

Analysis on the Eighth Iteration of GEO Work Programme (2023–2025)

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Abstract: The Secretary of Group of Earth Observation (GEO) released the third version of GEO work program 2023–2025 in December 2022. This is the eighth iteration of GEO work program since GEO was established in 2005. Five action lines were listed at the GEO work program 2023–2025, they were 5 flagships, 19 initiatives, 20 pilot initiatives, 4 regional GEOs and one foundational task. Based on the statistics, the authors indicated that there were 46 countries contributed to the flagships, in which, USA and Australia contributed in all the five, China contributed in 3, Germany contributed in 4. Among the 19 Initiatives, USA contributed in 14, about 78% of total, China contributed in 6. There were 47 countries contributed in 20 pilot initiatives, China in 9 just behind USA in 10. The article analyzed the work program impacts, indicated that the most value of earth observation lies in its long-term and continuous nature; the content diversity of earth observation is another unique impact for earth science and society, the international joint actions and cooperations are the key to make the program success. The authors believe GEO Working Plan 2023–2025 is GEO new milestone with its unique vision, goals, and objectives. Of course, there is also an imbalance in the layout and development of the work plan, mainly manifested in the existence of a large amount of earth observation data and the wide application of these data. Accelerating the processing and analysis of Earth observation data, promoting the widespread application of data, and achieving greater ecological, social, and economic benefits with new technology of artificial intelligent should be a special concern in the next stage of GEO work plan.

Keywords: GEO; Eighth Iteration; work programme; 2023–2025

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1 Introduction

Since Group of Earth Observation (GEO) was established in 2005, two decadal programs were made. The first one from 2005 to 2015 was focused on the Global Earth Observation

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System of Systems (GEOSS) which was for enhancing international data sharing and interoperability of earth observation. The second one from 2016 to 2025 was focused on the GEO services through the implementation mechanisms, including flagships, initiatives, foundational task, regional GEOs and a series of activities. Not only decadal programs, the iterations in each programs were identified. The Eighth Iteration of GEO Work Programme (2023–2025) is the update one in the two decadal programs. The GEO secretary released the third version of the eighth iteration of the GEO Work Programme 2023–2025 (“GEO Work Plan” for short) in December 2022^[1]. According to the GEO Work Plan, flagships, initiatives, pilot initiatives, regional task and foundational action were identified.

2 Action Lines

Five action lines were described in the GEO Work Plan 2023–2025. They are: five flagships, 19 initiatives, 20 pilot initiatives, 4 regional GEOs and one foundational action.

2.1 Action Line 1: Flagships

There are five GEO flagships in the GEO Work Plan 2023–2025, they are: GEO Biodiversity Observation Network, GEO Global Agricultural Monitoring, Global Forest Observations Initiative, Global Observation System for Mercury and GEO Land Degradation Neutrality. The national members and participating organizations of contributors for these flagships are listed in Table 1.

Table 1 List of flagships of the GEO Working Plan 2023–2025:

Code	Title	Short name	Contributors
F1	GEO Biodiversity Observation Network ^[2,3]	GEO-BON	Australia, Canada, Colombia, Finland, Netherlands, Norway, USA; ITC, and ESA
F2	GEO Global Agricultural Monitoring ^[4]	GEOGLAM	Argentina, Australia, Belgium, Brazil, Canada, Chile, China, Egypt, European Commission, France, Germany, India, Indonesia, Italy, Japan, Malaysia, Mexico, Morocco, Philippines, Poland, Russia, South Africa, Spain, Thailand, Tunisia, Ukraine, UK, USA, Uruguay, Vietnam, Zimbabwe; ESA, FAO, IIASA, ITC, RCMRD, WFP, and WMO
F3	Global Forest Observations Initiative ^[5]	GFOI	Australia, Germany, Japan, Norway, Spain, UK, USA; CEOS, ESA, FAO, and The World Bank
F4	Global Observation System for Mercury ^[6]	GOS4M	Argentina, Australia, China, Cote d’Ivoire, Czech Republic, Denmark, Finland, France, Germany, Greece, Russia, Slovenia, South Africa, Sweden, Ukraine, UK, USA, Italy
F5	GEO Land Degradation Neutrality ^[7]	GEO-LDN	Australia, Brazil, Burkina Faso, China, Denmark, European Commission, Finland, France, Germany, Ghana, Italy, Japan, Kenya, Netherlands, Mexico, Poland, Senegal, South Africa, Spain, Switzerland, Ukraine, UK, USA; ISESTEL, AARSE, CI, UNCCD, FAO, EEA, EARSC, CEOS, and ESA

2.2 Action Line 2: Initiatives

There are 19 initiatives in the GEO working program 2023–2025 they are: AquaWatch, Data Integration and Analysis System, Digital Earth Africa, Earth Observations for Ecosystem Accounting, Earth Observations for Health, Earth Observations for Disaster Risk Management, Earth Observations for the Sustainable Development Goals, GEO Blue Planet, GEO Capacity Building in North Africa, Middle East, Balkans and Black Sea Region, GEO Global Water Sustainability, GEO Human Planet, GEO Vision for Energy, GEO Wetlands, Geohazard Supersites and Natural Laboratories, Global Drought Information System, Global Network for Observations and Information in Mountain Environments, Global Observation System for Persistent Organic Pollutants, Global Urban Observation and Information, Global Wildfire Information System. The national members and participating organizations

of contributors for these initiatives are listed in Table 2.

Table 2 list of initiatives of the GEO Working Plan 2023–2025

Code	Title	Short name	Contributors
11	AquaWatch ^[8]	AQYAWATCH	Australia, Bangladesh, Belgium, Germany, Ghana, Netherlands, Switzerland, UK, USA,
12	Data Integration and Analysis System ^[9]	DIAS	Indonesia, Japan, Philippines
13	Digital Earth Africa ^[10]	DE-AFRICA	Australia, Ghana, and South Africa; OSS, AGRHYMET, GPSDD
14	Earth Observations for Ecosystem Accounting ^[11]	EO4EA	Canada, European Commission, Mexico, Netherlands, USA; ESA, FAO, The World Bank, CI, EEA. ESRI
15	Earth Observations for Health ^[12]	EO4HEALTH	Canada, Costa Rica, Mexico, South Africa, UK, USA, WHO, WMO, RCMRD, SICA/CCAD
16	Earth Observations for Disaster Risk Management ^[13]	EO4DRM	Argentina, Belgium, Canada, France, Italy, Luxembourg, Switzerland, USA; ESA, FAO, CEOS
17	Earth Observations for the Sustainable Development Goals ^[14]	EO4SDG	Australia, China, Costa Rica, European Commission, Germany, Greece, Japan, Kenya, Mexico, Namibia, Netherlands, Norway, South Africa, Sweden, Switzerland, United Arab Emirates, UK, USA; UNCCD, WDS, EARSC, ESA, i-BEC, IEEE, IIASA, UNOOSA, WHO, UNITAR, CEOS, AGRHYMET
18	GEO Blue Planet ^[15]	GEO-BLUE-PLANET	France, European Commission, Ghana, USA; IEEE, IOC, POGO
19	GEO Capacity Building in North Africa, Middle East, Balkans and Black Sea Region	GEO-CRADLE	Cyprus, Greece, Italy, Spain, Ukraine
110	GEO Global Water Sustainability ^[16]	GEOGLOWS	European Commission, France, Japan, Switzerland, USA; RCMRD, CI, The World Bank, WMO
111	GEO Human Planet ^[17]	HUMAN-PLANET	China, European Commission, Germany, Greece, Ireland, Netherlands, UK, USA; EU SatCen
112	GEO Vision for Energy ^[18]	GEO-VENER	Australia, Denmark, France, Germany, Greece, Switzerland, USA; ESA
113	GEO Wetlands ^[19]	GEO-WETLANDS	Australia, Austria, Denmark, France, Germany, Greece, Japan, Netherlands, Spain, Sweden, UK, USA; IWMI, ESA, CI
114	Geohazard Supersites and Natural Laboratories ^[20]	GSNL	Argentina, Canada, Chile, China, Ecuador, Germany, Greece, Iceland, Italy, Japan, New Zealand, Portugal, Spain, Sweden, Switzerland, Turkey, USA; CEOS, EPOS
115	Global Drought Information System ^[21]	GDIS	Australia, Austria, Brazil, European Commission, Korea, Paraguay, Slovenia, USA; ECMWF, WMO
116	Global Network for Observations and Information in Mountain Environments ^[22]	GEO-MOUNTAINS	Austria, European Commission, Italy, Switzerland, UK, USA; MRI, ICIMOD
117	Global Observation System for Persistent Organic Pollutants ^[23]	GOS4POPs	Australia, Brazil, Cameroon, China, Costa Rica, Czech Republic, Denmark, Greece, Italy, Japan, Kenya, Morocco, Norway, Russia, Slovenia, Spain, Sweden, Uruguay,
118	Global Urban Observation and Information ^[24]	GUOI	Austria, Brazil, Canada, China, Germany, Greece, India, Japan, Pakistan, Spain, USA; GRSS
119	Global Wildfire Information System ^[25]	GWIS	Argentina, Australia, Brazil, Canada, China, European Commission, Germany, Greece, Indonesia, Mexico, Netherlands, New Zealand, Portugal, South Africa, Spain, UK, USA, Zimbabwe; ECMWF, ESA, FAO

2.3 Action Line 3: Pilot Initiatives

There are 20 pilot initiatives in the GEO work plan 2023–2025, including two catalogues, one is the community activities accepted as pilot initiatives, and the other one is new pilot initiatives.

2.3.1 Pilot Initiatives

There are 15 communities accepted as pilot initiatives. The titles, GEO members and participating organizations of contributors for these pilot initiatives are listed in Table 3.

2.3.2 New Proposals of Pilot Initiatives

There are five new proposals of pilot initiatives. The titles, GEO members and participating organizations of contributors for these pilot initiatives are listed in Table 4.

Table 3 List of community activities accepted as pilot initiatives of the GEO Working Plan 2023–2025

Code	Title	Short name	Contributors
CP1	ArcticGEOSS ^[26]	ARCTIC-GEOSS	Canada, Finland, Germany, Italy, Netherlands, Norway, Portugal, UK, USA; SAON
CP-2	Digital Earth Pacific ^[27]	DE-PACIFIC	Australia, Tonga, USA; SPC, CEOS, WFP
CP-3	Earth Observations for multi-scale monitoring of mining impacts ^[28]	EO4MIN	China, Czech Republic, France, Germany, Greece, Israel, Pakistan, Portugal, Switzerland; UN Environment, EuroGeoSurveys
CP-4	Earth Observations for the Water-Energy-Food Nexus ^[29]	EO4WEF	China, Norway, Sweden, USA
CP-5	Forest Biomass Reference System from Tree-by-Tree Inventory Data ^[30]	GEO-TREES	Austria, Brazil, France, Germany, UK, USA; ESA, IIASA
CP-6	GEO Citizen Science ^[31]	GEO-CITSCI	Australia, Austria, European Commission, Greece, European Commission, Norway, Spain, UK, USA; IHE, IIASA, RCMRD
CP-7	GEO Essential Variables ^[32]	GEO-EV	Belgium, Spain, Switzerland, USA
CP-8	Geodesy for the Sendai Framework ^[33]	GEODESY4SEN DAI	Australia, China, France, Germany, Italy, Japan, Switzerland, Tajikistan, Tonga, USA; IAG, IUGG
CP-9	Global Ecosystems and Environment Observation Analysis Research Cooperation ^[34]	GEOARC	Australia, China, Israel, Russia
CP-10	Global Vegetation Pest and Disease Dynamic Remote Sensing Monitoring and Forecasting ^[35]	GEO-PDRS	China, Italy, Pakistan, UK; FAO, GBIF, CABI
CP-11	In-Situ Observations and Applications for Ecosystem Status of China and Central Asia ^[36, 37]	IN-SITU-ESC	China, Kazakhstan, Tajikistan; UNEP
CP-12	Night-Time Light Remote Sensing for Sustainable Development Goals ^[38]	NIGHT-LIGHT	China, Uzbekistan; UNITAR
CP-13	Open Earth Alliance	OEA	USA
CP-14	Space and Security	SPACE-SECURITY	Germany; ESA, EuroGeoSurveys, IHE, WFP, EUSatCen
CP-15	Urban Heritage Climate Observatory ^[39]	UHCO	Austria, Canada, Sebruce, Ecuador, France, Germany, Greece, India, Israel, Italy, South Africa, Spain, UK, USA; Eurisy, MKF, UNU-EHS, ECMWF, ACCREC

Table 4 List of new proposals of pilot initiatives of the GEO Working Plan 2023–2025

Code	Title	Short name	Contributors
NP-1	Antarctic Ice Sheet Monitoring	AIS-MONITORING	Australia, Belgium, China, Denmark, France, Germany, Italy, New Zealand, Norway, Sweden, UK, USA
NP-2	Earth Observations for Global Typical Karst	EO4KARST	Brazil, China, Indonesia, Philippines, Serbia, Slovenia, South Africa, Thailand, Zimbabwe; International Research Centre on Karst under the auspices of UNESCO
NP-3	GEO Cold Regions Initiative	GEOCRI	Canada, China, Finland, Germany, Italy, Japan, Netherlands, Norway, USA
NP-4	Global Geochemical Observation Network and Digital Chemical Earth	CHEMICAL-EARTH	Argentina, Brazil, Cambodia, China, Colombia, Ireland, Mongolia, Peru, Russia, Thailand, Turkey; ICGG
NP-5	Global Products of Common Essential Variables from Multiple Satellite Data	GEO-EV-PRODUCTS	Australia, China, EU, France, Spain, UK, USA

2.4 Regional GEOs

According to the regions of the world, there were four regional GEOs, they are: African Group on Earth Observations, Americas Group on Earth Observations, Asia-Oceania Group on Earth Observations and European Group on Earth Observations. The contributors of each of the regional GEOs are listed in Table 5.

Table 5 GEO Working Plan 2023–2025: list of regional GEOs

Code	Title	Short name	Contributors
R1	African Group on Earth Observations	AFRIGEO	Congo, Egypt, Gabon, Ghana, Kenya, Madagascar, Morocco, Nigeria, Senegal, South Africa, Uganda, Zimbabwe; RCMRD, ASREN, COMIFAC, EIS-AFRICA, OSS, UNECA, ARCSSTE-E, AGRHYMET; Swaziland
R2	Americas Group on Earth Observations	AMERIGEO	USA, Argentina, Brazil, Canada, Chile, Colombia, Costa Rica, Ecuador, Panama, Mexico, Paraguay, Peru, Salvador, Guatemala, Nicaragua; SICA/CCAD, CLARA, ESRI
R3	Asia-Oceania Group on Earth Observations	AOGEO	China, Australia, South Korea, France, India, Indonesia, Japan, Malaysia, USA, Philippines, Thailand, UK, Vietnam; FAO, IOC
R4	European Group on Earth Observations	EUROGEO	European Commission, European Caucus including European GEO Members and Participating Organizations

3 Statistics on Contributors of GEO members in GEO Work Plan 2023–2025

3.1 Contributors in Flagships

There were 45 GEO members contributed to the GEO Flagships. They are: USA, Australia, Germany, China, Finland, South Africa, Japan, Italy, UK, Ukraine, Spain, EU, Norway, Mexico, Canada, Netherlands, Russia, Denmark, Poland, Brazil, Argentina, Chile, Vietnam, Indonesia, India, Greece, Uruguay, Tunisia, Thailand, Slovenia, Senegal, Switzerland, Sweden, Morocco, Malaysia, Kenya, Côte d'Ivoire, Zimbabwe, Czech Republic, Ghana, Colombia, Philippines, Burkina Faso, Belgium, and Egypt.

Among them, the USA and Australia contributed in all 5 flagships, Germany contributed in 4 flagships, 8 countries including China contributed in 3, 9 countries including Brazil contributed in 2. China was missing out on GEO Biodiversity Observation Network and Global Forest Observations Initiative (Figure1).

3.2 Contributors in Initiatives

There were 52 countries listed in the contributors of the 19 GEO initiative, including USA, Greece, EU, Germany, Australia, UK, Switzerland, Japan, China, Canada, Spain, Netherlands, Italy, Sweden, South Africa, Mexico, France, Brazil, Austria, Ghana, Costa Rica, Denmark, Argentina, Indonesia, New Zealand, Slovenia, Portugal, Norway, Kenya, Belgium, Chile, India, Uruguay, Ukraine, Turkey, Cyprus, Namibia, Morocco, Bangladesh, Luxembourg, Cameroon, Zimbabwe, Czech Republic, South Korea, Philippines, Ecuador, Russia, Iceland, Paraguay, Pakistan, Ireland, United Arab Emirates. Among them, the USA contributed in a maximum of 15 initiatives. Secondly, Greece contributed in 9 initiatives; the European Union, Germany, and Australia in 8 respectively. UK, Switzerland, and Japan each contributed in 7. China contributed in 6, about one-third of the total initiatives (Figure2).

3.3 Contributors in Pilot Initiatives

There were 48 countries to contribute 20 pilot initiatives, including USA, China, Germany, UK, Australia, France, Italy, Norway, Switzerland, Spain, Greece, Austria, Brazil, Canada, EU, Israel, Pakistan, Belgium, Russia, Finland, South Africa, Portugal, Japan, Sweden, Tajikistan, Thailand, Tonga, Argentina, Ireland, Denmark, Ecuador, Philippines, Colombia,

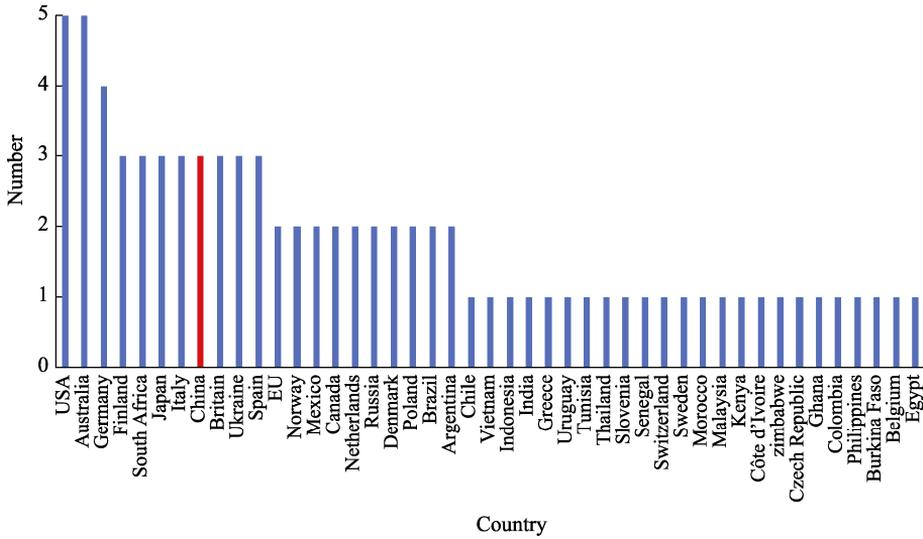


Figure 1 Statistics of GEO member contributing in two or more GEO flagships

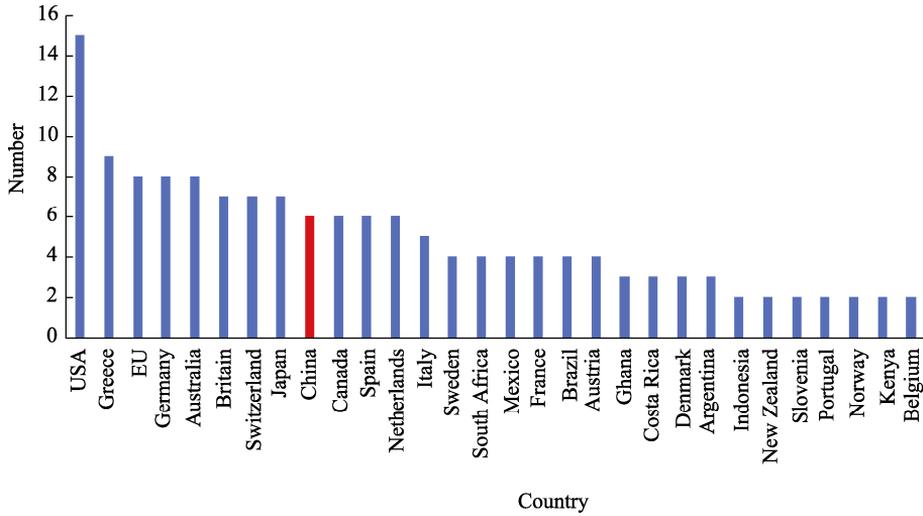


Figure 2 Statistics of GEO member contributing in two or more GEO initiatives

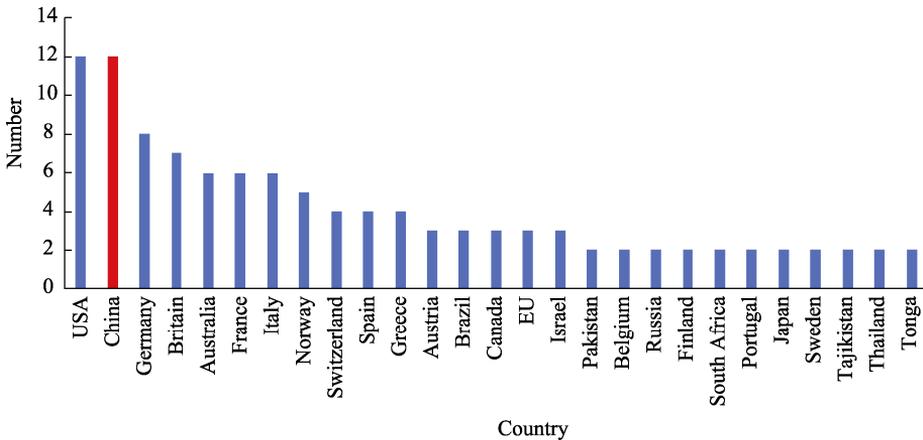


Figure 3 Statistics of GEO member contributing in two or more GEO pilot initiatives

Kazakhstan, Netherlands, Cambodia Czech Republic, Zimbabwe, Mongolia, Peru, Serbia, Cyprus, Slovenia, Turkey, Uzbekistan, New Zealand, India, Indonesia. Among them, USA and China were most active countries, who contributed in 12 pilot initiatives individually, and Germany in 8, UK in 7 separately (Figure3).

3.4 Contributors in Regional GEOs

Almost of all of GEO members joined the regional GEOs, since the regional GEO groups were more focused on the regional issues and thematic priorities which the region concerned. South Africa, USA, China, and European Commission played the coordinating roles at the African Group, Americas Group, Asia-Oceania Group and European Group.

3.5 Contributors in Foundational Task

The GEO foundational task was the most important task for GEO progresses. It covered five aspects, including GEO engagement priorities coordination; GEOSS data, information, and knowledge resources; GEOSS Infrastructure development; GEO work programme support; and GEO secretariat operations. The GEO foundational task was operated by GEO secretariat with collaborative teams from GEO communities.

4 Summary

GEO work plan 2023–2025 is a joint, opening, and international program, engaged in multilateral cooperation, with over 70 GEO members. This includes the adoption of a multilateral cooperation mechanism in project implementation, and the leading countries and units of the project also reflect the characteristics of multilateralism. The member countries and organizations participating in the project further demonstrate the characteristics of multilateral participation and contribution. For example, the flagship project of GEOBLAM attracted contributors of 30 GEO members and 7 international organizations.

The most value of Earth Observation lies in its long-term and continuous nature. Although GEO work plan 2023–2025 has launched at different year, however, adhering to long-term observation is a common characteristic. For example, the GEO Biodiversity Observation Network is a long-term plan that has undergone 15 years of multilateral cooperation framework.

The content diversity of earth observation is the most prominent characteristics of GEO work plan 2023–2025. The content diversity of earth observation can be clustered into five catalogues:

(1) Global Observation Plan on earth factors, such as: GEO BON, GEOGLAM, GFOI, AQUAWATCH, GEO-BLUE-PLANET, GEOGLOWS, GOS4M, GEO-LDN, GEO-TREES, HUMAN-PLANET, GOS4POPs, CHEMICAL EARTH, GEO-VENER, GEO MOUNTAINS, EO4KARST, EO4MIN, UHCO, GUOI, GEO-WETLANDS.

(2) Observation plan for key areas, such as: DE-PACIFIC, DE-AFRICA, AIS-MONITORING, ARCTIC-GEOSS, GEOCRI, IN SITU-ESC.

(3) Earth observation program with a focus on natural disasters, such as: GSNL, GEODESY4SENDAI, EO4DRM, GEO-PDRS, GDIS, GWIS.

(4) Observation and analysis plan, such as: EO4SDG, NIGHT-LIGHT, EO4HEALT, DIAS, EO4EA, EO4WEF, GEOARC, GEO-EV-PRODUCTS, SPACE-SECURITY, SPACE-SECURITY.

(5) Development cooperation and capacity buildings, such as: OEA, GEO-CITSCI, and GEO capacity building.

The implementation of GEO work plan 2023–2025 had focused on two levels: global and

regional levels. The implementation of regional level was divided into two types. One is in four geographical regions: Africa GEO, Europe GEO, Asia Pacific GEO, and the Americas GEO. And the other one was by joint observation methods in crossing regions. For example: Antarctica, Arctic, cold regions, Central Asia, etc.

In summary, the GEO Working Plan 2023–2025 is GEO new milestone plan with its unique vision, goals, and objectives. Not only, and a clear implementation roadmap is included. It is of great significance for the implementation of GEO's second decade development strategy since GEO was established in 2005. Of course, there is also an imbalance in the layout and development of GEO's 2023–2025 implementation plan, mainly manifested in the existence of a large amount of Earth observation data and the wide application of these data. The imbalance between the two is a common problem in the current GEO project execution process. Accelerating the processing and analysis of Earth observation data, promoting the widespread application of data, and achieving greater ecological, social, and economic benefits with new technology of artificial intelligent should be a special concern in the next stage of GEO work plan.

Author Contributions

Fan, J. L. designed the framework of the paper. Wu, J. J., Liu, Y. H. and Li, L. M. collected and processed the statistical data of GEO. Liu, C. wrote the paper.

Conflicts of Interest

The authors declare no conflicts of interest.

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