- Generation

5 AQUAWATCH

5.1 Status of implementation for the 2017-2019 period

In 2017 an informational booklet was produced on the monitoring of Earth Observation of water quality, the production of a new website (www.geoaquawatch.org) and transitioned to the governance structure of AquaWatch.

During the 2018 workshop in Stirling, UK, 2018-19 annual work plan was developed with specific task for cross-functional teams comprised of members of 2-3 related working groups to accomplish within the next 12-18 months. The tasks advance the goals of the identified work packages, including a revised approach to building the Water Quality Information Service leveraging existing data products and infrastructure.

6 EARTH OBSERVATIONS FOR ECOSYSTEM ACCOUNTING (EO4EA)

6.1 Status of implementation for the 2017-2019 period

The EO4EA initiative is still very new within GEO and is continuing to develop, however, there have been numerous achievements over the past year. The EO4EA initiative hosted and participated in numerous key meetings this year including:

- The Forum of Experts in SEAA Experimental Ecosystem Accounts hosted by the UNSD
- Co-hosting The Natural Capital Assessment and Accounting side event at the 6th GEF General Assembly along with the most important agencies mandated to spearhead NCA.
- NASA funded workshop on EO for ecosystem service assessment at the University of Minnesota
- The UN Statistics Commission's London Group on Environmental Accounts in Dublin
- EO4EA side event at the GEO Plenary in Kyoto
- The Third Natural Capital Policy Forum in Paris
- Progress on various individual government projects conducting ecosystem accounting including Australia, US, Canada, Liberia, Mexico, Netherlands, Indonesia, and Rwanda.

Members also published three key synthesis reports over the course of the past year. UNEP-WCMC published a reported entitled "Technical proposal on opportunities for using earth observation data in KIP-INCA" which examined how ESA Copernicus product could be used to support ecosystem accounting in the European Union. To compliment the report, WCMC also published a database of the Copernicus products and provides an interactive tool to link data products to the extent, condition, and services accounts (link). The major synthesis entitled, "Earth observation for official statistics: Satellite imagery and geospatial data task team report", was authored by the United Nation, Australian Bureau of Statistics, Queensland University of Technology, the Queensland Government, Commonwealth Scientific and Industrial Research Organization, the National Institute of Statistics and Geography (INEGI) in Mexico and Statistics Canada. The report was produced as an input to the United Nation Working Group on Big Data for Official Statistics and outlines the current and potential future applications of earth observation to support national statistics, including SEEA. Finally, a third report was written by the government of Australia, entitled "Earth Observation for Environmental-Economic Accounting", which focuses specifically on how EO data could be used to inform the Australia ecosystem accounts. These three reports highlight the increasing role of earth observation data in environmental accounting and represent significant progress toward the Case Study and Synthesis workstream in EO4EA. Additionally, EO4EA members contributed to peer reviewed publications on natural capital accounting in the United States (link) and the role of earth observation in ecosystem service assessment (link).

Finally, there has been much progress from the overall community throughout the year promoting ecosystem accounting with the United Nations and national governments. At present over 73 countries have expressed interest in undertaking some form of ecosystem accounting and many more are developing environmental-economic accounts under the Central Framework. This is a very positive trend and only provides further opportunities for EO4EA to simultaneously expand its activities and reach important user communities.

7 EARTH OBSERVATIONS IN SERVICE OF THE 2030 AGENDA FOR SUSTAINABLE DEVELOPMENT (EO4SDG)

7.1 Status of implementation for the 2017-2019 period

In 2016-2018, EO4SDG has made progress on a range of the quantitative breakdown objectives set against its three goals, outlined in the 2016-2020 Implementation Plan.

To identify and map how GEO Member Countries are using - or planning to use - EO data for the SDGs, the EO4SDG team, in collaboration with the GEO Secretariat, conducted a survey of SDG user needs. The Initiative received seventy-two unique responses, with a large majority coming from governmental agencies, commonly environmental, geographical or statistical. EO4SDG is in the process of developing a report that summarizes key findings from this survey, including lessons learned, challenges, and recommendations for advancing the use of EO for SDG analysis and reporting.

The Initiative is also in the process of completing an in-depth review of the contribution of EO to the Global Indicator Framework with the objective to produce an exhaustive EO compendium on the SDG Indicators. This will involve individual Indicator factsheets that will be used as a baseline to centralize all SDG-related activities.

EO4SDG has conducted several pilot projects in support of SDG method development, distribution and adoption. Examples of such pilot activities include, among others:

- A project on using Earth observations to monitor changes in the spatial extent of wetlands in Uganda (SDG Targets 6.6, 15.1). This project is led by the Ramsar Center in East Africa in collaboration with the European Space Agency (ESA), the Bureau of Statistics in Uganda, and the GEO Wetlands Initiative, among other contributors.
- A project on integrating Earth observations and national statistics for mapping changes in urban extent, population, and Indicator 11.3.1, which tracks the ratio of land consumption rate to population growth rate. This project is led by NASA and Conservation International, in collaboration with UN Habitat and countries (e.g., Colombia, Mexico, Morocco, others).
- A series of projects supporting the use of EO for monitoring SDG 6 (Clean water and sanitation) and in particular: changes in spatial extent and quality of open water bodies. This is a collaborative effort among the UN Environment Programme, individual countries (including Zambia, Uganda, Colombia, Peru, United Arab Emirates, Malaysia), NASA, the European Commission's Joint Research Center (JRC), ESA, and Google Earth Engine, among others.
- A project to develop capacity for implementing the Mexican Geospatial Data Cube, a collaboration between Mexico (INEGI) and Australia (Geoscience Australia). This project aims to enable processing and analysis of Earth observations to help generate useful data for INEGI's national resource information production, surveys, censuses, and in support of SDG analysis and reporting.
- A project led jointly by JAXA and the Japan International Cooperation Agency (JICA) involving the implementation of a 'Forest Early Warning System in the Tropics (JJ-FAST)'. This web-based system monitors tropical forests every 1.5 months. As of June 2018, the system's service coverage was expanded to include seventy-seven countries.

EO4SDG has been improving capabilities with Earth observations, supporting countries and stakeholders in the implementation of methods using EO to address the 2030 Agenda.

As part of the Eighth Session of the United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM), EO4SDG collaborated with UN-GGIM Americas, Mexico (INEGI), the NASA Applied Sciences Remote Sensing Training program and CEOS to run a training workshop focused on water, land cover, land degradation, and their related SDG Indicators. In addition, a 2018 workshop on "Implementing and Monitoring the Sustainable Development Goals in the Caribbean: The Role of the Ocean," brought together GEO Initiatives (including EO4SDG), governments of the Caribbean Small Island Developing States, UN Agencies, and regional non-governmental organizations. This led to the development of a "geospace for SDGs", a grass-root driven, bottom-up approach complementary to the government-driven, top-down approach to the implementation of the 2030 Agenda.

EO4SDG developed a handbook to highlight case studies of how EO respond to sustainable development needs, and contributed input to CEOS' Handbook on "Satellite Earth Observations in

Support of the Sustainable Development Goals". EO4SDG has also been working closely with the CEOS SDG Ad-Hoc Team and the CEOS Working Group on Data Democracy and Capacity Building to organize SDG awareness webinars. To support the collection of EO solutions that enable countries to achieve the 2030 Agenda and the SDGs, EO4SDG and the CEOS SDG Ad-Hoc Team organized two special issues in the Remote Sensing, and the Remote Sensing of Environment, Scientific Journals.

In collaboration with the GEO Secretariat, the Initiative developed a book on *Earth Observation Applications and Global Policy Frameworks*, with a focus on disaster risk reduction, climate change, and sustainable development. The book is currently under formal review and will be published in the American Geophysical Union (AGU)'s Geophysical Monograph Series. More information on additional capacity building activities, including webinars and in-person trainings, as well as technical briefs and case studies is available at the Initiative's website (http://eo4sdg.org) under 'What We Do' and 'Get More Information'.

As part of its federated approach, EO4SDG has collaborated with GEO Blue Planet in aspects of preventing and significantly reducing marine pollution as part of Goal 14. Blue Planet has hosted several meetings between UN Environment and relevant GEO groups to discuss GEO's support for the development of an index for coastal eutrophication potential for Indicator 14.1.1 (index of coastal eutrophication and floating plastic debris density) and to facilitate coherence between water quality efforts in relation to Goals 6 and 14.

EO4SDG has engaged in efforts that support the development of data infrastructures and platforms to enable integration of EO into national data streams and decision support systems. Examples of such efforts include the Trends.Earth Urban Mapper web interface and Trends.Earth tool that help analyze changes in urban extent and population, providing the added capability of putting the data into the UN-required reporting format. The African Regional Data Cube is a supplemental example of a tool that harnesses the latest Earth observation and satellite technology to help Kenya, Senegal, Sierra Leone, Ghana, and Tanzania address food security as well as issues relating to agriculture, deforestation, and water access. In addition, ESA's Thematic Exploitation Platforms support end-user needs by providing online tools for SDG monitoring and reporting.

These efforts are in alignment with the creation of an SDG EO/GI interactive knowledge resource, and the proposed evolvement of GEOSS from an information hub to a knowledge hub, allowing for the sharing of experiences and serving as means for collaborative work.

7.2 Evidence of use of the outputs and their impacts

EO4SDG has been instrumental in helping UN custodian agencies enhance their SDG indicator monitoring guidelines through the use of Earth Observations, leading to advancements in method development and data availability. In particular, collaborations with UN Environment on Indicators 6.6.1 (spatial extent of water-related ecosystems) and 6.3.2 (ambient water quality), with UNCCD on Indicator 15.3.1 (proportion of degraded land per total land), and with UN Habitat on Indicator 11.7.1 (average share of the built-up area of cities that is open space for public use) enabled these 4 indicators to be recognized as conceptually clear with internationally accepted methodologies. In addition, the Initiative contributed input to UN Habitat's SDG 11 Synthesis Report 2018 on *Sustainable Cities and Communities*.

8 GEO-CRADLE

8.1 Status of implementation for the 2017-2019 period

The GEO-CRADLE project was funded by the European Union and ran for 34 months from February 2016 to November 2018. In this timeframe the following key highlights were achieved:

Integration of existing EO capacities

- Extensive inventorying of the EO capacities: Space/air-borne, Ground-based/In-situ monitoring, Modelling and computing.
- Detailed collection of user needs (93 interviews from 14 countries, 19 regional workshops and exchanges in outreach activities), followed by gaps analysis, and Priorities Action Plan.
- 4 pilot activities showcasing advanced EO Services to address regional challenges (e.g. SDGs).
- Regional Data Hub connected to GCI (25.534.239 datasets, 45 regional portals and sites, including the 4 pilots).

Engagement of the EO stakeholder community

- Networking Platform (268 profiles of EO actors from 29 countries).
- Liaison activities (GEO, Copernicus-DG GROW, DG RTD and ESA).
- Stakeholder engagement and capacity building events (including 19 regional workshops) and dissemination activities (including 31 scientific papers and articles).
- Communication materials (e.g. website, social media).

Uptake of EO services and data

- Regional Data Hub providing access to EO services and data.
- 4 pilot activities addressing the daily needs of key stakeholders.
- Development of a novel methodology for EO Maturity Assessment (32 indicators) and application in 11 countries.

Implementation of GEOSS and Copernicus

- Advocacy on the importance of data sharing and data opening, in line with GEOSS data sharing principles, and operation of the Regional Data Hub in this direction.
- "Exporting" of Copernicus data and core services through regional workshops and capacity building activities.
- Enhancing the establishment of GEO liaisons (e.g. Albanian GEO Office established in 11/2018).
- Delivery of a Roadmap with an Action Plan by 2030 for the implementation of GEOSS & Copernicus.

The GEO-CRADLE project had a remarkable progress beyond the state of the art:

- The novel methodology for EO maturity assessment provided a common standard for evaluating the countries' involvement in the implementation of GEO and Copernicus for mutual benefit.
- The Networking Platform presents an up-to-date status of the regional capacities, and facilitates the networking and synergies among the stakeholders, helping to set region-based consortia.
- The Regional Data Hub provides access to millions of regional datasets, and thus fosters further data sharing and EO service development for the benefit of the relevant science and geo-information sector.
- The Adaptation to Climate Change pilot supported the sustainability of regional EO infrastructures. It focused on the holistic monitoring and forecasting of region-specific atmospheric components, ECVs and hazards, in line with the standards and vision of GEOSS & Copernicus. It provided services related to desert dust, climate change, and air quality, benefiting key end users, and engaging aviation authorities, environmental and civil protection institutions and state agencies, as well as public/private sectors e.g. tourism, agriculture, natural hazards and water management.
- The Improved Food Security – Water Extremes Management pilot transferred state-of-the-art know-how between the involved countries on soil spectroscopy, and built for the first

time a standardized regional Soil Spectral Library, as a complement to the EU Soil Sample Data Base, serving the food security and agriculture sectors. It provided detailed thematic soil maps by analysing the soil spectra with Sentinel-2 image acquisitions. Moreover, in support to the agriculture production and flood/drought mitigation, the pilot adapted and launched a region specific version of the myDEWETRA web platform. The delivered services have strong potential to support EU agricultural policy and initiatives (e.g. SDGs, PRIMA).

- The Access to Raw Materials pilot studied mining and post-mining sites, focusing on EO based solutions to support the sites' management and mitigation of their environmental impact on the surrounding areas. All the methodologies were elaborated on the basis of Copernicus data integration and were delivered having a universal character, applicable for other RoIs as well. The pilot engaged key private and public/state organisations from the mining and environmental sectors.
- Finally, the detailed Roadmap further promotes multi-actor, cross-border and interdisciplinary collaboration among EO stakeholders in the RoI for the delivery of EO-based benefits to society and economy. The Roadmap concludes with a concrete Action Plan by 2030 for the implementation of GEOSS & Copernicus which is structured so that the different actions fall under five main categories: (i) Infrastructure and data exploitation, (ii) EO in support to policy implementation and decision-making, (iii) Ecosystem Capacity Building, (iv) EO Services Sustainability and (v) Uptake of EO market.

Overall, the GEO-CRADLE project achieved great scientific, societal and economic impact through the networking and exchange of EO methodologies, know-how, datasets and services. For the first time in the RoI the current state-of-play was captured and the provision of EO value-adding services was beneficial for the local societies and the EO market uptake towards sustainable development.

8.2 Evidence of use of the outputs and their impacts

The Access to Solar Energy (SENSE) pilot took advantage of the free access to Copernicus data and Core services, innovative modelling and state-of-the-art real-time solar energy calculating systems, and delivered reliable and high resolution solar Atlases and broader climatology studies. It engraved strategic methods to integrate a solar energy nowcasting system into a wider GEOSS driven system at global scale. It stimulated the interest of key energy stakeholders and decision makers from the private and public/state sector in various countries, e.g. Egypt where it was acknowledged by the Ministry of Electricity and Renewable Energy and is currently integrated in its official website, serving the needs of potential solar investors.

9 GEO GLOBAL WATER SUSTAINABILITY (GEOGLOWS)

9.1 Status of implementation for the 2017-2019 period

Significant progress has been achieved in the following areas:

Global Streamflow Forecasting

Built on the hydrological runoff forecasts made freely available by ECWMF, the global streamflow services completely disrupt the paradigm for how streamflow information is created and disseminated. Rather than each water organization accessing large global datasets and develop models to forecast their own streamflow that is useful for decision-makers, the streamflow forecasting, with all its accompanying modeling resources, are created and run on proven global systems, and then made accessible locally through web services. This freely provided streamflow information, which leverages the hydrometeorological computational expertise of the GEOGLOWS Partnership, delivers forecasts that support national and local decision-makers and allows them to focus resources on developing solutions and applications specific to their local water resources management needs.

Essential Water Variables (EWVs)

Initial general guidelines for EWVs were adopted: (1) Standards and best practices: The study should identify such process guidelines for defining EWVs; (2) Source: EWVs can be measured, modeled, or a proxy. The most acceptable ways of providing an EWV will be identified in this analysis; (3) Redundancy: Select the variable that is easier to acquire even if it is not perfect; (4) Hierarchy: The more direct and less prescriptive an EWV is, the more likely it will be to accept a variety of different measurement sources and methods; (5) Attributes: A single variable can have a variety of sub-variables (aka attributes), which will be explicated in the definition process; (6) Stages of approval: An EWV will be "conditional" until it is demonstrated in the field to actually work, with the target status of "sufficient consensus, and to know its accuracy and sources or error"; (7) Updates: The EWV list will be updated periodically; (8) Distribution: Open data distribution is key, starting with existing data portals, and considering more broad-based solutions, such as GEOSS links to other systems (e.g., WIGOS).

Monitoring indicators of SDGs

In 2018 (continuing through 2019 and beyond), NASA-ESD and GSFC initiated activities for the application of EO (e.g., Landsat and Sentinel satellite data) to the monitoring of SDG-6 (Freshwater and Sanitation) in collaboration with and as a contribution to the UN Environment (custodian agency for SDG 6) and countries, focusing on SDG indicators: 6.6.1, 6.3.2., in particular: Water quality of open water bodies, and Spatial extent of coastal mangroves. Examples of Initial countries with pilot projects either already initiated or under discussion include: Peru, Uruguay, Brazil, Columbia, Panama, Zambia, Uganda, Senegal.

Research Projects from NASA

The NASA Applied Sciences Program through its Water Resources Projects participates in GEOGLOWS by coordinating the provision of data from current and planned satellite missions and develops and shares tools and applications from its research activities. Current missions meet the needs of GEOGLOWS related to the measurement and understanding of precipitation, snow cover and snow dynamics, soil moisture, evapotranspiration, groundwater change, sea level rise, surface water extent and elevation, and indicators of water quality, among other hydrologic variables. The ongoing GEOGLOWS contributions build on projects that have received funding in 2018 and are now producing outputs for use in water management.

Research and operational projects from CNES

CNES has created a working group in hydrology from space to leverage new services gathering scientists, experts, private companies, public institutions and local organizations. The Congo basin, the world's second largest river basin, has been selected as the first pilot project to foster the research in altimetry and runoff estimation and, inter alia, to study the hydropower potential. It is supported by AFD, the France inclusive public development bank and moderated by IOWATER, the International Office for Water.

The first part of the implementation plan over the Congo basin was focused on altimetry and quantitative water resources management. As a matter of fact, the current operating gauge stations (~30) over the Congo basin are not sufficient for a good water resource management and the hydropower potential of the basin is underexploited. Within the working group we worked on enhancing the water elevation network with space altimetry: more than 500 virtual stations (measurement point at the crossings between the river and the ground track of the orbits) provides now water levels all over the Congo basin and complement the in-situ measurements. They are freely available on the Hydroweb website supervised by LEGOS http://hydroweb.theia-land.fr. An hydrological information system has also been built. It gathers in-situ + altimetry measurements so that the CICOS has now an operational tool to better understand the hydrodynamic of its basin. The ongoing work focuses on estimating discharge with both a hydraulic model assimilating the observed water levels and a hydrological model. Meanwhile we investigate the potential of the SWOT mission for hydrological forecasts for navigation and hydropower potential estimation.

The first results are very encouraging and have been acknowledged by national and regional agencies. This motivates to spread this initiative to other watersheds in Africa (Niger, Senegal, Chad), in South Asia (Mekong) and in South America (Amazona) and also to emphasize other variables derived from Earth Observation satellite: land cover maps, water quality products, monitoring of water bodies, groundwater storage, soil moisture products. A working plan for each watershed with their own distinctiveness is being drafted in close cooperation with all the current partners. The question of funding is however a matter of concern.

9.2 Evidence of use of the outputs and their impacts

GEOGLOWS partners developed global streamflow forecast services that fill gaps and provide actionable information to national and local agencies charged with the responsibilities of water supply and extreme weather/water management, as illustrated by the testimonial of end-users in Nepal, Bangladesh, Dominican Republic, and Colombia in which pilot projects were implemented.

10 GEO HUMAN PLANET

10.1 Status of implementation for the 2017-2019 period

The GEO Human Planet Initiative contributes to all three Strategic Objectives that guides GEO activities through 2025: advocacy for the value of Earth observations as a fundamental component of timely information; engagement with stakeholder communities to address societal challenges; and delivery of critical data, information and knowledge to inform decision-making. A set of joint and coordinated activities targets each of the strategic objectives as follows.

Strategic Objective 1: To Advocate the importance of Earth observations as irreplaceable resources that must be protected, rendered fully and openly accessible (including through contribution to GEOSS), and integrated to provide maximum value in support of achieving national and international calls for resilient societies, sustainable economic growth, and a healthy environment worldwide. The HPI addresses this by demonstrating the relevance of EO extracted information to the user community that includes scientist, practitioners, and decision makers.

In fact, GEO Human Planet aims to:

- Continue to improve information extraction from EO data archives and generate EO-derived global open data describing the spatial extent of the physical infrastructures of human settlements and its characteristics (coordinated by EC JRC GHSL, contributors CIESIN, WorldPop).
- Generate attributes for physical information products including building height and/or building stock volume and use.
- Test new EO-based measurement technologies for characterizing the built environment.
- Benchmark existing global information products on settlements.

Strategic Objective 3: To Deliver data, information and knowledge enabling stakeholders to improve decision-making processes and inform policy requirements, promote the exchange of best practices, enable the uptake of new technologies, and create new economic opportunities while leveraging public sector investment through standardization, collaboration and innovation. The GEO Human Planet aims to:

- Improve the available open global gridded population density datasets by combining settlement physical data with census data (coordinated by CIESIN, contributor WorldPop, GHSL).
- Generate continental and global gridded population attributes (coordinated by WorldPop, contributor CIESIN, GHSL).
- Integrate physical human settlement data and generate an harmonized definition of human settlements of all sizes (GHSL, OECD, DG Regio, FAO).

- Integrate geo-spatial settlement information with statistical data for use by national statistical offices.

Strategic Objective 2: To Engage with stakeholder communities and foster strategic partnerships to address global and regional challenges, by increasing the understanding and use of Earth observations available in support of science-based and data-driven decision and policy-making. The HPI aims to:

- Co-produce with decision makers the Settlement Model used in the New Degree of Urbanization
- Promote the uptake of the New Degree of Urbanization model. The model is used in international fora including the United Nations (European Commission/DG REGIO) to compare urbanization globally.
- Test and demonstrate the use of new integrated global spatial data in support of the monitoring of the implementation of post-2015 frameworks (coordination by GHSL, contributor extended partnership).
- Reach out to GEO Flagships, GEO initiatives, and international programs and identify areas of cooperation and data integration.

10.2 Evidence of use of the outputs and their impacts

The geospatial information products of GEO Human Planet are requested and used as evidence in: i) modelling *exposure and vulnerability* to natural hazards, violent conflict, environmental contamination, environmental degradation, climate change, and other issues of concern; ii) measuring the *impact* of human activities and their metabolic output on life supporting ecosystems and Earth's biogeochemical cycles; and iii) in estimating human/societal demand for and usage of natural and other resources.

The current users of GEO Human Planet products include Scientists, Practitioners, and Decision Makers mostly from the International Community. For example, planners and hazard analyst use gridded population and built-up produced to address urbanization and exposure in disaster risk assessment. Crisis management practitioners from the international community rely on the Global Disaster Risk and Coordination System (GDACS) to alert and monitor for hazard impact. GDACS relies on HPI core detests. Decision makers use INFORM a set of composite indicators that include HPI data layers, to guide allocation of humanitarian and development aid.

11 GEO-VENER

11.1 Status of implementation for the 2017-2019 period

Essential Variables for Renewable Energies

The H2020 ConnectinGEO project (2015-2017) has an activity related to identification of essential variables for renewable energies, gap analysis and industrial challenges on in-situ measurements (http://www.connectingeo.net). It contributes to all objectives of GEO-VENER. Publication in revision.

Status: Completed

European Network of Earth Observation Networks (ENEON)

The European Network of Earth Observation Networks (ENEON), part of the ConnectinGEO project will try to establish its activities on the long-run. Renewable energies are linked with the involvement of the private energy sector. Activities of the GEO Energy activities will contribute to ENEON. It contributes to objective 3 of GEO-VENER

Status: Completed

Atmosphere Monitoring Service for Solar Radiation

The-operational COPERNICUS Atmosphere Monitoring Service for Solar Radiation (http://macc.copernicus-atmosphere.eu/catalogue/#list?st=Solar%20radiation) will serve the solar community. It contributes to the delivering of RE-EV to the community (objectives 1 and 4 of GEO-VENER). End of first period in Dec. 2018 - New programme for 2019-2021). (see http://www.soda-pro.com/web-services/radiation/cams-radiation-service/info for a description of the service)

Status: In Progress

In-situ measurement for the Energy

A Sensor Observation Service capacity for the in-situ measurement for the Energy societal benefit area (SBA) has been established. In 2017, this activity will continue thanks to the support of ConnectinGEO H2020 project. This component (http://insitu.webservice-energy.org) has been added to the webservice-energy.org community portal. This Spatial Data infrastructure is operated by MINES ParisTech and will support GI-10. It contributes to objectives 3 and 4 of GEO-VENER.

Status: Completed

Resource efficiency and environmental management

The launch of the call for project within H2020 ERA PLANET project is expected for 2016 with beginning of activities end of 2016, beginning of 2017. This project is a major contribution from Europe to GEOSS, with specific inputs for Energy within the Strand 2 – Resource efficiency and environmental management. This project will possibly contribute to all objectives of GEO-VENER. See GEO CRADLE initiative.

Status: Completed

Involvement of the private sectors

Activities of the Federation of Earth Science Information Partners (ESIP) Energy & Climate Working Group to enhance communication between data providers at US Federal agencies and RE decision makers. It contributed to the involvement of the private sectors within GEO.

Looking for interaction with the Terawatt Initiative. It contributes to the involvement of the private sector within GEOSS.

Status: Completed

Energy community portal

Continuation of the compilation of resources in the catalogue of the energy community portal http://www.webservice-energy.org. The webservice-energy.org is weekly harvested by the GEO DAB. It contributes to the GEO Data CORE (Collection of Open Resources for Everyone) in link with GEO Data Sharing Principles and in respect with GEOSS Data Management Principles and to objectives 1 and 4 of GEO-VENER. The catalogue included within the webservice-energy.org portal is developed based on the recommendations from GEOSS (formally known as GCI).

Status: Completed

Global Atlas for renewable energies

Improvement of the Global Atlas for renewable energies from International-Renewable Energies Agency – IRENA (http://irena.masdar.ac.ae). It contributes to the GEO Data CORE in link with GEO Data Sharing Principles and in respect with GEOSS Data Management Principles and to objectives 1 and 4 of GEO-VENER. The Global Atlas infrastructure is developed on the model of GEOSS.

Status: In Progress

Climate Change impacts to Energy sector

Contribution of Copernicus Climate Change Service to exploration of Climate Change impacts to Energy sector through the European Climatic Energy Mixes project (ECEM). It contributes to

objective 3 of GEO-VENER but also to the exploration of the links between Climate and Energy. ECEM project achieved, follow-up project C3S Energy. Linked with the C3S community activity.

Status: In Progress

Environmental impact assessment

Exploration of collaboration between IEA and IRENA on Environmental impact assessment through the IEA Photovoltaic Power Systems Program (PVPS) task 12 through the development of impact assessment of PV systems service. It contributes to objective 3 of GEO-VENER but also to the exploration of the links between Climate and Energy. See: http://viewer.webservice-energy.org/project_iea/

Status: Completed

Solar training

Organisation of the series of Solar training in Sophia Antipolis, France (since 2013). This contributes to capacity building, involvement of the private sector, science and technology within GEOSS. Similar training dedicated to other RE energies will be targeted in the new implementation plan. 7th session held in January 2019 with 44 professionals of solar energy (see https://tinyurl.com/y4rpsrao)

Status: In Progress

Collaboration with GFCS

Explore collaboration with Framework for Climate Services (GFCS) for Energy. It contributes to objective 3 of GEO-VENER but also to the exploration of the links between Climate and Energy.

Status: Open

New European Wind Atlas

H2020 ERA NET Plus project "New European Wind Atlas" (NEWA) http://euwindatlas.eu/ (2015-2020). It contributes to the delivering of RE-EV to the community. It contributes to the delivering of RE-EV to the community (objectives 1 and 4 of GEO-VENER)

Status: In Progress

Stakeholder Engagement

In 2016, Battelle and NASA conducted a stakeholder ideation workshop where stakeholders from across the energy management sector discussed current uses of EO data for energy management applications, including RE monitoring, building and energy efficiency, energy access, and other areas. Impediments to greater EO uptake were discussed.

Status: Completed

12 GEO WETLANDS

12.1 Status of implementation for the 2017-2019 period

In 2008, the Scientific and Technical Review Panel (STRP) of the Ramsar Convention on Wetlands initiated the establishment of a Global Wetlands Observation System (GWOS) to bring together available information on the status and values of wetlands and water in a way that can support policy processes and decision making at various geographic scales. It was expected to describe extent and condition as well as change and trends over time of a variety of wetland types. From 2011 onwards, the development of the GWOS has been one component of the GEO BON Work Plan and tightly linked to the activities of the GEO BON working group 4 “Freshwater ecosystem change”. During several meetings and two workshops the conceptualization of GWOS has evolved, coordinated by Wetlands International and the Ramsar Secretariat together with many other partners. The proposed

GEO-Wetlands initiative strongly builds on these prior activities. It also draws from activities of the former GEO Societal Benefits Implementation Board that initiated a closer cooperation between the GEO Biodiversity and Water Tasks. In 2016, this cross-cutting cooperation, together with the successful acquisition of funding for projects directly supporting its goals, led to the establishment of the GEO-Wetlands initiative as part of the GEO Work Programme 2017-2019.

Since then, GEO-Wetlands reached several of the objectives set in its first implementation plan. The most important achievements being the establishment of a Community Portal and Knowledge-base for Earth Observation of wetlands. While both platforms are still under development, they already reached an operational level and will support the work of GEO-Wetlands over the coming years. The Community Portal is already publicly available since 2018. The GEO-Wetlands website and knowledge-base will be publicly launched in early 2019. The idea behind both infrastructures (which are also both linked to each other and to the GEOSS Common Infrastructure) is to support the wetland community through eased access to data, information products, tools, guidelines and case studies and through possibilities for connecting and collaborating on a community level.

In different projects, several important datasets, methods and toolboxes have been developed for the wetland community. Several of these projects already committed within their proposals to support GEO, the development of a GWOS and GEO-Wetlands. Therefore, their results directly feed into the initiative and GEO-Wetlands on the other hand is aiming to ensure the long-term availability and further development of these contributions.

13 GEOHAZARD SUPERSITES AND NATURAL LABORATORIES (GSNL)

13.1 Status of implementation for the 2017-2019 period

The most important achievements of the initiative during 2017-2019 have been:

- provision of open access to in-situ geophysical data for the Supersites;
- CEOS support for the provision of thousands of satellite images to the Supersite scientific communities;
- generation of new scientific results over the Supersites, based on the open data;
- approval of the GSNL Data Policy Principles;
- establishment of the Geohazard Exploitation Platform as the reference portal for EO data access;
- establishment of the EVER-EST Virtual Research Environment (from an EC H20202 project) as provider of data processing services for Supersites in developing countries;
- provision of scientific monitoring information to DRM decision makers at several Supersites;
- capacity building by training, collaboration, and provision of resources.

The completion of planned tasks:

Task 1.1 Management (85% completion)

A draft for the new governance structure has been submitted to the Scientific Advisory Committee and is under discussion.

Eight biennial progress reports have been received and evaluated by the SAC and the CEOS, and are available on our website. Three more are under evaluation.

Constant collaboration with the CEOS space agencies within the WG Disasters has resulted in their support to three new Supersites and a Natural Laboratory. Full coordination with the CEOS Disaster Pilots and Demonstrators is in place.

Six meetings of the GSNL community have been organized at the AGU and EGU conferences.

Task 1.2 Networking activities (70% completion)

We have established the San Andreas Fault Natural Laboratory and three new Supersites: multihazard Supersite in the Southern Andes of Chile, Virunga volcanoes in D.R. Congo, Gulf of Corinth in Greece, all supporting local end users.

We coordinated with EPOS, UNAVCO, ESA, for the provision of data and processing services to the Supersites. We have established contacts with WB and UNISDR to explore the possibility to fund activities of Supersites in developing countries, however no result has been obtained. We have established an agreement with the Charter on sharing scientific products during crises.

We have presented the initiative to researchers and stakeholders in 14 different countries, stimulating the participation in the initiative. A few new Supersite proposals are now in preparation. One for Peru was submitted in February 2019.

Task 1.3 Data provision (80% completion)

We analyzed the various Supersite contexts and issued the GSNL Data Policy Principles, to promote the adoption of the GEO Data Sharing Principles in the long term. We have implemented e-collaboration, processing and information services through the GEP and the EVER-EST VRE, promoting an Open Science approach for GSNL.

We obtained further support from the CEOS, with access to over 5000 new images. We have established new procedures for satellite data access using specialized data infrastructures as the UNAVCO SSARA, EVER-EST and the GEP. We have documented the new procedures on our website. We have set up an agreement with ESA to provide access to over 10,000 Supersite COSMO-SkyMed satellite images through the GEP portal. Part of the images are already available.

Task 1.4 Dissemination& Outreach (85% completion)

We have created and populated a new website and prepared new material for dissemination, as a GSNL brochure and a 4-page summary. We placed all the Supersite reports on the website, and we are gradually extracting success stories from each report for more immediate communication of results. We have started to use the Research Object Hub (ROHUB) to implement a repository for the scientific results and other information generated within the Supersites.

Task 2.1 Supersite management (70% completion)

Comprehensive reports are submitted and evaluated by the SAC and the CEOS every two years from the date of establishment of the Supersite. Coordinators have been instructed by the GSNL Chair on the satellite tasking and data request procedures. Coordinators report on the scientific achievements and provide the relevant information to their national end users.

A few Supersites are now supported, at least in part, by national or regional projects. The new Open Science approach has started to be implemented at some Supersites; technological resources are available to support this step (e.g. the EVER-EST platform), but the community still needs to be fully engaged. Supersite coordinators report periodically on the Supersite achievements to their end users, and deliver the information support products according to independently established agreements.

Task 2.2 Supersite community building (70% completion)

Community building around Supersites has been promoted mainly through dissemination at scientific meetings. Capacity building at some Supersites has been provided supported by in kind resources and EC projects (EVER-EST, FUTUREVOLC), and has focused on short stages at the coordinating institutions (4), and ad hoc technical courses on the use of platforms and software for EO data processing (2 on EVER-EST in Colombia and Peru, 4 on the GEP at AGU and EGU meetings).

Task 2.3 Supersite infrastructure maintenance & development (60% completion)

A few Supersites have developed their own data infrastructures to share in situ data. Others use community infrastructures provided by IRIS, UNAVCO, and EPOS services.

Most satellite data are now provided through specific portals, and most data become available in few hours to 8 days from acquisition. The Virunga Supersite has elaborated a specific Data Policy to promote the engagement of the international scientific community in local activities, while maintaining a fair level of collaboration, to develop local resources.

Task 2.4 Supersite dissemination /outreach (60% completion)

Supersite coordinators have provided to CEOS and GEO material showcasing the results of their Supersites. These have been published in public reports. Update of the website proceeds, although not very frequently.

13.2 Evidence of use of the outputs and their impacts

All the volcano and seismic monitoring products based on Supersite in situ and EO data are constantly delivered to the reference end-users shown in Table 1. Several micro-decisions based on this information are constantly taken at various levels but are difficult to describe singularly. Some prominent examples are summarised below.

The ground motions associated with the 2018 Kilauea (Hawai‘i Supersite) earthquakes and eruption were constantly monitored using S-1, CSK, TSX, and Pleiades data. The repeated deformation products were used for tracking the migration of subsurface magma and for mapping the collapse of the summit (over 700 m at places) and the emplacement of lava flows. These data were used in combination with in situ data to draft multiple public documents about the potential hazards of continued eruptive activity. They were released to the public and formed the basis for the response by both Hawai‘i Volcanoes National Park and the County of Hawai‘i. Results were published on HVO’s website, so that the general public could track the evolution of activity in amplitude imagery and SAR interferograms.

In 2018, the Copernicus EMS services were activated by the Virunga Supersite to generate hazard and exposure maps for Goma City and a HR DEM to simulate the lava flow pathways and identify the affected areas. These maps were validated by the scientists of the Goma Volcano Observatory and delivered to the Conseil Provincial de prévention des catastrophes au Nord-Kivu, in D.R.C., which includes the national Civil Protection, Red Cross, Ministries of Interior, Urbanism, research. They were also delivered to similar institutions in Rwanda, where the risk from a Nyragongo eruption is also very high.

The 2017, Mw 3.9 earthquake in the Campi Flegrei Supersite (Ischia Island). The INGV data inversion based on S-1 and CSK InSAR results allowed to identify a seismic source due to gravitational deformation mechanisms, not due to volcanic origin.

An actively deforming slide was mapped following the 2016 eruption along the inner slope of the White Island volcano (Taupo Supersite, NZ). Continuous monitoring using stripmap TerraSAR X data showed slope motions up to 20 cm/yr, and this information was provided to the local authorities which used it to ban access to this popular touristic area for a number of months.

The Bardabunga volcano in the Iceland Supersite started erupting in August 2014, under a 800 m-thick ice cap. The worst scenario was magma-water interaction and strong ash emissions, possibly replicating the Eyjafjallajokull eruption in 2010, with risk of strong impacts on aviation across Europe. This caused issuing a red alert level, blocking overflight by commercial airlines. Seismic, geodetic, InSAR, and field geological data were shared and jointly analysed by a large scientific community under an EC Supersite project. The scientists constantly provided evolutionary models for the eruption to the Iceland Civil Protection, and the latter used this information to lower the alert level and let airlines resume flights.

13.3 Effectiveness of the governance structure and resourcing strategy

Presently GSNL is managed by a Scientific Advisory Committee (SAC) which is composed by prominent researchers and practitioners in seismic/volcanic/geodetic science or data infrastructures. However much of the burden of the governance lies on the SAC Chair (including the website update, reporting to GEO, etc.), whom is not supported by a secretariat. To improve the governance structure of GSNL was decided in 2017 to identify an operational team to support the SAC Chair, and the best way to do this would be to obtain support from the single Supersites. However this has not yet been agreed within the initiative. It is an objective for 2019.

The initiative is reviewed by GEO and by the CEOS Working Group on Disasters (WGD). The CEOS Data Coordination Team (a subset of the WGD) has the task of examining and approving the GSNL requests for satellite data support to the Supersites. The CEOS WGD receives updates every 6 months from the GSNL SAC Chair on general issues, and reviews every two years detailed reports from each Supersite. If the accomplishments are in line with objectives, the CEOS confirms the attribution of image quotas for the next two years. Until now all the 15 Supersite biennial reports examined by the WGD since 2014 have passed the reviews. In some cases, appreciating the successes of the Supersite, the CEOS has granted an increase of the yearly satellite data quotas.

13.4 Lessons learned and proposed actions for amendments or improvements

The main lessons learned from the 2017-2019 Implementation period have been the need for more consistent funding sources, for the Supersites and for the initiative management, and the need to ensure more active contribution for the outreach and dissemination of the Supersite results.

The reform of the management should help reach the latter objective, while for the funding issue we would need to develop a sponsoring scheme. GEO support would be much welcome in this subject.

Challenges for 2020-2022:

- identify a way to ensure that EO data from public space agencies are made fully open for risk management use, at least in developing countries;
- establish a Supersite or Natural Laboratory in Asia;
- establish further Supersites in regions with high geohazard and risk levels;
- improve open sharing of further data types, research products and software;
- promote international collaboration and capacity building;
- fully implement an Open Science approach in the GSNL initiative.

14 GLOBAL DROUGHT INFORMATION SYSTEM (GDIS)

14.1 Status of implementation for the 2017-2019 period

Africa

Before the 1st international Global Drought Information System workshop, UNESCO had contacted Princeton University (a GDIS partner) to develop an African Drought Monitor. (https://www.researchgate.net/publication/309470376_Strengthening_drought_risk_management_and_policy_UNESCO_International_Hydrological_Programme's_case_studies_from_Africa_and_Latin_America_and_the_Caribbean

During the 1st international Global Drought Information System workshop, this was more cohesively integrated with the West Africa Regional Drought Center. (AGRHYMET) https://journals.ametsoc.org/doi/pdf/10.1175/BAMS-D-12-00124.1

This has now been extended to IGAD Climate Prediction and Applications Centre (ICPAC) in the Greater Horn of Africa region, but both of these products are limited to monitoring *current* drought conditions, through both use of Standardized Precipitation Index and modelled soil moisture.

Princeton has the capability to extend this system to mapped predictions, but their system is limited to the North American Multi-Model Ensemble of North American climate models and seasonal forecasting models (i.e., the ECMWF forecasts are not included).

South America

A second Global Drought Information System workshop was held in Pasadena (JPL) in December 2014. GDIS hosted the first, face-to-face meeting of the Southern South America and Western South America Regional Climate Centres that was held in Pasadena to discuss the formation of a unified South American drought monitoring system https://gmao.gsfc.nasa.gov/pubs/docs/Schubert805.pdf. The subsequent Buenos Aires meeting was also attended by the GDIS co-PoC, Richard Heim http://www.crc-sas.org/es/pdf/capacitacion/cursos/0810_08_2017_buenosaires/SADIS_Strategic_Plan.pdf.

The JRC maps, both the Global Drought Observatory and the Latin American and African Drought Observatories, were developed as part of the Copernicus Emergency Management Service https://emergency.copernicus.eu/. (EDO is a GDIS partner)

Princeton also has extended its African Drought Monitor approach to South America.

Both of these products have been made available through the GDIS portal; however, the Regional Climate Centre Regional Drought Management Plan is grounded by the actual meteorological services in South America.

South Asia

During the 1st GDIS international workshop, Robert Stefanski, for WMO, expressed an interest in setting up a South Asia Regional Drought Center. After the 2nd international GDIS workshop, Stefanski contacted the International Water Resources Institute in Sri Lanka to set up this center. The maps from this center are now displayed on the GDIS portal.

GDIS and Global Drought Forecasting

The European Union sponsored two international drought projects (Drought Early Warning System for Africa (DEWFORA) (Micha Werner) (2011-2013) and the Global Water Scarcity Information Service (GLOWASIS) (Rogier Westerhoff) (2011-2013). GDIS participated with these projects, while the Pozzi was hosted by the University of Technology, Vienna. Both European Framework projects included work packages, located at the European Centre for Medium Range Weather Forecasting (ECMWF), designed to develop drought prediction, both for Africa (in DEWFORA) and world-wide (in GLOWASIS). The global test of regional drought forecasting skill was peer-reviewed published in 2014: https://www.hydrol-earth-syst-sci.net/18/2669/2014/hess-18-2669-2014.pdf

During the second Global Drought Information System workshop, held in Pasadena (JPL) in December 2014, these global forecasting efforts were reviewed. Mo (NOAA CPC) and Lyon (IRI) received funding from NOAA MAPP to develop a global drought forecasting system (using the North American Multi-model Ensemble (NMME) of climate models), which is now experimentally operative at NOAA CPC: https://journals.ametsoc.org/doi/pdf/10.1175/JHM-D-14-0192.1.

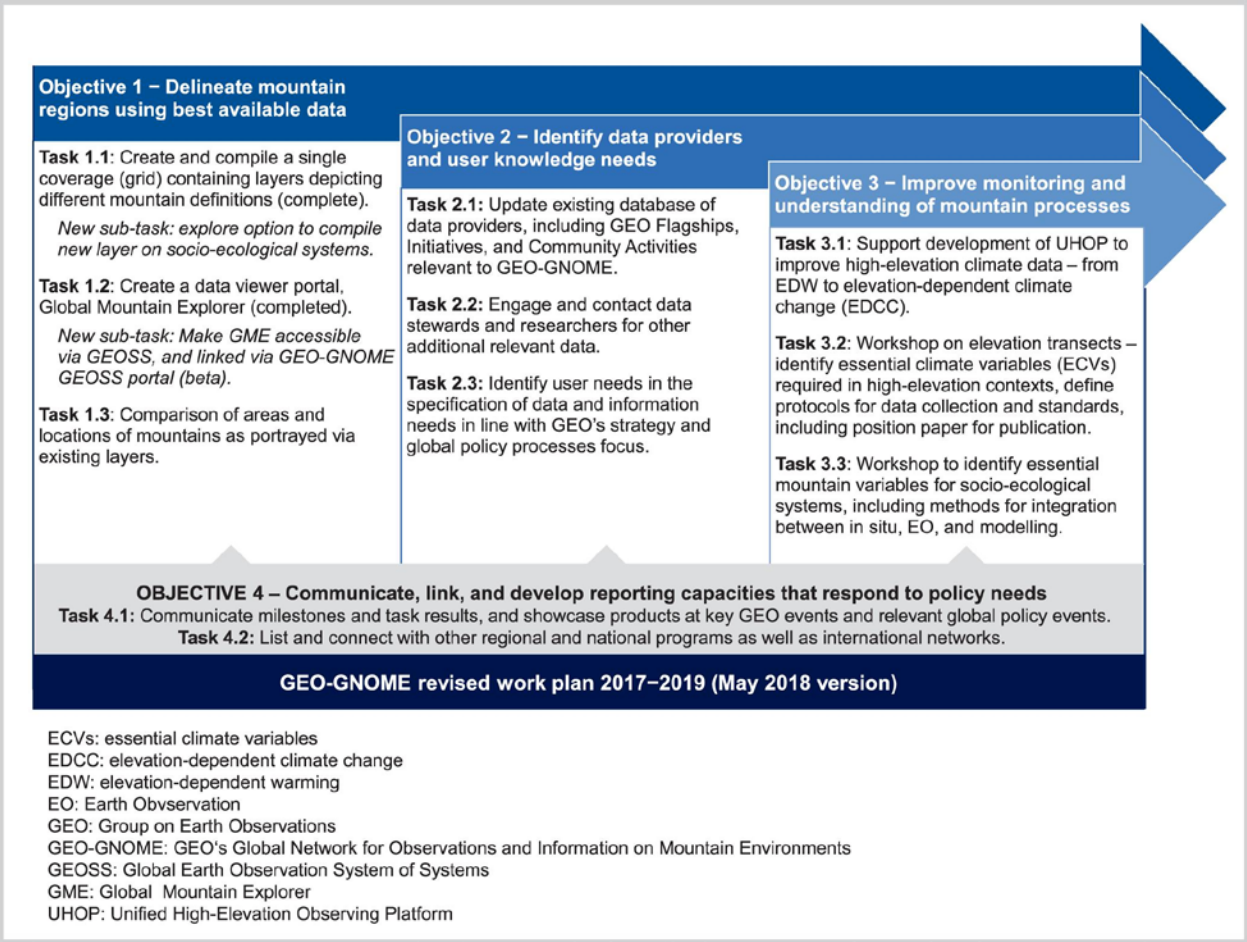
14.2 Lessons learned and proposed actions for amendments or improvements

The importance of developing a less spatially biased technique for monitoring global precipitation is critical to the success of this mission and for the success of global drought forecasting. Some of the NOAA and NASA activities have been heavily impacted by domestic political events within the USA. The government shutdown has delayed twice, for example, the production of a combined TRMM-GPM archive for use in precipitation monitoring. Furthermore, the cost of ECMWF seasonal forecasts was a significant barrier to drought forecasting, one that has recently been lifted through the Copernicus C3S Climate Change Services program.

15 GEO GLOBAL NETWORK FOR OBSERVATION AND INFORMATION IN MOUNTAIN ENVIRONMENTS (GEO-GNOME)

15.1 Status of implementation for the 2017-2019 period

Since the GEO-GNOME 2017-2019 Work Plan revision, conducted as part of the GEO-GNOME workshop in May 2018, a reorganisation and reformulation of objectives and tasks were agreed upon by the GEO-GNOME co-leads and participating core group members. This review also served as an opportunity to check on progress and status on the implementation of tasks. Figure 1 (see Adler, et al 2018) summarises the scope of objectives and activities and their status:



Tasks 1.1 and 1.2 are now completed under GEO-GNOME's Objective 1. GEO-GNOME is currently working to build and establish a data and information access portal via GEOSS, thereby fulfilling new identified Task under Task 1.2. GEO-GNOME completed Task 1.3, through the publication of Sayer et al., 2018.

GEO-GNOME is currently working to define a workplan to complete Objective 2 and its associates tasks, which will be facilitated through the establishment of a GEO-GNOME Secretariat at MRI towards the end of 2019. The task is not yet completed.

Objective 3 requires foundation work to strengthen the scientific basis and define scope for monitoring and observation in mountains. This will be facilitated through its associated Tasks, starting in 2019 (tasks 3.2 and 3.3), with further work envisioned as part of task 3.1 into the next Work Programme 2020-2022. An additional workshop was identified as needed to support the foundational work under Task 3.1. This workshop will be conducted in 2020.

Task 4.1 under Objective 4 is an ongoing task. So far we have updated the basic information relating to GEO-GNOME on the GEO website, given that a new website is under development and so we will reserved further development of content until this new website is set up. For Task 4.2, this is an ongoing task, and one which become operational once we establish a Secretariat.

Nevertheless, our presence at key GEO events such as GEO WEEK in Kyoto, and hosting side events, ensure we continue to engage and communicate the value of GEO-GNOME. We have also taken steps to ensure presence online, with social media. A new logo for GEO-GNOME has now been developed, and a Twitter account (@GEO_Mountains) is also now active.

15.2 Evidence of use of the outputs and their impacts

Outputs generated from the activities carried out within GEO-GNOME in the past year have been applied by end users that are largely linked to the MRI network. Example of these output uses are:

- MRI-CDE pilot desktop study (2018). An evidence-informed preliminary assessment of an SDG indicator subset tailored to a 'sustainable mountain development (SMD)' context was performed in a desktop study from September to December 2017. Data availability and possibilities to disaggregate SDG indicator data to meaningful spatial contexts for SMD were assessed. The pilot accessed the GEO-GNOME Global Mountain Explorer tool and its shape files for analyses. See Bracher C, Wymann von Dach S, and Adler C. (2018).
- Issue Brief by MRI and the Centre for Development and Environment (CDE). Here the document presents initial steps towards localization of the 2030 Agenda to mountain areas. The Issue Brief highlights common development priorities in mountains, such as sustainable resource use, climate action, and strengthening people's livelihoods and resilience. But it also reveals significant differences based on mountains' diversity. Some of the analyses reported in this Issue Brief accessed the GEO-GNOME Global Mountain Explorer tool and its shape files for analyses. See Wymann von Dach, S., Bracher, C., Peralvo, M., Perez, K., Adler, C., and a group of contributing authors. (2018).
- The lead authors in the Chapter "High Mountains" in the IPCC Special Report on Ocean and Cryosphere in a Changing Climate (SROCC) SROCC accessed and used the shape files produced via GEO-GNOME and made available and downloadable via the GME, to produce figure maps that will be published in the special report in Sept 2019.
- The same shape files will be used by the IPCC AR6 Atlas author team to depict and map mountain regions, over which trends on Elevation Dependent Warming (EDW) in mountains will be overlaid and mapped (under development).
- The Global Mountain Biodiversity Assessment (GMBA) has also used previously generated databases and shape files that are now compiled and available via the GME created under GEO-GNOME.

15.3 Effectiveness of the governance structure and resourcing strategy

GEO-GNOME began its activities and operations with few resources for effective coordination and overview/delivery of tasks, which were largely all conducted through in-kind contributions. In the original GEO-GNOME proposal, there were few practical proposals for putting in place a governance structure that could be implemented in practical terms with the existing resources, especially since 'membership' to the Initiative remained rather aspirational and informal. This means that commitments towards contributions were often not effectively followed through. Furthermore, much of the burden regarding key decisions rested on the co-leads, without an effective mechanism in place for consultation and validation of measures or suggestions for moving forward. A 'core' group of individuals were identified and selected through their interest in the Initiative and active participation in key calls and virtual meetings, and this served as a default 'advisory body' in subsequent calls and decisions in shaping a new plan. In future, and as part of the 2020 plan, the idea is to certainly move towards a structure that allows us to identify more specifically the actual membership into this Initiative, ideally through a registry or membership mechanism that also gives visibility to members

and their role in GEO-GNOME. The governance structure will also include a rotating role for advisory board members that comprise a mix of GEO participating organisations, GEO members and individual contributions and participants.

15.4 Lessons learned and proposed actions for amendments or improvements

- Personnel in a dedicated and resourced 'project manager' role are indispensable for making sure coordination of tasks are carried out effectively, as well as followed through with the tasks that members volunteered to pursue, as well as those tasks designated to Initiative members to conduct. With the funding source now flagged for GEO-GNOME from 1 October 2019, the task for the co-leads will be to recruit a suitable project officer/manager to be hosted at MRI.
- Regular virtual meetings are needed to ensure communication among those carrying out on progress on joint tasks/activities and to connect with other members, as well as information inputs on key events and meetings attended by the co-leads. These regular meetings would also serve to gather key information and insights/suggestions from members, effectively re-calibrating the set goals and practical implementation of objectives as the need arises.
- Physical meetings at last once a year are also important to maintain momentum and relevance, particularly if these can be combined with thematic workshops and content-related matter for elaboration and contribution to set tasks.
- Active participation at GEO-led events not only ensure we continue to link to and communicate our progress with respect to the overall GEO aims, but would also provide fruitful opportunities to engage more productively with other GEO Flagships, Initiatives and Community Activities that, on the one hand have relevance for our goals, and on the other hand for us to offer useful input to their efforts.

16 GLOBAL OBSERVATION SYSTEM FOR PERSISTENT ORGANIC POLLUTANTS (GOS4POPS)

16.1 Status of implementation for the 2017-2019 period

The outcomes of GOS4POPs Initiative (2017-2019) after the first two years include:

- The inventory of existing monitoring programmes was performed including the inventory of monitored substances with respect to substances newly added to Annexes of the Stockholm Convention (with support of the ERA PLANET H2020 ERA NET and the IGOSP project);
- Two joint meetings of the GMP Global Coordination Group, the GMP Regional Organizing Groups and the GMP experts were organized in 2017 and 2018 to prepare the updated GMP Guidance document for the 3rd phase of the GMP;
- The updated GMP Guidance document was prepared (with support of the ERA PLANET H2020 ERA NET and the IGOSP project) to be submitted to the COP in 2019;
- Several studies were performed to assess existing programmes for their uncertainities (Holt, E. et al.: Using long-term air monitoring of semi-volatile organic compounds to evaluate the uncertainty in polyurethane-disk passive sampler-derived air concentrations. Environmental Pollution 2017, 220, 1100-1111) and previously collected data for long term trends (Kalina et al.: Passive Air Samplers As a Tool for Assessing Long-Term Trends in Atmospheric Concentrations of Semivolatile Organic Compounds. Environmental Science & Technology 2017, 51(12), 7047-7054, Kalina, J. et al.: Characterizing Spatial Diversity of Passive Sampling Sites for Measuring Levels and Trends of Semivolatile Organic Chemicals. Environmental Science & Technology 52 (18), 10599-10608) (with support of the ERA PLANET H2020 ERA NET and the IGOSP project);

- More studies are on-going evaluating performance and intercomparability of various sensors used in the networks as well as intercomparability of the large monitoring networks (with support of the ERA PLANET H2020 ERA NET and the IGOSP project);
- A pilot phase of the new global aquatic monitoring programme (AquaGAPS) was initiated with a support of the European Structural and Investment Funds in the Czech republic;
- The joint meeting the GMP Global Coordination Group, the GMP Regional Organizing Groups, PIs of the GEF capacity building projects and the UNEP/SSC representatives was organized in 2019 to discuss the sustainability of the monitoring programmes, the gaps and future needs.

16.2 Evidence of use of the outputs and their impacts

Three face-to-face meetings of the GMP GCG (the GOS4POPs Steering Committee) together with the ROGs and invited experts were organized in Brno between 2017-2019 which defined the expected progress of GOS4POPs.

The expert meeting on 7-9 November, 2017 set a timeline for updated GMP guidance document and its presentations for adoption (2019 - COP9 and 2021 - COP10). Adding new chemicals into the guidance was discussed together with challenges, availability of methods, and adaptation of the GMP DWH for effectiveness evaluation and data collection (2019-2020). Chemical groups (added to the original 12 groups and 11 additions from 2009, 2011 and 2013) listed as of 2015 and 2017 include hexachlorobutadiene, pentachlorophenol with its salts and esters, polychlorinated naphthalenes, decabromodiphenyl ether and short-chain chlorinated paraffins. Chemicals under review expected for listing in 2019 are dicofol, pentadecafluorooctanoic and perfluorohexane sulfonic acids with related compounds.

The GCG meeting on 30 May - 1 June, 2018 considered the outcomes of the process for revision and updating of the GMP guidance document, implementation of the GMP-3 for air monitoring, human milk survey, water monitoring and presentation of regional activities and provided directions for further revisions of the guidance document as well as for the regional strategies for GMP-3 for data identification, generation and use. The guidance for further development of the GMP DWH was also provided: The GMP data warehouse was designed to support the work of the ROGs in collecting, processing and analysing data for the purpose of developing the regional monitoring reports. Only data that have been validated and approved by the ROGs (and used for the development of the monitoring reports) are included in the GMP DWH. Data compilation (and subsequent analysis and assessment within the reports) is conducted in accordance with the six year evaluation cycle for the GMP and the next one comprises period of data covering 2014-2019 inclusive. The GMP DWH should include tools for electronic data collection, standardized data structure and code lists as well as visualization tools. Data providers are those identified by ROGs and data are reported either as annually aggregated or as primary data (and later aggregated in GMP DWH). To enable data work, the updated GMP DWH management console will be available as mid 2019. The GMP-2 data visualization will remain unchanged until GMP-3 will be published. All data from the third phase will be password protected until publication (spring 2021). After the publication of regional monitoring reports public access to the GMP DWH will be enabled (spring 2021). Available visualization tools will include those that had been used in GMP-2 (spatial distribution, data availability, summary statistics, time series, and data exports - either figure and/or maps or real data exports) to which other tools could be added to expand the scope of the analysis. Updated DWH will also comprise better referencing and provide literature sources for the data along with web links to original sources as available. This information will be included among other metadata and included in the GMP data warehouse.

16.3 Lessons learned and proposed actions for amendments or improvements

As the GMP is implemented in the 6-year cycles (the 3rd phase will be completed with the Regional report in 2021 and the Global report in 2023), the GOS4POPs will also continue in the updated form in the next (2020-2022) GEO Work Programme. Long term and high precision observations and

analysis of cycles of such pollutants in the different domains of the Earth system are required to better quantify sources and sinks; understand the impact on environment and human health and address their minimization/elimination.

A base for an effective and sustainable global system for monitoring persistent organic pollutants (POPs) concentrations in core media supporting the effectiveness evaluation of the Stockholm Convention over time has been developed during the last decade. The mandate for the effectiveness evaluation is Article 16 of the Stockholm Convention and decisions SC-5/18 and SC-7/25. The first phase of the global monitoring plan (GMP) for POPs was implemented between 2005 and 2009 and covered the 12 initially listed POPs (aldrin, dieldrin, endrin, heptachlor, chlordane, mirex, toxaphene, hexachlorobenzene, polychlorinated biphenyls, polychlorinated dibenzo-p-dioxins and dibenzofurans). The first monitoring reports using data collected over the period 1998-2008, have been published in 2009 and provided a baseline against which concentrations in core matrices will be studied over the long-term. In the second phase of the GMP (2010-2015), a particular attention was given to gathering baseline data for the ten new POPs listed in the Stockholm Convention in 2009 (hexabromobiphenyl, penta- and octa-brominated diphenylether, pentachlorobenzene, lindane, α- and β-hexachlorocyclohexane, chlordecone, PFOSs) and 2011 (endosulphane), to filling existing regional data gaps and supporting sustainability of on-going monitoring activities to enable assessment of how POPs concentrations evolved since the first monitoring reports. The results have been archived in the central GMP Data Warehouse (DWH) built for strengthening regional POPs monitoring systems supporting the effectiveness evaluation, and capacity building in regions where monitoring coverage is limited or lacking.

Nevertheless, new POPs added to the Stockholm Convention in 2013 (hexabromocyclododecane), 2015 (polychlorinated naphthalenes, pentachlorophenol, hexachlorobutadiene) and 2017 (decabromodiphenylether, short-chain chlorinated paraffins, hexachlorobutadiene) are posing additional challenges including new consideration of the monitored core matrices, development and standardisation of sampling and analytical methods, further development of the GMP DWH to support data collection and analysis and setting up the baseline levels for these compounds. All of these will require close collaboration of existing monitoring programmes.

With the above in mind, the proposed Initiative on the Global Observation System for Persistent Organic Pollutants (GMP4POPs) is aimed to: i) increase the availability and quality of Earth observation data and information needed to track these chemical pollutants and anticipate changes to the environment; ii) harmonize metadata production, archiving and sharing networks; and iii) develop advanced services in support of the policy mandate through Stockholm Convention on Persistent Organic Pollutants.

17 GLOBAL URBAN OBSERVATION AND INFORMATION (GUOI)

17.1 Status of implementation for the 2017-2019 period

Global Urban Supersites Initiative

To estimate urban extent, change detection, and assess risks associated with natural disasters, air/water qualities, and health hazards; 8 megacities selected (Los Angeles, Atlanta, Mexico City, Athens, Istanbul, Sao Paulo, Beijing, Hong Kong); Website incl. data repository launched (www.indstate.edu/cuec/UrbanSupersites/home.html). Global Urban Supersites have recently been funded through two international projects:

- “Earth Observation for Global Urban Services” (EO4Urban)”, ESA Invitation To Tender (ITT) AO/1-7829/14/I-NB DUE – Innovators III, 1/1/2015 – 12/31/2017.
- “Improving the Estimation of Impervious Surfaces Using Optical and Polarimetric SAR Data in Humid Subtropical Urban Areas”, Hong Kong Research Grants Council, 1/1/2016-12/31/2017.

Global Urban Remote Sensing Laboratory (GURSLab)

Aiming at developing a tool for online processing, visualizing, and sharing of urban data sets. This project has been recently funded with €999,870, entitled "Thematic Urban Observation Hub (TUrbO-Hub) - Platform for the Mapping, Analysis, Monitoring and Assessment of Urban Development," PI, Thomas Esch, DLR, with participation of several co-Leads of SB-04, through ESA Invitation To Tender/1-7870/14/I-NB Thematic Exploitation Platforms (TEP) program, 1/1/2015 – 12/31/2016.

Global Human Settlement Layers using satellite data

The US (NOAA National Geophysical Data Center) has produced global radiance calibrated VIIRS low light imaging products: 1) nightly, 2) monthly, and 3) annually. NGDC is still developing algorithms for producing research quality nighttime lights, with background noise, fires, and aurora removed. The World Bank (Sustainable Development Unit) is using the radiance VIIRS products to rate the success and longevity of electrification projects in India, Vietnam and Indonesia;

- The European Commission (JRC) has contributed its whole image repository for information extraction (Global Human Settlement Layer (GHSL) project). This data (derived from fine scale optical images) cover 100's of millions of km2 with resolution ranging from 0.5 to 100 m;
- The Global Urban Footprint (GUF), the Global Urban Area Map (AGURAM), and the Global Urban Extent, generated by Germany Space Agency (DLR), include user groups of the World Bank Group, the European Environment Agency (EEA), DG Regio of the European Commission, the International Society of City and Regional Planners (ISOCARP) etc. Moreover, DLR has produced a time-series analysis (1975-2010) describing the spatiotemporal development of 26 mega-cities, also setting up a global data base of binary settlements masks (Global Urban Footprint) derived from SAR data of the TanDEM-X mission (grid cell size: ~50x50 m);
- Sweden (KTH) and Italy (University of Pavia) have developed an "Urban Extractor" to map global urban extent at 30m resolution using ENVISAT or Sentinel-1 SAR data;
- Japan (GEO Grid/AIST, University of Tokyo) has developed the ASTER Global Urban Area Map (AGURAM). 3734 cities of more than 0.1 million people urban area have been mapped using ASTER (15m). Gaps will be filled using PALSAR data.
- U.S. Geological Survey has recently released the National Land Cover Database (NLCD) 2011 products, including impervious surface changes between 2001-2006, and 2006-2011. The NLCD urban land product has been widely used by many scientific studies including land cover change and climate change impact in the United States and around the world. Many GEO participants are the users of NLCD products.

Other achievements include:

- Reference/Text book "Global Urban Monitoring and Assessment through Earth Observation" (published in 2014) and "Remote Sensing for Sustainability" (published in 2016), with contributions from GUOI participants.
- Annual workshop/symposium focusing on GUOI (IGARSS 2018, EORSA 2018, AAG 2017-2019).
- The alpha version of the Global Human Settlement Layer (GHSL) produced by Landsat data 1975-2014 has been released. The user list includes circa 30 research groups inside World Bank, UN agencies, European Commission, several national space agencies and other governmental and academic entities.
- EXTREMA offers real time surveillance and evaluation of heat health risk during the summer and heatwaves. EXTREMA is a tool for City Authorities for central management of heat waves and Citizens/Visitors for personalized heat risk assessment. It uses real-time satellite data, along with other model and city-specific data to estimate the temperature, humidity, and discomfort index for every square kilometer in the city. Through the

EXTREMA mobile application, citizens receive a personalized heat stress risk for their current location and recommendations on measures to reduce their risk. Recommendations are based on those issued by the World Health Organization (WHO) or provided by City authorities. EXTREMA has been launched in Paris, Athens and Rotterdam (2018) and will be launched in Milan and Lisbon (2019). It is expected to scale up in 2020-2022. .

- Students and young researchers worldwide attracted to GEO Urban Symposia and various activities through the GEO Trust Fund.
- The International Program on Global Urban Observation and Public Health (IPUP) was initiated in Changsha, China, in June 2014, aiming at monitoring global urban environment and public health concerns from space and with in situ measurements. This initiative has recently been proposed for funding through an international cooperation project by the Ministry of Science and Technology of China.

18 GLOBAL WILDFIRE INFORMATION SYSTEM (GWIS)

18.1 Status of implementation for the 2017-2019 period

The GWIS services are available through its website: http://effis.jrc.ec.europa.eu/applications/global-viewer. In the period 2017-2019, the following GWIS activities were considered:

Task 1

Establish and further develop a prototype Global Wildfire Information System (GWIS) providing harmonized fire information (e.g. fire danger) – building on initial activities of the European Commission in the European Forest Fire Information System and the Global Observation of Forest Cover-Global Observation of Land Dynamics Fire Implementation Team (GOFC-GOLD Fire IT).

State of implementation: Work well in progress according to plan, with continuous development of the GWIS web services.

Task 2

Promote the networking of major national and regional fire information providers by organizing an annual workshop convening key international organizations and initiatives (e.g. GOFC-GOLD Fire IT) and national and regional providers, e.g. Australia, Canada, China, Central and South America and South Africa.

State of implementation: Activity implemented through the organization of GWIS/GOFC Fire IT meetings in London (2017) and Washington DC (2018) and the planned meeting in Frascati, Italy (2019).

Task 3

Establish operational links and, if possible, arrangement with other wildfire communities dealing with wildfire aspects at global scale (e.g. burned area assessment, emission estimation).

State of implementation: Links to the ECMWF were established and data on wildfire emission are published in GWIS. Ongoing work is ongoing with other emissions communities (e.g. GFED) to make the data available through GWIS.

Task 4

The wildfire fuel map developed by the University of Alcala is displayed in the GWIS web site and the data available through appropriate links to the scientific article and datasets.

Further develop the GWIS by integrating and harmonizing regional wildfire data information sources.

State of implementation. Only EFFIS is fully integrated with GWIS. Contact exist with other national/regional information services and data are shared with those, such as the Advance Fire Information System (AFIS; https://afis.co.za/) in South Africa.

Task 5

Develop, implement and promote the establishment of mechanisms for interoperability and communication among national, regional and global wildfire information systems following OGC standards and guidelines, and the GEOSS Data Sharing Principles.

State of implementation: Collaboration is ongoing with the GEOSS Portal in which GWIS data can be accessed and displayed.

Task 6

Coordinate and promote capacity building and training activities in close cooperation with the GOFC-GOLD Fire Implementation Team regional networks and the EFFIS network.

State of implementation: GWIS is funding the participation of the GOFC Fire IT regional network representatives to the annual GWIS/GOFC Fire IT meetings. Furthermore, when requested, GWIS contributes to the organization and funding of Regional Network meetings, such as that of SAFNET (South Africa) in April 2018.

18.2 Evidence of use of the outputs and their impacts

Users are already incorporating GWIS products in the daily routine for wildfire management at national or regional scales. The graphic shows the geographical dispersion of the users. The collaboration with UN organizations such as FAO or ISDR can provide a large impulse to the usage of the system by national wildfire management administrations. The example of EFFIS in Europe, where most countries have a national wildfire management system, shows the potential of a regional or global system that provides information. EFFIS is currently used by 192 distinct countries worldwide and has about 300000 users. The potential use of GWIS worldwide is much greater than that of EFFIS, as it can support many countries that do not have a wildfire monitoring system in place.

Although GWIS is not yet fully operational, the number of users has greatly increased during the last year.

In 2018, The number of unique visitors of the web site was above 11000, from 144 distinct countries. The figure below shows the spatial distribution of countries accessing GWIS in 2018.

Decisions on intervention in relation to wildfires are taken at the European Response Coordinating Centre (ERCC) on the basis of available information in GWIS. Information from GWIS is routinely used for the production of the maps used by the European Commission Humanitarian Office, whose operational arm is the ERCC. The following link provides information on the use of GWIS by ERCC regarding fires in e.g. Australia, USA. Daily maps are available for fires in e.g. USA (2016), Chile, Australia, California (USA), South Africa, Canada (2017), California (2018). In Europe, EFFIS, with the same scheme as GWIS, covers the operational needs of the wildfire management administrations and the ERCC.

As an example of the success in the initial development of the system, GWIS was included in the GEO Highlights 2016-2017 report Request for access to information and/or updates of the system are received by the JRC from nearly all locations worldwide, e.g. South Africa, Australia, USA (Pacific coast), Middle East countries, Chile, etc.

Although GWIS is not fully operational, it is routinely used by many administrations worldwide as shown by the number of countries that access its services. The next years will be decisive for the dissemination of information about the system and the strengthening of relations with final users via FAO and the GOFC Fire IT networks. Also, despite its novelty, either the GWIS data or the system itself have already been referred to in 35 scientific articles and literature.

19 OCEANS AND SOCIETY: BLUE PLANET

The creation of the "Oceans and Society: Blue Planet" Task was an initiative of POGO in 2011, to coordinate all the existing ocean observation programmes within GEO, to add new ones to the GEO portfolio, and to create synergies between them. GEO Blue Planet was introduced formally into the GEO work programme in 2012 (as SB:01) (GEO, 2014). The GEO Blue Planet Secretariat was established in late 2015 by the U.S. National Oceanic and Atmospheric Administration (NOAA) leading to GEO Blue Planet being incorporated in the GEO work programme as an initiative in 2017 (GEO, 2017).

In 2017, GEO Blue Planet created a formal Steering Committee and Advisory Board composed of ocean and coastal-observers, social scientists and end-user representatives from a variety of stakeholder groups, including international and regional organizations, NGOs, national institutes, universities and government agencies. GEO Blue Planet has also established a web presence (see: www.geoblueplanet.org and @GEOBluePlanet on Twitter). Working groups have been established as outlined above and the development of decision support tools and data services is underway.

Through the efforts of Steering Committee, Advisory Board, Working Groups and Secretariat, GEO Blue Planet has been working to provide a networking service to the ocean and coastal observing community and other stakeholders. These efforts include supporting the development of partnerships and sharing of information. Though difficult to quantify, this service has played an important role and is recommended as a key focus for the initiative to play moving forward (GEO Blue Planet, 2017, 2018).

Major events and publications that have been supported by GEO Blue Planet in recent years are summarized below.

Symposia

GEO Blue Planet hosts symposiums every one to two years in different regions for the purpose of increasing regional linkages, promoting linkages between stakeholders and the observing community and gathering community feedback on the focus of GEO Blue Planet activities.

- Kick-off Symposium - Ilhabela, Brazil, 2012
- 2nd GEO Blue Planet Symposium – Cairns, Australia, 2015
- 3rd GEO Blue Planet Symposium – College Park, MD, USA, 2017
- 4th GEO Blue Planet Symposium – Toulouse, France, 2018

Workshops

GEO Blue Planet works with various partners to organize workshops that aim to identify stakeholder information needs, support the development of decision-support tools and identify technology and data gaps.

- Workshop on Implementing and Monitoring the Sustainable Development Goals in the Caribbean: The Role of the Ocean – St. Vincent and the Grenadines, 2018
- Workshop on Understanding Flooding on Reef-lined Island Coasts – Honolulu, HI, USA, 2018
- Workshop on Sargassum and Oil Spills Monitoring for the Caribbean Sea & Adjacent Regions – Mexico City, Mexico, 2018
- Workshop on Technologies for Observing and Monitoring Plastics in the Oceans – Brest, France, 2018

Publications

- Blue Planet: Oceans and Society, 2014. URL: http://www.cambridgescholars.com/oceans-and-society

- GEO Blue Planet (in press). Ocean Observing for Societal Benefit. Journal of Operational Oceanography Supplemental issue.
- The role of stakeholders and actors in creating societal value from coastal and ocean observations. Frontiers in Marine Science.
- Earth Observation Applications and Global Policy Frameworks. Washington, DC: American Geophysical Union.
- Writing a Communication Strategy: A Step-by-Step Guide and Template, Tailored for International (Marine) Science Organisations. URL: https://www.oceandocs.org/bitstream/handle/1834/10736/OCU%20Communications%20Strategy%20Guide_2017.pdf?sequence=1&isAllowed=y
- GEO Blue Planet (2018). What can the ocean tell us? Why ocean observation products and services are vital for us and our planet. URL: https://3iiz1x2nd4vl3b8ewe4frxdf-wpengine.netdna-ssl.com/wp-content/uploads/2018/05/Blue-Planet-Ocean-Observation-brochure-221217-WEB.pdf

20 ACCESS TO CLIMATE DATA IN GEOSS

- Status of implementation for the 2017-2019 period:
- Successfully engaged the WGCM Infrastructure Panel of WCRP, which is responsible for describing infrastructure requirements and defining technical specifications for WCRP Coupled Model Intercomparison Project (CMIP6).
- Started the dialog between WGCM Infrastructure Panel of WCRP and GEOSS team.
- Started the registration process for the climate simulation data, especially those are being produced by CMIP6 participants, in the GEOSS yellow page system.

21 ADVANCING COMMUNICATION NETWORKS

Task1: Document existing communication infrastructure within GEOSS and develop concept architecture for a worldwide communication network of networks available to GEOSS. This concept should incorporate how to complement existing use of the Internet and operational data transmission services such as the WMO Information Systems (WIS) and GEONETCast;

- This is now more a lesson learned document for delivering global EO services which is still in development.

Task 2: Draft a plan delineating how individual services could complement the other networks for the benefit of GEO Members, outlining requirements for operation, maintenance and administration;

- Still to be completed

Task 3. Engage with AfriGEOSS and potentially other Flagships and Initiatives to assess network requirements and possible improvements of data dissemination;

- The ACN group has surveyed a number of research establishments and facilities across Africa, who are members of AfriGEOSS, to understand their connectivity requirements. This work was led by representatives of ASREN.

Task 4. Support AfriGEOSS and the African National Research and Education Networks (NRENs) to discuss existing communication infrastructure, requirements and developing activities in the region;

- GÉANT has worked with Ubuntunet Alliance and the Kenyan Research and education network (KENET) to enable native support for EUMETCast services on their network. This resulted in RCMRD in Kenya acquiring EUMETCast data via the R&E internet, rather than solely via satellite.

Task 5. Investigate state of art information technologies, such as cloud services, available through existing and potential contributing networks and how these may be applied to GEOSS.

- GÉANT presented at GEO Plenary on latest GÉANT services as well as AOGEOSS and AfriGEOSS latest developments

Task 6. Engage with GEOSS data providers to seek potential cooperation with and requirements to the GEOSS communication networks;

- GÉANT led a communications infrastructure requirement gathering session at GEO data providers workshop in 2018.

Task 7. Discuss further development and seek cooperation with new GEO partners on the initial progress and findings of this task (e.g., Single Sign On, Cloud Computing, Multi Cast), which were reported at the 16th session of the WMO Commission for Basic Systems (CBS) held in November 2016.

- GÉANT worked with AOGEOSS and AmeriGEOSS to investigate existing and future network requirements. GÉANT also established contact with EuroGEOSS and NEXTGEOSS projects to offer support for t&i services. GÉANT also facilitated a meeting between the GEO secretariat and R&E global cloud coordination group to explore cloud services. During this period the WMO presented on latest cloud services they have developed for the GEO data providers workshop in 2018.

22 CITIZEN OBSERVATORIES AND CROWDSOURCING

Task 1: Scoping and initiation of a global GEOSS Citizen Science inventory – reviewing already existing Citizen Science projects that are of relevance to GEOSS and providing access to the most relevant information

- Produce a collection of exemplary Citizen Science projects that can be of use in GEOSS: a study, funded by the JRC, has resulted a collection of over 500 CS projects in the environmental domain. This has been made public.
- Report on which Citizen Science projects can provide inputs for monitoring and supporting the SDGs: an international workshop was held at IIASA in 2018 bringing together experts from the SDG and citizen science community. A publication is in progress.

Task 2: Analysing existing Citizen Science projects that are relevant for GEOSS and specifying recommendations for Citizen Science to cover gaps in in-situ observations

- This work is ongoing.

Task 3: Providing guidelines for using and managing Citizen Science in GEOSS – Part 1: use of existing standards for data collection and management:

- Conduct interoperability experiments and recommend how to offer access to Citizen Science through GEOSS: this work is ongoing within the OGC supported by members of the activity and WeObserve and the Wilson Center. Earth Challenge 2020 was introduced to the OGC IE in order to support alignment with the citizen observatories.
- Conduct interoperability experiments and produce recommendations on a single sign on mechanism: these efforts are continuing, particularly within the LandSense CO and the NextGEOSS projects.

The activities of this GEO Community Activity (CA) have matured and generated a critical mass of committed members and practitioners as well as supporting project resources such that this CA is now ready to transform into a GEO Initiative, with a detailed work programme and more ambitious goals.

Through this GEO Initiative we intend to leverage pilot activities to help citizen science scale globally through the GEO platform.

23 COPERNICUS ATMOSPHERE MONITORING SERVICE

CAMS combines observations from satellite remote-sensing and from other sources and numerical models to deliver value added information services about atmospheric composition and its changes over the globe and, with refined resolution, over Europe.

Specifically, it delivers the following services:

- daily production of near-real-time analyses and forecasts of global atmospheric composition;
- reanalyses providing consistent multi-annual global datasets of atmospheric composition with a frozen model/assimilation system;
- daily production of near-real-time European air quality analyses and forecasts (including also pollens) with a multi-model ensemble system;
- reanalyses providing consistent annual datasets of European air quality with a frozen model/assimilation system, supporting in particular policy applications;
- products to support users in the environmental policy sector, adding value to “raw” data products in order to deliver information products in a form adapted to policy applications and policy-relevant work;
- solar and UV radiation products supporting the planning, monitoring, and efficiency improvements of solar energy production and providing quantitative information on UV irradiance for downstream applications related to health and ecosystems;
- greenhouse gas surface flux inversions for CO2, CH4 and N2O, allowing the monitoring of the evolution in time of these fluxes;
- climate forcing from aerosols and long-lived (CO2, CH4) and shorter-lived (stratospheric and tropospheric ozone) agents.

All the products can be found on the CAMS website at http://atmosphere.copernicus.eu using the catalogue search tool. Support functions are also available to the users.

User uptake is continually monitored in CAMS and through surveys. At the end of 2018 number of registered users is in excess of 10500. On a quarterly basis, the number of “active” users (effectively downloading data) is in excess of 2600. But this only represent the direct users: the audience of CAMS is much larger. CAMS air quality bulletins aired several times daily on Euronews are seen by 18 million users. CAMS global air quality forecasts are also used by the default Apple “weather” iphone app as well as by The Weather Channel, with audience of several hundred million people. Many more smartphone applications relying on CAMS data have numbers of downloads between tens and hundreds of thousands. In short, CAMS is now a mainstream global source of air quality monitoring and forecasting information.

CAMS supports several policy areas that are pivotal for the European Union, especially in the areas of air quality, of greenhouse gases and of the ozone layer. Working with the World Meteorological Organization and the World Health Organization, CAMS intends to support monitoring the indicators of the Sustainable Development Goals which are within its thematic areas.

The two key highlights of 2018 were:

- CAMS has released in September its global reanalysis of atmospheric composition, covering the period 2003 to 2018. It is a quite unique dataset, which allow users to look at trends and impacts over the past 15 years -the period with satellite instruments measuring atmospheric composition.

- The uptake of observations from the Copernicus Sentinel-5P satellite in the CAMS operational streams. Sentinel-5P is now an essential input contributing to the quality of most CAMS products and to the resilience of the system in case of issues.

24 COPERNICUS CLIMATE CHANGE SERVICE (C3S)

2018 has been a critical year for C3S. The Delegation Agreement with the European Commission, which kick-started C3S, was signed in November 2014. After 3 years of development and pre-operational preparation, C3S migrated from a concept into an operational Service during 2018. In particular, Europe's Climate Data Store (CDS), has been launched in June 2018. The CDS is a one-stop-shop for past, present and future climate information. The CDS greatly improves access to climate data and tools, is open and free for all to use, and will change the ways in which society can benefit from Earth observations and climate science.

The CDS is a cloud-based tool that allows policy-makers, businesses and scientists to browse and combine online petabytes of raw data, build their own applications, maps and graphs online in real time, and access all relevant climate information at the push of a button.

The CDS includes a toolbox enabling users to build their own web-based apps, and to analyse, monitor and predict changes in climate drivers – such as surface temperature and soil moisture – and their impact on business sectors such as energy, water management or tourism. Transforming data into climate-related information is therefore key added value of the Climate Data Store.

At the time of writing, the CDS has already 8200 registered users having downloaded more than 3 Pbytes of data and products.

The other highlights of the year 2018 have been the systematic production of monthly climate bulletins on the C3S website and in partnership with Euronews, as well as the publication of the first European State of the Climate 2017 (published in April 2018), compiled by the Copernicus Services at the European Centre for Medium-Range Weather Forecasts (ECMWF), C3S and the Atmosphere Monitoring Service (CAMS), with some support from the Marine Environment Monitoring Service. This report is available at https://climate.copernicus.eu/CopernicusESC and covers two main themes: The Climate in 2017 and Headline Climate Indicators.

C3S is now contributing routinely to the WMO State of the Climate, as well as the GCOS climate indicators portal.

25 EARTH OBSERVATIONS FOR MANAGING MINERAL RESOURCES

Task 1: A preparatory work for global mineral mapping program using existing (ASTER) or future missions, on the model of the Australian Mineral Map performed by CSIRO using ASTER imagery, to be delivered to the GEO data archive.

- A proposal for funding a Global Geoscience Map has been refused by NASA. ASTER mineral mapping over parts of China and Greenland using the ASTER Version 2, using green and dry vegetation unmixed methods developed at CSIRO.

Task 2: Developing a global spectral library of soils for future quantitative soil spectroscopy from laboratory to spaceborne applications, towards the definition of possible product standards for global, public hyperspectral satellite mapping of soil surface composition

- The Global Soil Spectral Library (GSSL) is going on. Mediterranean SSL under GEO-CRADDLE H2020 project (http://datahub.geocradle.eu/dataset/regional-soil-spectral-library). This SSL consists of 4000 soil samples from Israel, Turkey, Cyprus, Greece, Bulgaria, Serbia, Albania and Egypt. All the samples within the SSL were measured under the CSIRO

protocol which enables a merging of SSLs from different spectrometers, laboratories and conditions.

Task 3: The definition, or refinement, of a set of area-specific essential variables to be validated by the CoP and GEO in view of measuring and monitoring the status of mineral resources assessment and exploitation.

- On going, through the GEOESsential EC H2020 project

Task 4: The definition of methodologies and tools to map these essential variables from existing and future sensors, including citizen observatories.

- No specific progress made, due to lack of dedicated project over the period.

Task 5: A global mining waste inventory program by adapting e.g. the PECOMINES project methodology to currently available sensors (Landsat TM, Sentinel -2) and/or future high spectral resolution missions.

- No progress made to date. It has not been possible so far to arouse the interest of the competent authorities, despite lobbying efforts

26 EARTH OBSERVATIONS FOR THE WATER-ENERGY-FOOD (W-E-F) NEXUS

Overall assessment

Although there has been only limited time and financial support allocated for these activities some progress has been made in the completion of the final Future Earth/Belmont Forum W-E-F Nexus cluster report and in outlining a path for the implementation of W-E-F Nexus data and information systems. In addition, a paper has been prepared and submitted to a Frontiers special issue on the W-E-F Nexus that outlines a plan and design for a W-E-F data and information system (WEFDIS).

Resource Summary

The CA continues to advance through in-kind support. NASA has provided some support for the follow-up to the Future Earth W-E-F Nexus workshops. Currently, support is being sought for the printing of the final Future Earth/ Belmont Forum W-E-F Nexus report. In the longer term the W-E-F Nexus Science Community will seek support through proposals to appropriate funding agencies.

Progress of activities

- The W-E-F Nexus report from the Future Earth Cluster project is being finalized and will be printed in 2019. This report includes a number of recommendations related to data services that this Community Activity will explore.
- A special issue of the Frontiers open journal on this topic is nearing completion. At present, more than 20 papers have been approved and at least 6 more are progressing through the review and finalization stages. The focus of the issue is to explore the balance between the role of data, information, and policies for advancing the implementation of the W-E-F Nexus.
- Some members of the EO4WEF group will participate in the Water Futures conference in Bangalore, India in 2019 and will explore interest there in moving forward with a pilot project to test a WEFDIS in that region.

More generally, in moving forward some of the steps that will be taken include:

- Selecting several areas for pilot projects and initiating coordination in these areas to obtain resources and facilitate the implementation of the pilot project.
- Clarify the data and software needs for a data and information system through meetings with user groups either generally or within specific basins.

- Building on the effort that has gone into developing an interest for this activity in one or more sub-basins of the Lake Winnipeg Basin carry out an assessment to determine if one of these sub-basins could serve as an early pilot project.
- Participate in scientific conferences to encourage the engagement of the scientific community with W-E-F Nexus issues.

User engagement

A user engagement workshop is being discussed for the Lake Winnipeg Basin. In addition, the EO4WEF project will seek to establish a W-E-F Nexus Community of Practice (CoP) to begin coordinating these W-E-F Nexus activities among interested people. Other Stakeholder consultation events and the co-design of data products will promote user engagement. One of the goals of the CoP will be to develop interest among younger scientists who will provide leadership for W-E-F Nexus activities beyond the 2020-2022 time frame.

27 GLOBAL ECOSYSTEMS AND ENVIRONMENT OBSERVATION ANALYSIS REPORT COOPERATION (GEOARC)

Ecological and environmental monitoring and analysis has been partially conducted in various GEO activities, such as AfriGEO, AmeriGEO, AOGEO, EUROGEO, GEO BON, GEOGLAM, GFOI. For public decision-maker support, a user-oriented easy-reading and comprehensive report is required. Following the Global Ecosystem and Environment Observation and Analysis Annual Reports, which were launched by the Ministry of Science and Technology of the People's Republic of China in 2012, the GEOARC has been adopted as a Community Activity in the 2017-2019 GEO Work Programme. There are series outputs have been released in 2018.

- Regional Ecosystem Trends along the Belt and Road
- Supply Situation of Maize, Rice, Wheat and Soybean
- Temporal Dynamics and Spatial Distribution of Global Carbon Source and Sink

The Annual Reports in 2018 mainly focus on the typical ecological environment elements and hot environment issues, the dynamic monitoring and comprehensive analysis was conducted using the advantage of the earth observation technology. The Annual Reports were published, and the related datasets have been released on the website (http://chinageoss.org/dsp/home/index.jsp) and published by the Global change scientific research data publishing system (http://www.geodoi.ac.cn/WebCn/), all of which are open to public for free. Until June 17, 2018, according to incomplete statistics for 2012-2017 Annual Reports, more than 1000 reports have been made by major news media, the downloads of Annual Report were 11107, and the downloads of related products were 12,136, and the downloaded datasets reached 124.95TB.

The Annual Report has made a positive impact in China and abroad, and has attracted extensive attention from the industry, the public and the media. The Annual Report has been widely publicized through international cooperation, and its international influence has been increasingly enhanced, highly recognized by international peer experts and closely watched by international organizations. In order to keep good continuity and cooperation, the Annual Reports during 2020 to 2022 have been planned and organized, which has great significant for the implementation of SDGs.

28 GLOBAL AGRICULTURAL DROUGHT MONITORING

The task team was mainly from Asian and the activities was carried out in Asia as well. The Team took the occasions of the GEOSS AP symposia during 2017-2019 and promoted the drought mechanism in Asia with the UNESCAP. Mongolia and Sri lank were the pilot case study areas and have built their own drought monitoring systems with the support partially from this task. One training workshop was organized in the Beijing Normal University in 2017 which brought around 20

participants from Asia and Africa. In the large community, the FAO is running a remote sensing based agricultural drought monitoring system. The NOAA is producing the drought indices, such as VCI, TCI and VHI in global coverage. The Chinese community is producing the ET based drought monitoring covering the region or the global in coarse resolution. These efforts are expected to be coordinated through GEO framework in the new GEO work plan.

29 GLOBAL FLOOD AWARENESS SYSTEM (GLOFAS)

The main achievement of 2018 was that GloFAS became fully operational in April. This means a very high service level and 24/7/365 support. 2018 also saw a major model upgrade which resulted in the release of GloFAS v2.0 on 14 November 2018. The release included a new calibration, updates to the initialisation, a new long-term reanalysis and better documentation. The GloFAS interface was also upgraded to improve the user experience. In addition, GloFAS now delivers WMS-T as web map service which enables the users to import layers into their own applications.

The interaction with the GloFAS user community has been very intense and fruitful during the period. A workshop on "Hydrological Services for Business" was held in May 2018, which brought together users and developers of the system to discuss the current and future developments of the system.

GloFAS shares data with a number of research groups, institutions and NGO's all over the world. This includes, for example, CEMADEN (Brazil), SENAMHI (Peru), the Regional Integrated Multi-Hazard Early Warning System for Africa and Asia (RIMES), Red Cross/Red Crescent Climate Centre, and many more. These are using the output for their own decision making and are refining the product for further dissemination. GloFAs now has over 2000 registered users from all over the world. A major addition to the launch of GloFAS v2.0 was the release of a long-term reforecast dataset that enabled users to, for example, re-calculate their customised flood thresholds and perform their own assessments of forecast performance for their area of interest.

30 GLOBAL FLOOD RISK MONITORING (GFRM)

The Global Flood Risk Monitoring (GFRM) community activity, directly supported by NASA Research Opportunities in Earth and Space Science (ROSES) grants, addresses various aspects of global flood risk. The 2018 and 2019 activities include targeted opportunities and ad hoc instances to invite and organize community contributions of data and data products, geospatial analytics, and services in support of real world flood events or related long-term studies. In some instances these were significant large-scale or extended regional events related to tropical storms or seasonal variability.

Ongoing efforts in 2019 include expanding the community contributions to build a sustainable data sharing architecture and knowledge platform to transform actionable information. The Committee on Earth Observation Satellites and the Coordination Group for Meteorological Satellites are the primary satellite contributors to the GFRM. Public, private and civil society groups are also playing an active role.

There are several on-going pilot projects:

The first one is 'Towards a Global Flood and Flash Flood Early Warning Early Action System driven by NASA Earth Observations and Hydrologic Models', which aims to enhance analysis and decision making of localized flash floods with globally consistent user methodologies and open data sets, including development of a historical flash flood dataset, an inter-comparison of forecasts, and a prototype early warning framework. Demonstration of forecast-based financing mechanisms in target GEO countries. Users and stakeholders include Concern World/Humanitarian; Red Cross Climate Center; International Federation of Red Cross Red Crescent; Peru Red Cross; Bangladesh Red Cross; European Centre For Medium Range Weatherforecast/GLoFas, and UN World Food Programme.

The second one is 'Global Rapid Flood Mapping System with Space borne Synthetic Aperture Radar (SAR) Data', which streamlines a SAR-based end-to-end automated flood response process, making available flood extent mapping products to select users. The demonstration outcome is an optimal SAR framework for future near real time flood responses to augment modeling methods and flood risk analysis in 10 GEO member countries. Users and stakeholders include: The World Bank/International Bank for Reconstruction and Development ; Spanish Red Cross/Disaster Management; Ecuador Escuela Superior Politécnica del Litoral; South Korea Ewha Womans University; Singapore Nanyang Technological University; S Korea Water Resources Corp.; Japan ICHARM-UNESCO; and Netherlands Red Cross.

The last one is 'Integrating Global Remote Sensing and Modeling Systems for Local Flood Prediction and Impact Assessment'. Users and stakeholders include: the World Food Program, the World Bank, the International Red Cross/Red Crescent, the European Commission's Global Disaster Alert and Coordination System, the GeoSUR project (for Latin America).

The CA will continue to support and manage outreach efforts to expand participation in the CoP, welcoming additional pilot, demonstration and integration projects.

31 GLOBAL MANGROVE MONITORING

Previous Achievements include:

- Secured funding for annual mangrove monitoring in South Asia and preliminary classification of South Asia completed
- Secured funding from USGS to perform global mangrove mapping and monitoring
- Mangrove mapping of the Pine Islands in Bahamas completed
- Mangrove monitoring of Puerto Rico started
- Monitoring of mangrove forests of Continental United States from 1980 to 2015 completed – Paper published
- Global annual mangrove monitoring began

32 GLOBAL MARINE ECOSYSTEM MONITORING (GMEM)

GMEM that was listed as one of the GEO Work Programmes in 2018 with an expectation to realize a Technique-Service-Community-Application framework for monitoring and understanding global marine ecosystem. Status of implementation of planned activities and outputs are as follows:

- Developed preliminary theoretical and practical framework of the oceanic lidar in the period of 2017-2019.
- Held the International Workshop on Ocean Optical Remote Sensing in 2018.
- Preparing the 6th International Symposium on Atmospheric Light Scattering and Remote Sensing that will be host in 2019.

33 GLOBAL LAND COVER (GLC)

The achievements made by this community activity include the following events:

- GEO/ISPRS Workshop on Analysis and Application of Global Land Cover Information, September 24-25, 2016, Beijing, China
- ISPRS/GEO Workshop on Collaborative and Dynamic Land Cover Information Services Supporting UN Sustainable Development Goals, Jinan, China, 16th Sep. 2017
- ISPRS/GEO Seminar, Validation of Global Land Cover Data, Sept 14-16, 2017, Beijing

- ISPRS/GEO Seminar "Capacity Building for High-Resolution Land Cover Inter-comparison and Validation", September 3, 2018, Nairobi, Kenya

The representative publications include:

- Chen J, Cao X, Peng S, et al. Analysis and applications of GlobeLand30: a review. ISPRS International Journal of Geo-Information, 2017, 6(8): 230.
- Chen J, Li S, Wu H, et al. Towards a collaborative global land cover information service. International Journal of Digital Earth, 2017, 10(4): 356-370.
- Kilsedar C E, Bratic G, Molinari M E, et al. Open educational resources for the validation of global high-resolution land cover maps. Report in PeerJ Preprints, 2018.

And some major presentations include:

- Chen J., A comprehensive measurement of progress towards SDGs by China at a county level, invited presentation at the panel 'Earth observations in Support of the Sustainable Development', 2018 GEO Week (Oct 31--Nov. 2, 2018, Kyoto, Japan).
- Chen J., Comprehensive measurement of Deqing's progress towards 2030 SDGs, presentation at UN World Geospatial Information Congress, Deqing China, Nov., 20, 2018.
- Ban, Y. Earth Observation & GeoSpatial Big Data for Monitoring SDG Indicators. presentation at UN World Geospatial Information Congress, Deqing China, Nov., 20, 2018.

34 GLOBAL WHEAT PEST AND DISEASE HABITAT MONITORING AND RISK FORECASTING

This community activity aims to optimize the crop pests and diseases control and management, further to improve the efficiency (and therefore cost) of resource use, and protect environmental and human health (by reducing release of chemical pesticides into ecosystems). It will provide a comprehensive approach to dealing with major agricultural pests combining cutting edge technologies, modelling and biological information. It developed pest and disease monitoring, forecasting and management service products on global, national and regional levels including dynamic crop pest and disease warning and risk assessment maps.

During 2017-2019 period, this community activity integrated multi-source Earth observation data, including meteorological data, field data, and remote sensing data, and self-developed models and algorithms for wheat aphid and rust monitoring and forecasting, and released the thematic maps and reports to show the spatial distribution and damage levels of pest and disease. Our outputs illustrated that, during April to May 2018, pests and diseases slightly occurred in ten main wheat production countries, including Russia, France, Turkey, China, Pakistan, United States, Germany, Iran, Uzbekistan, and United Kingdom.

These achievements have been released in the official crop pests and diseases website (http://www.rscropmap.com/) and wechat official account (rscrop_english). Worldwide users are able to access the result of wheat aphid and rust monitoring and risk forecasting products, and benefit from the thematic maps and scientific reports.

35 HIMALAYAN GEOSS

A regional workshop was organized on 10 – 11 August 2017 at ICIMOD, Kathmandu, Nepal. The workshop included participants from seven regional countries, global SERVIR network, GEO Secretariat Director including the representatives of private sector. A draft implementation framework was developed based on the deliberations at the workshop. Himalayan GEOSS is drawing inputs mainly from the initiative like SERVIR-HKH which has been working on promoting Earth observation applications and capacity building in the region. Many of its activities are contributing to GEOSS objectives. Some of the key interventions of SERIVR-HKH such as drought monitoring and

early warning system, stream flow prediction system, and regional land cover monitoring system are directly contributing to the societal benefit areas of food security and sustainable agriculture, disaster resilience, and biodiversity and ecosystem sustainability.

Through ICIMOD's Regional Database System initiative, its metadata catalogue is brokered through GEOSS Common Infrastructure. As a result, users can now search and find datasets stored in our Regional Database System through the GEOSS GeoPortal.

A training titled "Asia-Oceania GEOSS Network for Capacity Building and Regional Sustainable Development: Agriculture and Disaster Monitoring in Hindu Kush Himalaya" was jointly organized with AOGEOSS in Kathmandu from 17-21 September 2018.

36 IN-SITU OBSERVATIONS AND PRACTICES FOR THE WATER CYCLE (IN-SITU WATER)

Significant progress has been achieved in most planned activities in the working period as summarized below with limited personal and financial resources made available through GEO Members to the federated data centers of GTN-H and GTN-H itself. The POC for the CA has however no resources to perform coordination tasks and liaison with other groups and entities of relevance for the CA. There is the need for closer coordination and consultations specifically between the POC of the CA, GTN-H and the Secretariat of GEOGLOWS.

At present there are no extra budgetary funds available to develop and operationalize the CA. CA partners provide all resources on the basis of in-kind contributions and derivatives from activities already under planning and/or implementation. The new sub-activity on surface water storage needs to be further developed on voluntary inputs from leads and contributors still to be identified. Some additional financial and in-kind resources need to be made available to enable improved coordination of the WP activities and including the development of integrated data products in cooperation with existing global data centers of relevance to the CA.

37 MULTI-SOURCE SYNERGIZED REMOTE SENSING PRODUCTS AND SERVICES (GEO MUSYQ)

Multi-source Synergized Remote Sensing Products and Services (GEO MUSYQ) has delivered more than 10 kinds of long time series of global biophysical parameter products by synergizing multi-sensor datasets including MODIS-Terra/Aqua, MERSI-FY3A/B/C, and VIRR- FY3A/B/C. The global biophysical parameter products include Aerosol Optical Thickness, Vegetation Index, Leaf Area Index, Fractional Vegetation Coverage, Land Surface Reflectance, Fraction of Photosynthetic Active Radiation, Photosynthetic Active Radiation /Downward Shortwave Radiation and Net Primary Productivity from 2010-2015. The multi-source remote sensing data normalization or standardization, terrestrial parameter retrieval algorithms development and product validation have been conducted by the partners. The financial support comes from several related projects of the Ministry of Science and Technology of China, Natural Science Foundation of China, Chinese Academy of Sciences et al.

The key philosophy of GEOMUSYQ is to integrate multi-sensor data to achieve high accuracy and good spatial-and-temporal continuous common remote sensing products. All the dataset have been shared through the GEO portal to support different applications. For example, GEOMUSYQ have supported the GEOARC and AOGEOSS for the global ecosystem environment monitoring and analyzing, which include several typical ecological environment elements and hot environment issues. GEOMUSYQ products have been directly used to support the TG 7 'Environment Monitoring and Protection' in AOGEOSS to evaluate the environmental status of Asia and Oceania region. The products have also been utilized to serve for the annual GEOARC (Global Ecosystems and Environment Observation Analysis Report Cooperation) report as the major data source.

Furthermore, we have organized several international conferences and training workshop to promote the GEOMUSYQ and the leader and partners have been invited by different organizations and universities to present the related work. With such exchanges and communications, the MUSYQ has engaged the users, attracted potential users and meanwhile enquiry the users' demands for further improvements.

38 SPACE AND SECURITY

The SSCA activities started in November 2015 with the approval of the Community Activity during the GEO Plenary held in Mexico. The 2017-2019 period was dedicated to the engagement of an initial set of partners in response to the identified need of having a community of users making use of Space assets to deal with Security issues.

The SSCA was promoted in a number of open events (e.g. the ESA-SatCen-JRC Big Data from Space Conference, the ESA Living Planet Symposium, the ESA EO Open Science Conference and the SatCen Big Data in Secure Societies Workshop) and in a number of restricted events (e.g. the SatCen Expert User Forum). Thanks to this, key partners such as ESA and IHE were engaged in the SSCA from the beginning, and WFP has recently joined the community.

With respect to participation in relevant innovation activities, SatCen is a task leader in the H2020 NextGEOSS project in charge of implementing the Space and Security Innovation Pilot, linking the project outcomes with the GEO SSCA activities, and contributing to the dissemination and communication of the project results.

In terms of links with other GEO initiatives, SatCen participates in the European GEO HLWG and in the EuroGEOSS Coordination Group as well as takes part of EuroGEOSS Action Group for Disaster Resilience.

39 THE INTERNATIONAL GRAND GLOBAL ENSEMBLE (TIGGE)

The TIGGE database currently (Feb 2019) has over 3050 registered users. The S2S database has over 1050 registered users. The potential downstream users include all users of weather forecasts: the general public, decision makers, farmers, the energy sector, human health and civil protection etcetera.

The TIGGE database continues to acquire and serve data from ten data providers. Recently, India's National Centre for Medium-Range Weather Forecasts joined the group of data providers, supplying their ensemble forecast to TIGGE. The size of the database is 3.2 PiBytes and the service delivers an average of 15 TiBytes of data per month to some 220 users.

For the S2S database, it has been a period of consolidation. The database started activity in 2015, and during the last 3 years it has seen the addition of data from the 11 data providers originally planned. At the same time, it has been able to successfully accommodate changes in the configuration of various forecasting systems, such as upgrades to their models, changes in the number of ensembles and/or changes in the frequency of production. The size of the database is 96 TiBytes and the service delivers an average of 30 TiBytes of data per month to some 100 users.

In 2017 an S2S user survey was conducted, with questions ranging from current research topics using the S2S dataset, how to improve the dataset or how satisfied were they with the service and documentation. The survey can be accessed from the following address http://wwww.s2sprediction.net/file/database/S2S_survey_report-1.pdf.

In 2018 a TIGGE user survey was conducted, with questions ranging from current research topics using the TIGGE dataset, how to improve the dataset or how satisfied were the users with the service and the documentation. The survey can be access from the following address https://confluence.ecmwf.int/display/UDOC/2018+Survey%3A+TIGGE+dataset.

40 AMERIGEO

Outputs of AmeriGEO for the 2017-2019 period:

The 2017-2019 period improved coordination among GEO member countries, by way of both formal symposia, and regular coordination calls. Activities across the region have been concentrated on addressing the four priority SBAs and have engaged with GEOGLAM, GEOGLOWS, GFOI, GEONetCast-Americas, GEO disaster activities, and GEOBON. The annual AmeriGEOSS Week Symposia held in 2017 (in Costa Rica) and 2018 (in Brazil) have served as important platforms by which to highlight work in those areas. These have been complemented by monthly AmeriGEO Coordination Working Group (CWG) conference calls with the GEO Principals, whose discussions have served to (i) highlight EO-related activities being done [related to the priority areas], and also to (ii) identify capacity gaps and opportunities for collaboration. The CWG conference calls have also been open to non-member countries, as a way of further engaging them in GEO. In terms of the audiences reached, the 2017 and 2018 AmeriGEOSS Week Symposia had a cumulative total of 258 participants, with 110 people trained from across the region.

Multiple needs have been addressed case-by-case, e.g. needs for satellite data processing instruction, needs for better understanding of tools already developed, and needs to begin using new assets like GOES-16 and improved GEONetCast assets. Through the 19 USGEO-funded projects whose focus countries include 15 of the 16 GEO member nations in the Americas, we have advanced objectives of the corresponding GEO flagships and initiatives, and contributed to Earth observation capacity building in the Americas since the projects' inceptions in early 2018. Those projects have been done in conjunction with the respective GEO Principals. Annex I provides additional details on the accomplishments of the projects, while Annex II details how the projects relate to the GEO Work Programme, the SBAs, and the Sustainable Development Goals (SDGs).

Lessons learned and challenges:

Many lessons have been learned as we have progressed over the past three years. Examples include the value of the CWG in keeping countries engaged as changes in government occur, and the corresponding challenge to keep contact information current; and, the value of a distributed, multi-agency GEO construct in ensuring GEO's assets get to the right people and as resilience when government changes. Pragmatic lessons still being learned include how to bring the community together most effectively for the AmeriGEO Weeks, and how to get the training participants to the training given funding limitations.

AmeriGEOSS has leveraged social media (Facebook in particular) and at the moment the site has more than 700 followers. The site is used to share training opportunities to the general public, to share environmental activities from the GEO member countries, and to outreach to the broader community.

41 AOGEO

Outputs of AOGEO for the 2017-2019 period

The following list shows the then AOGEOSS's original implementation plan's objectives with our achievements against each nested underneath:

1) Engage with coordinate as appropriate all stakeholders, partners and sponsors working together in Earth observation activities in Asia Oceania region;

- The 11th AOGEO Symposium was held in Kyoto attended by 171 participants and approved "Kyoto Statement" which show the direction of the AOGEO activity in 2019.
- The 1st AOGEO Workshop was held in Deqing attended by 82 participants from 16 countries

2) Utilize infrastructure, resources and capacity to develop integrated and sustained observations;

- Room for improvement

3) Investigate user needs and address gaps on implementation of GEOSS and develop technological approaches;

- Targeted capacity building activities have been held by AOGEO in Nepal, Laos and China

4) Provide a platform for regional countries to advance data sharing and services;

- In addition to support from Sentinel Asia, AOGEO has projected data to four disasters since 2016
- Supported the rollout of Open Data Cube (ODC) deployments in Australia, Cambodia, Vietnam and several others with greater than six other countries exploring deployments
- Spread the development of Analysis Ready Data within the region and have initiated the process of establishing an Asia Oceania Data Hub
- Development meta-standards and cooperation between national oceanographic centers for the sharing of information

5) Cultivate regional collaboration network by providing technical support and knowledge sharing;

- We have initiated a multi and transdisciplinary case study in the Mekong Rivier Basin which aims to show how all global GEO tasks and the 8 AOGEOSS application tasks can create integrated knowledge.
- We have hosted a workshop to better define the EO needs of Pacific Island small island states and are progressing the development of regionally based information platform

6) Support decision-making and regional sustainable development with earth observation information.

- Facilitating the development of Communities of Practice in tkey areas such as water management, biodiversity, carbon and GHG monitoring, food security and ocean monitoring through the communications at GEOSS Asia Pacific symposia

The flexible and inclusive activities of AOGEOSS Initiative realized our cooperative contribution to achieve the international and global agenda; SDGs, Sendai Framework and Paris Agreement, which was clearly demonstrated at the latest GEOSS-AP symposium held in Kyoto, Japan in October 2018 (presented in the next section).

Lessons learned and challenges

Our main lessons learned since establishment are the vital importance of regional GEO's maintaining independence, so we can remain agile and the importance of valuing all voluntary contributions in any form to maintain our momentum.