



GEO Highlights 2023

UNLOCKING IMPACT THROUGH EARTH OBSERVATIONS



GEO Highlights 2023

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Citation: GEO Highlights 2023, GEO Secretariat

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Message from **Dr Mmboneni Muofhe**

Lead Co-chair,
South Africa



Earth observations are more than just data; they are a beacon of hope. They inform solutions in a world grappling with interconnected challenges. As GEO's Lead Co-chair from South Africa, I had the distinct privilege to steer the Post-2025 Strategy, emphasizing the vital role of Earth intelligence in mitigating disaster risks, tackling climate change, and understanding the intricate balance between our environment, health, and economy.

It's crucial to highlight Africa in this discourse. Often considered a bellwether for global developmental challenges and progress, Africa stands at an inflection point. While the continent grapples with developmental hurdles exacerbated by climate change, it's also a beacon of progress, especially with its vibrant youth who represent our future. Their energy and dynamism, combined with the power of Earth observations, can drive Africa towards sustainable growth. This dynamic mirrors the broader global need for intergenerational solutions.

The GEO Highlights 2023 report celebrates GEO's societal impact. Through collaborations like AfriGEO, we are rallying diverse stakeholders to address shared challenges, crafting solutions that can be amplified across regions. Initiatives like Digital Earth Africa exemplify this, where real-time Earth observation data is put to myriad uses—from flood prediction to land degradation monitoring—all aiming to safeguard lives and ecosystems.

As we navigate the path beyond 2025, our compass is set on continuous learning and innovation, with Earth intelligence as our guide. While we champion global collaboration, it's vital to remain sensitive to local community needs. In my role at GEO, I am committed to ensuring that South Africa, and by extension Africa, is at the forefront of this collaborative journey, unlocking the immense potential for transformative change.

Message from Yana Gevorgyan

Director,
GEO Secretariat



As global challenges intensify, GEO's mission to safeguard our planet through Earth intelligence becomes ever more critical. Our Post-2025 Strategy, shaped by a year-long consultative process, hones in on the need for transformative solutions and intergenerational collaboration. Importantly, the direction charted by this strategy is not a distant goal; it's already taking shape through the ongoing efforts of the GEO Work Programme.

The GEO Highlights 2023 report not only showcases these advancements but also underscores how they set the foundation for our future endeavours. The success of these endeavours rests on prioritizing users, embracing co-design and co-development, partnering across sectors and across disciplines, sustaining capacity-building, and securing necessary finance. This report paints a clear picture of our current achievements and how they propel us towards the vision outlined in Post-2025 Strategy.

Over a quarter of our initiatives leverage artificial intelligence and machine learning technologies, showcasing our commitment to innovation in this fast-paced technological era. But, innovation doesn't stand alone. The initiatives' impact on communities underscores the importance of local engagement—true progress aims for global equity from Earth Intelligence.

This report represents substantial progress towards the vision we set forth in the 2016-2025 Strategic Plan, highlighting the potential of accessible Earth intelligence. With continued collaboration and investment, I believe that a decade from now, GEO will have magnified its contribution to addressing global challenges.

As you delve into these narratives, I hope you find inspiration and recognize the boundless opportunities that lie ahead. They stand as a testament to human collaboration and innovation, guiding us towards a brighter, sustainable future.

GEO Work Programme

IN NUMBERS

The GEO community collaborates and partners through the GEO Work Programme to co-design and co-produce transformative solutions that address global challenges

THE GEO WORK PROGRAMME IS:

48 projects:

5	Flagships
19	Initiatives
20	Pilot Initiatives
4	Regional GEOs



Involving:

1603	individuals
689	organizations
103	countries

The GEO community has been embracing and experimenting with advanced technologies such as artificial intelligence, cloud computing, and machine learning through the GEO Cloud Credits Programmes.

GEO-Amazon Web Services Earth Observation Credits Cloud Programme: **22 projects**

GEO-Google Earth Engine Programme: **34 projects**

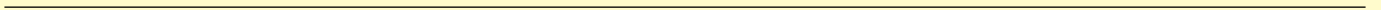
GEO-Microsoft Planetary Computer Programme: **21 projects**

In the **35 stories** included in the report, the **GEO community** is taking action and making impact in **68 countries.**



photo: Unsplash / Jack Millard

Featured Impact



15-day flood forecast reduces costs by 40%



PROJECT:
GEO Global
Water Sustainability

LOCATION:
Malawi

Challenge

Adverse climate hazards are common in Malawi. Seasonal droughts, storm cyclones and intense rainfall can result in riverine and flash floods. In 2022, Malawi experienced two tropical cyclone events - Tropical Storm Ana and Tropical Cyclone Gombe - inducing riverine and flash floods with devastating consequences. According to Malawi's Department of Disaster Management Affairs (DODMA), these events affected about 900,000 people in 17 districts.

Solution

GEOGloWS ECMWF Streamflow Service is a hydrologic modelling service that uses the best forecasts and expertise available to deliver reliable forecast information. In 2021, staff from the Regional Centre for Mapping of Resources for Development in Kenya leveraged technical developments from the NASA/USAID SERVIR Program to integrate the GEOGloWS ECMWF Streamflow Service into the Government of Malawi's Community-Based Flood Early Warning System (CBFEWS).

This system uses telemetric stations installed upstream of flood-prone areas and provides 3-8 hours of lead time to take preparatory actions. With this integration of the GEOGloWS ECMWF Streamflow Service, the forecast lead time increases from just a few hours to 15 days.

GEOGloWS is also able to support anticipatory activities and provides streamflow information to complement telemetric messaging during equipment failure due to network downtime or vandalism.

Impact

The integrated CBFEWS was deployed and immediately tested with remarkable results during Tropical Storm Ana and Tropical Cyclone Gombe. With the 15-day forecast, DODMA was able to conduct timely evacuations and implement a relief programme during both events.

DODMA's post-flood cost analysis found that the integrated CBFEWS reduced the financial impact from losses and damages by 40 percent compared to similar floods. Additionally, not a single loss of life was reported. In contrast, similar past floods resulted in significant loss of life.

The SERVIR Program has committed to funding the implementation of the integrated CBFEWS in Kenya and Tanzania in 2024. Additionally, the United States pledged US\$2 million to expand the GEOGloWS ECMWF Streamflow Service into five more African countries: Lesotho, Mozambique, Uganda, Zambia, and Zimbabwe.

Through this effort, GEO contributes to the World Meteorological Organization's Early Warnings for All (EW4ALL) Initiative, an ambitious plan for every person on Earth to be protected by early warning systems worldwide by 2027.

PARTNERS: Department of Disaster Management Affairs of Malawi (DoDMA), Department of Water Resources of Malawi (DWR), Department of Climate Change and Meteorological Services of Malawi (DCCMS), International Centre for Integrated Mountain Development (ICIMOD), Malawi Red Cross Society (MRCS), National Aeronautics Space Administration (NASA), Regional Centre for Mapping of Resources for Development (RCMRD), SERVIR Program, United Nations Development Programme (UNDP) and United States Agency for International Development (USAID)

Unlocking REDD+ payments to protect tropical forests



PROJECT:
Global Forest
Observations
Initiative

LOCATION:
Costa Rica,
Ghana

Challenge

Ghana is the world's second-largest cocoa producer. Its economy relies on cocoa, however, cocoa production is one of the main causes of deforestation and forest degradation in the south-eastern and western regions of the country. Additionally, the greenhouse gas (GHG) emissions associated with cocoa production contribute significantly to climate change. The World Bank trust fund for reducing emissions from deforestation and forest degradation, commonly known as REDD+, provides funding to developing countries who reduce GHG emissions, deforestation, and land degradation. To receive funding, countries must be able to measure, report, and verify their results-based actions.

Solution

For more than 10 years, GEO's Global Forest Observations Initiative (GFOI) and the World Bank's Forest Carbon Partnership Facility (FCPF) have worked with Ghana and other tropical countries to use Earth observations to measure, report, and verify GHS emissions from forests.

GFOI develops and disseminates IPCC-compliant methods and guidance materials for REDD+ Measurement, Reporting, and Verification (MRV). The materials provide a user-friendly approach to guide countries through the complex process of needs assessment, system design and implementation. They complement GFOI partners' own guidance materials and present these within the context of a complete national MRV framework for REDD+.

By providing access to quality data, methods, products and training, GFOI played a critical role in helping countries to build and improve their own capacities for forest monitoring.

Impact

As a result of this work, Ghana became the second country in Africa, after Mozambique, to receive payments for reducing its net forest loss and GHG emissions. In 2023, the FCPF paid Ghana US\$ 4.86 million to reduce 972,456 tons of carbon emissions for the first monitoring period. The funding will be used to shift from traditional, slash-and-burn agriculture to climate-friendly, climate-smart agriculture.

Similarly, Costa Rica has become the first country in Latin America and the Caribbean to receive FCPF payments (US\$ 16.4 million) for reducing 3.28 million tons of carbon emissions. These efforts exemplify how Earth observations can support better forest management and performance-based payments to save forests and drive global climate action.

PARTNERS: Australian Government, Committee on Earth Observation Satellites (CEOS), European Space Agency (ESA), Food and Agriculture Organization (FAO), Forest Carbon Partnership Facility (FCPF), German Federal Ministry of Economic Cooperation and Development (BMZ), Norway's International Climate and Forest Initiative (NICFI), SilvaCarbon, UK Government and World Bank

Bridging Data Gaps for the Global Biodiversity Framework

PROJECT:
GEO Biodiversity
Observation Network

LOCATION:
Global



Challenge

The Kunming-Montreal Global Biodiversity Framework (KMGBF) provides a framework for halting and reversing nature loss by the year 2050. A vision for living in harmony with nature, the framework consists of 23 targets to be achieved by 2030. However, too many countries are not able to effectively measure, monitor, and forecast trends in biodiversity change. An interconnected network of experts on biodiversity, from genes to ecosystems, can help by providing data, guidance, and tools for monitoring progress as the international community works to achieve the KMGBF goals.

Solution

In 2022, the Group on Earth Observations Biodiversity Observation Network (GEO BON) participated in the fifteenth meeting of the Conference of the Parties to the Convention on Biological Diversity (COP 15) to advise on the selection of indicators for the KMGBF monitoring framework. Tools like BON in a Box will help countries measure and report on indicators by connecting people and monitoring initiatives, providing data to essential biodiversity variable workflows, and prioritising biodiversity conservation efforts.

Impact

GEO BON has also been selected as a member of the Ad Hoc Technical Expert Group on Indicators to advise Parties to the Convention on Biodiversity (CBD) on further operationalizing the monitoring framework. This group provides important opportunities to discuss the capacity and service needed to help Parties carry out their biodiversity strategies and action plans.

All countries and Parties to the CBD have a role to play to slow and prevent the loss of biodiversity. By monitoring biodiversity trends and implementing policy action to slow the rate of biodiversity decline, the information and indicators on biodiversity change can help guide the world towards achieving the KMGBF.

PARTNERS: Convention on Biological Diversity (CBD) Secretariat, Fond de recherche du Quebec, Instituto de Investigación de Recursos Biológicos Alexander von Humboldt (IAVH), McGill University, Microsoft and Montreal International

Assessing the impact of conflict on agriculture production in Ukraine



PROJECT:
GEO Global Agricultural
Monitoring Initiative

LOCATION:
Ukraine

Challenge

The ongoing war in Ukraine has disrupted farming activities and critical agriculture infrastructure in the country. The repercussions have been felt far beyond Ukraine's borders, as global agri-food markets are strained from supply chain disruptions and soaring prices for food commodities, fertilizer and seeds, as well as equipment. The conflict has also rendered some areas of Ukraine inaccessible, making it impossible to monitor agricultural production. As such, agricultural information is limited and compromised, leaving it open to bias, misrepresentation and misinterpretation, and making it ultimately unreliable.

Solution

In response to these challenges, Ukraine's Ministry of Agrarian Policy and Food requested support from GEO Global Agricultural Monitoring (GEOGLAM) to boost their capacity to use Earth observation data for agriculture monitoring, especially in conflict-active territories where ground data was not available. GEOGLAM provides urgent, actionable information to accelerate the response during emerging food security crises. Using the Rapid Response Facility led by NASA Harvest, and in partnership with ESA WorldCereal programme and Planet, GEOGLAM created high-resolution analytical products that assess crop types and crop areas, planting and harvest progress, near real-time crop conditions, field boundary delineation, yield estimates and forecasts, and production estimates by occupation status.

Impact

Through this support, the Ministry of Agrarian Policy and Food was better able to access and coordinate information on agriculture production. An exemplary instance of this impact was evident in the assessment of the 2022 winter wheat harvest. Despite widespread speculation that the ongoing conflict would severely impede this harvest, the collaborative efforts of GEOGLAM and the Ukrainian Ministry of Agriculture revealed an astounding reality. Approximately 94 percent of the winter wheat across the nation was successfully harvested, surpassing leading estimates by an impressive margin of approximately 6 million tonnes.

By providing timely, transparent, and consensus-based information on agriculture conditions, GEOGLAM plays a critical role in supporting informed decision-making related to agriculture trade and commodity markets, disaster relief, and food security.

PARTNERS: Agriculture Market Information Systems (AMIS), European Space Agency (ESA), Food and Agriculture Organization (FAO), Ministry of Agrarian Policy and Food of Ukraine, NASA Harvest, Planet, Space Research Institute (NASU) of Ukraine, Ukraine Institute for the Study of War, United States Agency for International Development (USAID), University of Maryland, University of Strasbourg and WorldCereal

Land degradation mapping helps optimize decision making



PROJECT:
GEO Land Degradation
Neutrality

LOCATION:
Bhutan,
Bosnia & Herzegovina,
Colombia, Ecuador,
Panama, Turkey

Challenge

Estimating and mapping land degradation is necessary to make well-informed decisions to address land degradation and achieve SDG target 15.3, Land Degradation Neutrality (LDN). However, mapping land degradation is not easy. Most countries report on LDN using default global datasets, which are less reliable than national and sub-national data because they are based on models that do not consider local conditions. As a result, many countries underestimate the proportion of degraded land.

Solution

The GEO Land Degradation Neutrality initiative (GEO-LDN) supported Bhutan, Bosnia & Herzegovina, Colombia, Ecuador, Panama, and Türkiye in improving their national land degradation estimations. With local stakeholders, GEO-LDN produced land degradation maps for decision-makers combatting land degradation. To produce the improved maps, GEO-LDN conducted participatory, data-driven land degradation assessments informed by Earth observations data, cloud computing, and expert knowledge.

Impact

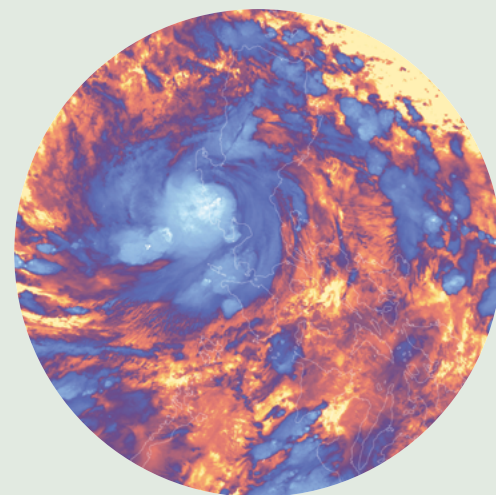
Following the assessments, the six countries used nationally validated datasets and reported higher levels of land degradation than the default estimations. In some cases, the reported levels were three times higher. Moreover, their resulting maps can now be used to optimise investments for restoration and sustainable land management.

For example, GEO-LDN, the Ministry of Environment of Colombia, and other partners conducted a two-year long participatory process in Colombia to map land degradation in the local context. As a result, Colombia reported 29.8 percent degraded land, instead of 8.9 percent, which was the default estimation.

The partners then developed a LDN decision support system, a web tool that has supported decision-making on land use in Colombia and other countries. In Ecuador, stakeholders use it for setting national LDN targets and in Türkiye, the results were used to develop a National LDN Action Plan. The Global Environment Facility uses the tool to guide investments in projects that focus on LDN, biodiversity conservation, restoration, and sustainable land management.

PARTNERS: Food and Agriculture Organization (FAO), German Federal Ministry of Economic Cooperation and Development (BMZ), German Agency for International Cooperation (GIZ), World Overview of Conservation Approaches and Technologies (WOCAT) and United Nations Convention to Combat Desertification (UNCCD)

Flood early warning system supports typhoon response



PROJECT:
Data Integration
and Analysis System

LOCATION:
Philippines

Challenge

In an era of escalating flood risk driven by climate change, the necessity of establishing flood management systems tailored to the local context cannot be overstated. Each region faces distinct environmental, infrastructural, and societal dynamics that influence flooding patterns and vulnerabilities. It is within these unique contexts that sustainable, efficient, and effective flood management solutions must be forged. However, the complexity of flood management demands a collaborative approach that engages all relevant stakeholders in the realm of water resources. This encompasses government bodies, local communities, scientists, engineers, and policymakers who must collectively navigate all factors influencing flooding, thereby ensuring resilient flood management strategies that safeguard lives, property, and ecosystems.

Solution

The Data Integration and Analysis System (DIAS), a GEO initiative, partnered with the Government of Japan to develop an integrated, interdisciplinary system that connects science and society to enhance flood resilience in local communities. The Online Synthesis System for Sustainability and Resilience (OSS-SR) is a web-based knowledge integration platform that brings together information from different disciplines including disaster risk reduction (DRR), resilience, and sustainability.

OSS-SR provides local, science-based knowledge and information such as real-time flood forecasting and climate change impact assessments. The diversity of information makes its flood forecasting function particularly effective. For instance, in case ground gauges become unavailable, OSS-SR was designed to use satellite-based rainfall data from the Japan Aerospace Exploration Agency (JAXA) Global Rainfall Watch (GSMaP) as an alternative. It also has an e-learning function, which provides users with introductory lectures, examinations, and training.

Impact

The OSS-SR successfully forecasted and monitored the inundation of Typhoon Noru (known locally as Typhoon Karding) that hit Luzon Island in the Philippines on 26 September 2022.

Before, during, and after the typhoon, 93 Philippine national and local stakeholders, including the Department of Science and Technology, the Department of Public Works and Highways, and the Metropolitan Manila Development Authority leveraged the OSS-SR to assist with forecasting, response, and evacuations.

By effectively providing real-time flood forecast information, the OSS-SR demonstrated the power of disseminating crucial information for flood early warnings, local prevention, and evacuation activities.

PARTNERS: Department of Public Works and Highways (DPWH) of the Philippines, Department of Science and Technology (DOST) of the Philippines, International Centre for Water Hazard (ICHARM), International Flood Initiative, Japan Aerospace Exploration Agency (JAXA), Japan International Cooperation Agency (JICA), Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan, Metropolitan Manila Development Authority (MMDA), United Nations Educational, Scientific and Cultural Organization (UNESCO), University of Philippines Los Banos and University of Tokyo

Mapping Guinea's Forests for Conservation



PROJECT:
Earth Observations
for Sustainable
Development Goals

LOCATION:
Guinea

Challenge

In the pursuit of conservation efforts and sustainable development, Guinea faced a significant challenge: the lack of comprehensive and up-to-date land cover and forest maps. The absence of such critical spatial information hindered the nation's ability to effectively fulfil its commitments to the Sustainable Development Goals.

Solution

Earth Observations for Sustainable Development Goals (EO4SDG) directly supports and pursues projects to develop, distribute, and adopt methods to meet the Sustainable Development Goals.

Launched in 2021 through a collaboration between the World Bank, the Universities Space Research Association (USRA), and NASA Goddard Space Flight Center, the Guinea Land Cover Mapping project stands out as a notable initiative. The project team has closely collaborated with the Government of the Republic of Guinea to create an advanced remote sensing classification methodology. This methodology relies on machine learning algorithms and has enabled the generation of land cover and forest cover maps of 30m resolution and 13 classes for the year 2014. Notably, these maps represent a ground-breaking achievement as the first of their kind for Guinea. In these maps, forest classifications adhere to Guinea's specific forest definition.

Furthermore, the team applied a spectral index anomaly-based approach to compute annual forest extent losses for subsequent years. Additionally, the Landsat imagery and NASA Global Ecosystem Dynamics Investigation (GEDI) was leveraged to produce annual land cover and

forest maps spanning from 1996 to 2020. These maps specifically focused on the coastal zone of Guinea, encompassing the coastal prefectures of Boffa, Boke, Conakry, Coyah, Dubreka, and Forecariah. These annual assessments revealed concerning trends, particularly the reduction in mangrove extent, primarily attributed to forest conversion into rice fields and the urbanisation of the Conakry region in western Guinea.

Impact

The impact of the Guinea Land Cover Mapping project has been substantial and multifaceted. Firstly, the project played a pivotal role in supporting Guinea's 2021 National Determined Contributions (NDC) and enhancing its commitments to the United Nations Framework Convention on Climate Change (UNFCCC). This noteworthy effort garnered attention and recognition, being highlighted by the UNFCCC and featured in Guinea's NDC report.

Secondly, these maps have supported Guinea's conservation endeavours as they have been instrumental in planning the establishment of 17 new national parks, including the notable Moyen Bafing National Park.

PARTNERS: Government of the Republic of Guinea, NASA Goddard Space Flight Center, Universities Space Research Association (USRA) and World Bank

Rapid estimation of earthquake source parameters

PROJECT:
Geohazard Supersites
and Natural Laboratories

LOCATION:
Syria, Türkiye



Challenge

On 6 February 2023, South-eastern Türkiye and Northern Syria were struck by two significant earthquakes, occurring within a span of approximately 9 hours. These devastating events affected over 10 cities in the area, resulting in the tragic loss of over 60,000 lives. Swift assessment of the damage distribution and fault parameters for these earthquakes became imperative for the Turkish Disaster Management Agency (AFAD). Their aim was to coordinate rescue efforts and identify areas with potential hazardous aftershocks in order to mitigate further loss of life through precautionary measures.

Solution

In response to this urgent need, the Geohazard Supersites and Natural Laboratories (GSNL) Event Supersite for the Kahramanmaraş seismic sequence was launched on 26 February. Complementary to routine analyses on existing damage conducted by the International Charter partners, the supersite focused on detecting additional potential hazards. Collaborating with the United Nations Satellite Center (UNOSAT), the International Charter project manager for this event, GSNL was able to directly channel the compiled information to the United Nations' humanitarian efforts.

The GSNL science community, supported by commercial data including high-resolution optical and synthetic aperture imagery, rapidly mapped the surface deformation and damage distribution caused by the earthquake. Significantly, they uncovered source parameters of the two large earthquakes, then projected areas of increased static stress, where likelihood of strong aftershocks or new large earthquakes would rise.

Impact

Similar to other GSNL event supersites, the local emergency management authority, AFAD, played an essential role within this event supersite.

The supersite coordinators consistently provided AFAD with real-time updates regarding evolving ground-level risks. In response, AFAD promptly implemented crucial life-saving measures, including evacuations and the restriction of building access.

Water information and determined women change lives in remote Azuay



PROJECT:
GEO Global Water Sustainability

LOCATION:
Ecuador

Challenge

Azuay is a province in Southern Ecuador located in the highland region commonly known as the Páramo, a critical water source for downstream populations. Azuay's population is about 882,000, and less than 40 percent have regular water access. The mountainous terrain of the community is difficult to build on, and the two available catchments are located in remote areas 3,100 metres above sea level. Azuay also experiences frequent droughts, posing a significant challenge to agricultural productivity, with only 8.24 percent of the province's total area having access to irrigation. The lack of streamflow data information compounds the issue of water deficit. There are few hydrometeorological stations in Azuay, but the local government doesn't have access to this information. Poverty is also prevalent in the community, partially stemming from the impacts of predominantly male emigration to urban areas and other countries. But the mothers, daughters, and sisters stay on, caring for their families and tending to the land.

Solution

In 2021, Gobierno Autonomo Descentralizado Provincial de Azuay, Azuay's provincial government institution, designed and implemented Cerro Negro, an irrigation system consisting of a 38 km pipeline with an irrigable area of 500 hectares. To design two siphons in the irrigation system, the community used historical streamflow and water level data from the GEO Global Water Sustainability (GEOGloWS) Service. The implementation of the service was

supported by SERVIR-Amazonia, a regional centre of SERVIR which is a joint initiative of NASA and USAID. EcoCiencia, an environmental NGO, is the primary implementing partner of the SERVIR-Amazonia programme in Ecuador and supported the customisation of the GEOGloWS services for use by the Instituto Nacional de Meteorología e Hidrología (INAMHI), Ecuador's national hydrometeorological agency.

Impact

Cerro Negro was initiated and implemented mainly by women - primarily mothers or heads of household whose sons, husbands, and fathers emigrated for economic reasons - to strengthen food security in their community.

Progress on the overall irrigation project is currently at about 65%. The construction of the first siphon is at 40% completion, and the second is at 10%. Given the difficulty and complexity of the mountainous terrain, the entire irrigation system is estimated to be completed in late 2024. When complete, the irrigation will provide access to water for human and animal consumption and is projected to benefit more than 5,000 people directly and 10,000 indirectly.

PARTNERS: Gobierno Autonomo Descentralizado de Azuay (GAD), Instituto Nacional de Meteorología e Hidrología (INAMHI), National Aeronautics Space Administration (NASA), SERVIR Program and United States Agency for International Development (USAID)

Improved agricultural statistics boost monitoring and reporting



PROJECT:
GEO Global Agricultural Monitoring

LOCATION:
Côte d'Ivoire,
Kenya, Tanzania,
Uganda

Challenge

The challenge of inadequate or subpar baseline data for cropland and crop type mapping in many developing countries presents a significant impediment to effective crop monitoring efforts, both at the national and sub-national levels. This data deficiency not only undermines the accuracy and reliability of crop monitoring but also hampers the development and validation of Earth observation-based methodologies for essential agricultural variables. In essence, the absence of robust baseline data deprives policymakers, researchers, and agricultural stakeholders of the critical insights required to make informed decisions, address food security issues, and implement sustainable agricultural practices.

Solution

The Copernicus4GEOGLAM activity addressed this challenge by supporting and providing GEO Global Agricultural Monitoring (GEOGLAM) partner countries with ground data on crop masks, crop type maps, and area statistics, both during and at the end of the cropping season.

The activity uses state-of-art methods, encompassing stratified random sampling to design field campaigns, offline delineation of field boundaries using highly detailed imagery before fieldwork, extensive field campaigns covering the entirety of each crop growing season, and the utilisation of Sentinel 1 and 2 satellite data in conjunction with advanced machine learning techniques for crop classification. These activities collectively span substantial areas, covering regions totalling up to 100,000 square kilometres.

Impact

The activity provided baseline agricultural statistics to national institutions in African countries, enhancing their reporting and monitoring capabilities. In addition to providing agricultural information to national authorities, Copernicus' free and open data policy has made it possible to publicly share the massive amount of ground data collected in these data scarce environments.

In Côte d'Ivoire, the activity was flexibly adapted to support the creation and validation of a reference land use map for 2020, which will help the country to prepare for the European Union Deforestation Regulation.

In Kenya and Tanzania, the impact has been so substantial that partner institutions have expressed their strong desire to renew the initiative for an additional year, coupled with an extension of the coverage area. This underscores the initiative's pivotal role in fostering agricultural resilience and progress in these regions and demonstrates its potential for further transformative impact in the future.

PARTNERS: Copernicus Programme and European Commission

Pest and disease monitoring system boosts species richness



PROJECT:
Global Vegetation
Pest and Disease Dynamic
Remote Sensing Monitoring
and Forecasting

LOCATION:
China, Eritrea,
Ethiopia, India,
Kenya, Nepal, Pakistan,
Somalia, Yemen

Challenge

Climate change is exacerbating the impact of crop pests and diseases, intensifying their severity and expanding their geographical reach, thus posing a substantial threat to global food security and sustainable ecosystem development. According to the Food and Agriculture Organization (FAO), pests and diseases already cause an estimated 20-40 percent reduction in global crop yields annually. Rising temperatures and altered precipitation patterns create ideal conditions for these agricultural threats to thrive. As a consequence, farmers face declining yields and increasing economic losses, while food prices surge, disproportionately affecting populations vulnerable to food insecurity.

Solution

To address these challenges, partners from the GEO Global Vegetation Pest and Disease Dynamic Remote Sensing Monitoring and Forecasting (GEO-PDRS) pilot initiative, established a remote sensing monitoring and early warning system for global vegetation diseases and insect pests. This project focuses on globally migratory and epidemic vegetation pests and diseases, such as desert locusts, armyworms, wheat rust, pine wilt disease, and more.

The system was developed using remote sensing, meteorology, agronomy, ecology, vegetation protection, and other multi-source spatio-temporal data as well as integrated technologies such as big data analysis and information mining. These technologies are leveraged to conduct habitat monitoring, hotspot analysis, and migration and spread risk prediction modelling in breeding and diffusion areas.

Impact

The project has been used to detect and control 18 major plant diseases and insect pests in China.

This work increased species richness by about 10 percent and reduced the amount of pesticide application by 20-30 percent. In partnership with Food and Agriculture Organization of the United Nations (FAO), the Global Biodiversity Information Network (GBIF), and CAB International (CABI), the project has scaled to Eritrea, Ethiopia, India, Kenya, Nepal, Pakistan, Somalia, and Yemen from 2020 to 2023 and supported scientific prevention and control over 33 million hectares.

PARTNERS: Alliance of International Science Organizations (ANSO), CAB International (CABI), Chinese Academy of Sciences (CAS), Chinese Ministry of Science and Technology, Center for Biological Disaster Prevention and Control of China (BDPC), Food and Agriculture Organization (FAO), Global Biodiversity Information Facility (GBIF), Manchester Metropolitan University, National Agro-Tech Extension and Service Center (NATESC), National Research Council (CNR), National Remote Sensing Center of China (NRSCC) and PMAS-Arid Agriculture University Rawalpindi

Seagrass mapping leads to new protection targets in Seychelles

PROJECT:
GEO-Google Earth Engine Programme

LOCATION:
Seychelles



Challenge

Around the world, seagrasses provide crucial ecosystem services, including carbon sequestration, coastal protection, and biodiversity maintenance. But currently, there is a severe lack of spatially explicit data on seagrass extent, provenance and ecosystem services. Additionally, seagrasses are broadly excluded from multilateral environmental agreements, which impacts the resilience of these ecosystems and the 3 billion people that rely on them.

Solution

Through the Programme, the German Aerospace Center (DLR) collaborated with global partners to design a scalable, cloud-based remote sensing system within the Google Earth Engine platform. This serverless apparatus produces large-scale, spatially explicit data and insights on seagrass extent, health, and ecosystem services. It is envisaged to evolve into a long-term decision support service to advance coastal conservation and restoration.

Impact

From 2021-2023, as part of a countrywide seagrass mapping project in Seychelles, this project estimated the seagrass extent and associated blue carbon stocks across the country's waters.

It was the first of its kind to produce spatially explicit data on seagrass carbon stocks with the aim to inform a country's Nationally Determined Contributions (NDCs) under the Paris Agreement and to safeguard the resilience of seagrasses across the country's vast Exclusive Economic Zone. It also led the Government of Seychelles to officially commit to integrate seagrasses and their blue carbon in its NDCs. In fact, Seychelles is the first country to include targets for such a large percentage of its seagrasses and mangroves in its NDCs. It commits to protect 50 percent by 2025 and 100 percent by 2030.

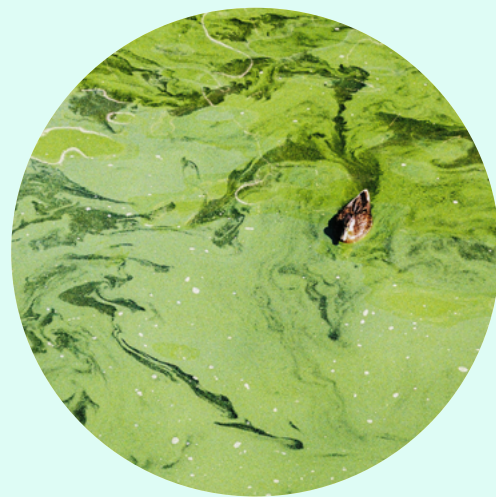
PARTNERS: FORTH, National Aeronautics and Space Administration (NASA), The Pew Charitable Trusts, World Wildlife Fund (WWF) Germany, University of Oxford and University of Queensland



photo: Unsplash / Paul With

GEO Work Programme Progress

Diagnosing the cause and effect of the 2022 Oder river algal bloom



PROJECT:
AquaWatch

LOCATION:
Poland

The GEO AquaWatch Initiative recommends best practices on water quality monitoring to inform better decision-making at the societal level. A recent example of this was a massive algal bloom in the summer of 2022.

Reports of a toxic harmful algal bloom of *Prymnesium parvum* on the Oder River sparked concern among long-time researchers starting from 17 August 2022. The bloom began near Wroclaw, Poland then spread very rapidly, covering nearly the entire Oder River within a week.

This particular algae releases a toxin that leads to massive deaths of fish, amphibians, and mollusks, and inflicts long term harm to surviving organisms. Though *Prymnesium* blooms are not uncommon in Europe, they are rare in this portion of the Oder. Scientists doubted natural causes and suspected human activities.

The toxin itself was first detected in water samples collected by the Leibniz Institute of Freshwater Ecology and Inland Fisheries (IGB-Berlin), host of GEO AquaWatch's Calibration/Validation thematic node. Researchers wanted a better understanding of the scope of the bloom, which might also hint at a source in time and space, hence, satellite scientist Kerstin Stelzer of Germany's Brockmann Consult and a member of GEO AquaWatch provided a time series of chlorophyll concentration in the Oder from July-August 2022. Combined with confirmatory water samples the temperature, pH, salt and nutrient content, scientists were able to pinpoint bloom causes as well as effects.

Profiles of chlorophyll concentrations in the Oder River revealed chlorophyll was moderate throughout most of the river in late July, but higher in the upper river near the town of Opole, Poland from 19-20 July 2022. By 3-4 August 2022, chlorophyll suddenly increased near Wroclaw and the bloom then spread very rapidly, covering almost the entire Oder River within one week, from 10-11 August 2022.

From the analysis, illicit discharges of industrial wastewater from upstream development and out-of-season navigational dredging in neighbouring Poland were diagnosed as a primary cause of the bloom, since *Prymnesium parvum* is found only in slightly salty water of estuaries, not freshwater rivers like the Oder.

Empowering African youth and women in geospatial innovation



PROJECT:
Digital Earth Africa

LOCATION:
Malawi, Nigeria,
Senegal, South Africa,
Uganda and Tanzania

The advancement of Africa has faced significant obstacles due to the restricted accessibility of geospatial data and technology, with a particular impact on its youth and women. This digital divide has impeded the continent's potential for growth and innovation, limiting opportunities for empowerment and economic development among these demographic groups. Bridging this technological gap is crucial to unlocking Africa's full potential and fostering inclusive progress across the continent.

Digital Earth Africa (DE Africa) seeks to exemplify diversity and inclusiveness by being mindful of gender, generational, and geographic diversity at all levels of the organisation. In partnership with YouthMappers and African Women in GIS, DE Africa organised two technical challenges to close the digital divide by providing a platform for the youth and women to leverage geospatial technology effectively. DE Africa offered technical support to the participants by providing access to the DE Africa platform and algorithms. The six projects were from Malawi, Nigeria, Sierra Leone, South Africa, Uganda, and Tanzania.

These projects were implemented with the Research Institute for Innovation and Sustainability (RIIS). They were made possible by the support of the Australian Government and Helmsley Charitable Trust.

DE Africa's partnership with YouthMappers and Africa Women in GIS holds profound importance on multiple fronts. Within local communities, the youth and women lead research grounded in local issues and develop solutions benefitting their communities. At the regional level, this collaboration acts as a bridge, connecting untapped potential with access to advanced technology, thereby promoting inclusivity. On the global stage, this initiative serves as a compelling example of the transformative impact of youth and women in driving innovation and effecting positive change.

PARTNERS: African Women in GIS, Australian Government, Leona M. and Harry B. Helmsley Charitable Trust, Research Institute for Innovation and Sustainability (RIIS) and YouthMappers

An Information hub for managing the Great Atlantic Sargassum Belt



PROJECT:
GEO Blue Planet

LOCATION:
Caribbean,
Gulf of Mexico and
West Coast of Africa

Since 2011, an unusual natural event has gripped the tropical Atlantic: massive strandings of holopelagic Sargassum. This floating brown algae, typically residing in the open sea throughout its lifecycle, now forms the renowned Great Atlantic Sargassum Belt, stretching from West Africa to the Gulf of Mexico. Its impact is staggering, with 20 million tons in June 2018, 10 million tons in June 2019, and 12.7 million tons in June 2020. In 2022, a record-breaking 24.2 million tons of Sargassum hit the shores, setting a historical precedent. This inundation disrupts coastal areas, harming marine ecosystems and local communities.

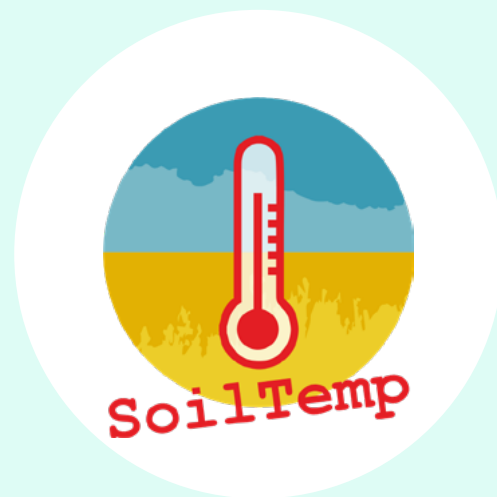
In collaboration with the Intergovernmental Oceanographic Commission of UNESCO Subcommission for the Caribbean and Adjacent Regions (IOCARIBE), the Atlantic International Research (AIR) Centre and other partners, GEO Blue Planet has created the Sargassum Information Hub (sargassumhub.org), which centralises access to information and tools for the monitoring and management of Sargassum blooms for all stakeholders spanning from local fishers to policymakers. Users of the hub can explore a comprehensive array of available observations, forecast reports, and ongoing research and development initiatives. The continuous development of the hub is guided by the co-design philosophy of GEO Blue Planet, ensuring that it delivers the maximum impact as a decision-support tool.

From January to October 2023, the hub has welcomed over 32,000 visitors. It has been showcased at high-level conferences, including OurOcean2023 in Panama, and has garnered significant media attention, with multiple features in CNN news articles.

Looking ahead, the hub's future developments are poised to make it even more accessible and valuable to its users. Plans include translating the hub into various relevant languages and launching additional regional pages, including one dedicated to Europe. There will also be a focus on promoting and disseminating observations and forecasts through an embedded viewer page to the hub.

PARTNERS: Atlantic International Research Centre (AIR), Intergovernmental Oceanographic Commission of UNESCO Subcommission for the Caribbean and Adjacent Regions (IOCARIBE), Mercator Ocean International (Moi), National Oceanic and Atmospheric Administration (NOAA)

Unlocking microclimates for ecosystem resilience in mountain regions



PROJECT:
GEO Mountains

LOCATION:
Global

Scientists rely on weather stations to collect climate data to understand the specific conditions required for various plants and animals to thrive. However, this information is often imprecise, especially for organisms close to the ground. That's where SoilTemp comes in, a global initiative that collects soil and near-surface temperature data from all over the world, even hard-to-reach places. This tool helps scientists understand microclimates - unique climate conditions where many organisms live. With this data, researchers can make more accurate predictions about the impact of climate change on organisms and ecosystem functions.

Such microclimate data is especially important for mountainous regions, where microclimatic variations occur over short distances, and environmental monitoring is limited. GEO Mountains provided financial support for two major advancements in the SoilTemp database.

Firstly, the existing datasets were further cleaned and prepared for open-access publication with the help of a data manager hired using GEO Mountains support. This manager addressed the backlog of data submissions and reprocessed 35,000 time series for inclusion in the upcoming relational database.

Secondly, GEO Mountains' support was used to expand microclimate monitoring in mountain regions worldwide, particularly in hard-to-reach areas where even weather stations are scarce. Various regions involved in the Mountain Invasion Research Network (MIREN) were equipped with sensors, achieving increased long-term monitoring in many cold-climate mountains, tropical mountains, and especially African regions.

A compelling example of the direct impact of microclimate research is the citizen science project Flanders, initiated by SoilTemp in Flanders, Belgium, with microclimate sensors installed by 5000 citizens. By informing garden owners and municipalities about their local microclimates, this initiative has promoted ecologically sound garden planning at a national scale to combat heatwaves and droughts. Microclimate research has already shown that prioritizing local connectivity between protected areas and natural patches is essential. It sets a model for mountain regions, where the concept of 'microclimate management' is still emerging.

EO-based surveillance of persistent organic pollutants: from data to policies



PROJECT:
Global Observation
System for Persistent
Organic Pollutants

LOCATION:
Global

Persistent organic pollutants (POPs), sometimes known as “forever chemicals”, are resistant to environmental degradation through various processes. They pose a global concern as they have the potential for long range transport, bioaccumulation, and biomagnification. The Stockholm Convention on Persistent Organic Pollutants was adopted on 22 May 2001 to protect human health and the environment from POPs.

Monitoring POPs is essential to evaluating the effectiveness of the Stockholm Convention. The Global Monitoring Plan for POPs plays a pivotal role in this effort by providing an organisational framework for collecting comparable monitoring data on the presence of POPs from all regions. This data helps identify changes in POP concentration over time and their transport patterns.

The GEO Initiative Global Observation System for Persistent Organic Pollutants (GOS4POPs) leveraged the e-shape Pilot 2.2 to make available an updated, multilevel database with expanded datasets on POPs in the Global Monitoring Plan Data Warehouse (GMP DWH). A visualisation portal has been developed to generate spatial distribution maps, time series analysis, and trend projection. With these new functionalities,

GMP DWH is better positioned to support the joint interpretation of global POPs data and assessment of related human risks, to support the effectiveness evaluation of policy measures under the Stockholm Convention, and to increase the availability and quality of information needed to track POPs and anticipate changes in the global environment through harmonising metadata production, archiving, and sharing.

In addition to visualisation tools, exports of data are also possible for regional reports on POPs occurrence and trends to support decision-making in chemical management and disease/health control. Outputs of the GOS4POPs serve in preparation of the five regional monitoring reports under the Stockholm Convention and in the development of the effectiveness evaluation report every six years.

Implementing shared Arctic variables to meet societal requirements



PROJECT:
Global Earth Observations
for the Arctic

LOCATION:
Global

People living in the Arctic are facing a rapidly changing environment and are subject to increasing human activity in the region. It is now more important than ever that the voices on the ground are heard to understand people's needs. Arctic observing is being revolutionized by including previously overlooked perspectives.

Shared Arctic Variables (SAVs) are responsive to the information needs of everyone that is affected by the rapid changes in the Arctic environment, including indigenous organisations, northern communities, operational agencies, academia, industry, and government. The three overlapping circles in the figure illustrate how local, regional, and global scales will define SAVs.

The communities join thematic expert panels to co-design and co-manage observation efforts, which include defining priority SAVs, spatial and temporal resolution, accuracy requirements, time period, comparability, observation commitments and requirements for engaging and supporting monitoring efforts in communities.

Funded by Horizon 2020's Arctic PASSION project, three SAVs including permafrost, wildfire, and sea ice are currently being developed. The Wildfire-themed SAV, implemented by IBA Arctic Wildfire Preparedness project, has been discussed among the Sámi representatives, regional and local stakeholders, and international participants at two national and one international workshop. An application is being developed to harness satellite observations and models to serve local needs. By the end of 2023, an Arctic Fire Danger web service will be launched with active fire detection and seasonal fire risk predictions targeted for rescue services and local indigenous users.

An AI approach towards efficient hydropower production in Sweden



PROJECT:
Earth Observations Data for
Water-Energy-Food Nexus

LOCATION:
Sweden

Snowmelt is a very important source for hydropower, which accounts for about 40% of the total electricity production in Sweden. One significant challenge in the hydropower sector is the water spills during snow-melting periods due to inaccurate quantification of the snow storage upstream of hydropower dams. This leads to significant losses of potential hydraulic energy. For instance, in 2015, water spills in Umeälven, a major hydropower producing river in Sweden, led to an economic loss of between 1 to 6 million Euros.

EO4WEF convenes researchers in the remote sensing fields to develop tools for large-scale and dynamic snow monitoring. SnowSat is one tool which combines Earth observations with AI algorithms and Internet-of-Things (IoT) to improve the estimation of snow water storage in Sweden. By developing a high-quality snow accumulation dataset and prototyping a snow service system, SnowSat supports the optimal planning and management of hydropower reservoirs. Consequently, it mitigates water spills and thus increases hydropower production. The developed snow service also provides risk assessments for snow-induced hazards, which can be used in flood prevention/preparedness, forest management and in the planning of ski and insurance industries.

To date, SnowSat has actively involved the local Sami community in the project design and ground snow measurement. The industrial partner, Vattenregleringsforetagen, the hydropower company managing the water in the river, is already using the information gathered by the distributed IoT stations to take informed decisions. The information from the IoT stations and the planned service could also be used by the local Sami community for reindeer herding.

Although the SnowSat service is still in the developmental phase and hasn't been fully deployed, its preliminary results have shown promising potential to revolutionize the management of hydropower systems dependent on snowmelt. Through its ability to offer more precise assessments of upstream snow water storage, it promises to minimize water spills, enhance dam safety, optimize reservoir operations, and ultimately elevate the efficiency and sustainability of hydropower solutions significantly.

Forest biomass reference system for open access



PROJECT:
Forest Biomass Reference System from Tree-by-Tree Inventory Data

LOCATION:
Sweden

Forests are among Earth's most powerful tools for combating the climate crisis. They account for 80 percent of Earth's total plant biomass, store more carbon than the atmosphere, and globally absorb the equivalent of three times the annual carbon emissions of the entire United States. However, uncertainties in forest carbon storage estimation are significantly reducing large-scale global investment in verified forest protection and restoration.

Forest Biomass Reference System from Tree-by-Tree Inventory Data (GEO-TREES) is the world's first open-access and equitable forest biomass reference system designed to make global satellite-based forest carbon assessments actionable. Central to GEO-TREES are extensive, long-term and large-scale forest monitoring plot networks, including ForestGEO, RAINFOR, TmFO, and AFRITRON. These networks comprise thousands of plots in over 50 countries run by hundreds of dedicated specialists and encompass more than 50 percent of the world's tree species. Through co-design with the remote sensing community, GEO-TREES will integrate detailed ground and airborne assessments of forest biomass stocks and fluxes with space-based assessments, establishing a global infrastructure for broad-scale forest monitoring and valuation.

GEO-TREES intends to establish 100 core sites and 200 supplementary sites worldwide to measure and monitor forest biomass stocks and fluxes. It will apply innovative technologies for ground-based measurement such as terrestrial laser scanning (TLS) and airborne laser scanning (ALS) and follow established biomass recommendations of the Committee on Earth Observation Satellites (CEOS).

The data will be delivered in the GEO-TREES portal that is accessible to the public, the science community, corporate stakeholders, and to space agencies that drive critical advances in satellite technologies for global forest biomass mapping and tracking.

Notably, GEO-TREES, the first system of its kind, was recently granted US\$ 12 million through the Smithsonian Tropical Research Institute from the Bezos Earth Fund to implement this Forest Biomass Reference System. The project has been labelled as a Major Forest Carbon Project.

PARTNERS: Austria, Brazil, Cameroon, France, Germany, Italy, Thailand, UK and USA

Partners: Bezos Earth Fund, Centre national d'études spatiales (CNES), European Space Agency (ESA), International Institute for Applied Systems Analysis (IIASA), the Smithsonian Tropical Research Institute (STRI), Tropical managed Forests Observatory (TmFO), University of Toulouse and University of Leeds

GLASS products serve national ecosystem monitoring and evaluation in China



PROJECT:
Global Products of Common
Essential Variables from
Multiple Satellite Data

LOCATION:
China

The ecological environment is the bedrock upon which the progress and endurance of human civilization rest. Its preservation represents an immense and complex global challenge, necessitating comprehensive and sophisticated assessments of its condition and status.

In addressing this formidable challenge, the Global LAnd Surface Satellite (GLASS) product suite emerges as a powerful toolset. Generated from an array of sensors, these products exhibit a host of remarkable attributes. They boast extensive temporal coverage, encompassing many years, with data often available from as far back as 1981 to the present day. Moreover, GLASS products offer high spatial resolutions for surface radiation information, with capabilities reaching down to 250 metres and 0.05 degrees. Ensuring the utmost reliability, these datasets provide spatial continuities that are devoid of missing pixels. Their quality and accuracy are attested to by rigorous validation processes, involving in situ measurements and meticulous comparisons with other established satellite products.

In a notable initiative undertaken in 2020, the GLASS team partnered with the Satellite Application Center for Ecology and Environment in China (SACEE) and various other research institutes. Together, they embarked on a comprehensive remote sensing survey and evaluation of ecological changes across China, spanning the period from 2015 to 2020. This ambitious assessment harnessed the rich dataset

provided by GLASS, including vegetation parameters, meteorological data, and land use information spanning from 2000 to 2020. The primary focus of this endeavour was to gauge the quality of ecosystems, with a particular emphasis on regions of significant ecological importance.

Capitalising on this collaborative effort, SACEE pioneered the development of an innovative ecological quality evaluation system. This system embodies a three-dimensional approach, encapsulating the critical dimensions of “function-stability-stress.” Importantly, it aligns seamlessly with the annual operational requirements for conducting national-scale ecological quality assessments. Within this framework, GLASS methodologies have been thoughtfully integrated into the standards governing data collection and processing. This integration ensures a heightened level of precision and reliability in the assessment of ecological health and well-being.

PARTNERS: Beijing Normal University (BNU), Wuhan University (WHU), University of Hong Kong (HKU), Sun Yat-sen University (SYSU) and Satellite Environment Application Center of Ecology and Environment of China (SACEE)

Advancing in-situ observations of ecosystems in Central Asia



PROJECT:
In-Situ Observations and Applications for Ecosystem Status of China and Central Asia

LOCATION:
China, Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan

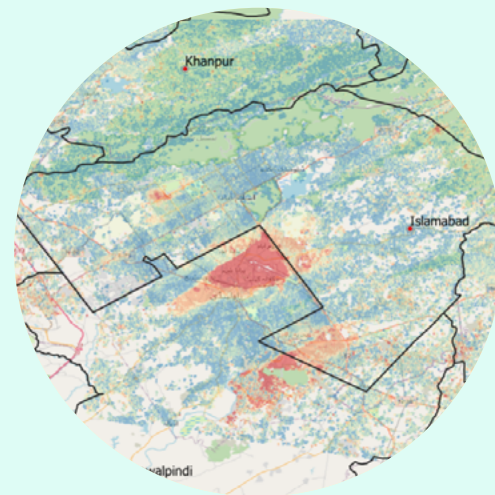
In Central Asia, limited in-situ ecosystem observations have hindered tracking progress against multi-lateral environmental agendas as well as the Sustainable Development Goals. Led by the Institute of Geographic Sciences and Natural Resources Research and the Xinjiang Institute of Ecology and Geography of the Chinese Academy of Sciences, the In-Situ Observations and Applications for Ecosystem Status of China and Central Asia (IN-SITU-ESC) team is committed to help address the issue building upon 35 years of experiences of the Chinese Ecosystem Research Network and a decade of ecosystem observation work in Central Asia. The goal is to strengthen ecosystem observation, data sharing and management capacities across Central Asia.

To further the collaborative network, the Ecological Monitoring and Management Research Alliance in the Central Asian Region was established with 16 organisations from Kazakhstan, Kyrgyzstan, Tajikistan, Uzbekistan, and other countries. Over 30 permanent observation stations were set up to cover the various types of ecosystems in the region.

The team developed protocols for in-situ observation, data processing, and data sharing specialised for Central Asian regions. A series of datasets focusing on Central Asia's ecosystems were produced and a special issue on key dataset for assessment of typical terrestrial ecosystems in the arid zone of Central Asia is being published. A dedicated data repository was established to provide data storage and sharing services. To date, it has shared 446 GB of data and has served 110,000 downloads.

Regular training sessions aimed at enhancing institutional capabilities have been consistently conducted. With the support from this project, Tajikistan's member organisations are now equipped to assume additional national responsibilities for routine ecosystem observation and assessment.

Monitoring land subsidence from groundwater exploitation in Pakistan



PROJECT:
SPACE-SECURITY

LOCATION:
Pakistan

Many nations rely on groundwater extracted from aquifers to provide fresh water to their populations. However, if groundwater is over exploited or withdrawn in excess, the land surface might be affected, resulting in risks for population and critical infrastructures. In Pakistan, groundwater meets around 70 percentage of the domestic water needs, making it crucial to have techniques to monitor the water extraction activities to support policy making in the domains of water, food, and climate security.

SPACE-SECURITY engaged with local Pakistani authorities, highlighting the importance of assessing potential land subsidence in the densely populated twin cities of Islamabad and Rawalpindi. They implemented an application to exploit Earth observation data, specifically Synthetic Aperture Radar (SAR) images acquired by Sentinel-1 satellite, to estimate and monitor the land subsidence in the region over the last seven years.

The team applied SAR interferometric techniques, proven reliable Parallel Small Baseline Subset (P-SBAS) in particular, to process more than 180 Sentinel-1 images, spanning from October 2016 until September 2022. The analysis revealed land deformation of up to 38 centimetres, confirming concerns raised by local entities and international organizations like the World Food Programme (WFP). Local decision-makers in Pakistan can use the relevant information to enhance groundwater resource management.

The results were also integrated in the SatCen Geospatial Data Management Platform, facilitating the interaction between partners, and supporting capability building initiatives. SPACE-SECURITY aims to expand its study to other vulnerable regions to promote sustainable water use in the face of increasing water scarcity, due to climate change.

The pilot project highlighted two key best practices for future implementation. Firstly, the need to involve local users in the development of solutions, which is essential to understand the specific problem, to identify the user needs, and the suitable solution to be implemented. Secondly, the need to collaborate between relevant partners to optimise resource utilisation for efficient investments in research and innovation.

PARTNERS: EuroGeoSurveys, European Space Agency (ESA), European Union Satellite Centre (SatCen), German Federal Agency for Cartography and Geodesy (BKG), IHE-Delft Institute for Water Education and World Food Programme (WFP)



photo: Unsplash / Gemma Evans

GEO Cloud Credits Programme Update



Global mobile tsunami warning system: GreatDetector



PROJECT:
GEO-Amazon Web
Services Earth Observation
Cloud Credits Programme

LOCATION:
Indonesia

Tsunamis have emerged as one of the most devastating hazards in recent history. Indonesia, as the world's most tsunami-prone country, underscores the critical need for effective communication during emergencies. Timely communication is paramount for issuing early warnings and ensuring appropriate responses. In this context, the rapidly evolving landscape of mobile communication technology assumes a pivotal role, enabling the rapid dissemination of vital information to a broad population.

Leveraging the GEO-AWS Cloud Credits Programme, the team has developed an innovative mobile app known as "GreatDetector" (Global Real-time Earthquake and Tsunami scale Detector). This app provides real-time detection of tsunamis resulting from earthquakes. By harnessing cloud-computing applications with AWS, the earthquakes and tsunamis can be analysed in real time and in an automated way, and the data products can be broadcasted to users through AWS.

GreatDetector, available for public testing, serves as a free app that informs users about tsunami threats along coastlines near them. It presents information on the likely size of the largest wave and the time remaining before the tsunami reaches their coast. The initial release caters to English-speaking users with iPhones, with plans to expand its availability to other languages and Android phones. The app as well as the archived results from previous events could be found at <https://gates.jpl.nasa.gov/>. To facilitate use of the app, the GreatDetector team has collaborated closely with the Indonesia Agency for Meteorology, Climatology, and Geophysics (BMKG), the authority responsible for tsunami early warning in Indonesia. An AWS account has been set up in BMKG and rigorous tests is being conducted transfer data from NASA/JPL to BMKG via AWS to operationalise the service.

Empowering food security in diverse african agricultural systems



PROJECT:
GEO-Amazon Web
Services Earth Observation
Cloud Credits Programme

LOCATION:
Ethiopia, Ghana,
Kenya, Mozambique,
Niger, Rwanda,
South Africa, Tunisia

Enhancing Food Security in AFRIcan AgriCULTUral Systems with the Support of REMote Sensing (AfriCultuReS), a project funded by the European Commission, sought to develop a web-based decision support system that integrates heterogeneous datasets such as Earth observation data, weather and climate data, and in-situ data, on current conditions and future scenarios about food production in Africa in a timely manner.

Ghana, Kenya, Mozambique, Niger, Rwanda, South Africa, and Tunisia are among the participating African countries of AfriCultuRes, thus representing the diversity of African agricultural systems and the main food production regions in Africa. The champion users for the AfriCultuReS platform span from agriculture ministries to space agencies and farmers. The users have leveraged the AfriCultuRes platform for monitoring diverse crops typical in their countries, such as avocado monitoring in Kenya, and rangelands (pasture) monitoring in Niger.

Through the GEO-AWS Cloud Credits Programme, the AfriCultuReS platform seamlessly transitioned into a cloud-based environment, streamlining access for users to a wide array of Earth observation informational products and expediting their efficient distribution.

In Mozambique, the Ministry of Science, Technology, and Higher Education now possesses the capability to deliver essential information and offer relevant capacity-building opportunities to farmers, ultimately boosting their productivity.

In Tunisia, the Regional Commission for Agricultural Development of Nabeul has leveraged the AfriCultuReS platform for centralized access to diverse products and data. This centralized approach eliminates the need to request information from 20 different sources, greatly simplifying and enhancing their operations.

PARTNERS: Agriculture, Hydrology, Meteorology Regional Centre (AGRHYMET), Aristotle University of Thessaloniki, Draxis, Eduardo Mondlane University, GeoSAS, GMV Aerospace and Defence S.A.U, Locatell, Observatoire du Sahara et du Sahel (OSS), Scoulia di Ingegneria Aerospaziale, South African National Space Agency (SANSA), University of Ghana and University of Rwanda

Enhancing urbanization monitoring in Kenya



PROJECT:
GEO-Google Earth Engine
Cloud Credits Programme

LOCATION:
Kenya

Monitoring for Information and Decisions using Space Technology (MIDST) is a pilot initiative that seeks to support and engage with national and county government institutions of Kenya in addressing the gaps and challenges on GIS hardware, software, human resources and access to spatial data.

Supported by the GEO-GEE Cloud Credits Programme, MIDST worked with stakeholders to co-design and co-develop Earth observation-based products and applications to deliver their mandate. Spatial planning is one of the three thematic areas selected for the pilot project. Modelling urbanisation trends in the cloud platform allows spatial planners and other actors to understand the manifestation of the urbanisation process within a country, and to project the likely growth trajectory of cities and urban areas.

The pilot modelled decadal urbanisation growth in the Nakuru municipality in Kenya from 1989 to 2020. It was noted that the built-up environment gradually increased its coverage from approximately 1 percent in 1989, to 2 percent in 2000, to 4 percent in 2010 and to 8 percent in 2020. To allow easy access to the generated information, a graphical user interface was developed to provide data-driven solutions in support of rapid decision-making.

The collaborative approach adopted for this project enhanced capacity in various sections of the project including data acquisition, cleaning, processing, and analysis. Co-developing the products brought together diverse perspectives and expertise to enable the project to generate valuable insights and information. These insights could be relied upon to inform decision-making and shape the future of urban development. By engaging in the collaborative process, the project team ensured that the results are evidence-based and meet the needs of all stakeholders, including government agencies, urban planners, and community members. This approach could ultimately lead to more informed policy decisions and more sustainable urban development practices.

PARTNERS: County Government of Nakuru, Directory of Resources Surveys and Remote Sensing of Kenya, Kenya Roads Board, Kenya Space Agency, State Department for Physical Planning of Kenya, State Department of Housing and Urban Development of Kenya, University of Nairobi and UN-Habitat

The first algae bloom monitoring application in Latin America



PROJECT:
GEO-Google Earth Engine
Cloud Credits Programme

LOCATION:
Argentina,
Brazil, Peru

Algae blooms, marked by the rapid growth of certain algae types in water bodies, can signify deteriorating water quality and even pose health risks due to toxin release. Across the globe, several institutions are working to monitor and assess these blooms over time. Early detection is crucial, aiding health officials, environmental managers, and water treatment operators in targeting their testing and interventions effectively.

While extensive efforts have been made to monitor algae blooms in North America and Europe, Latin America lags behind in developing such tools. Fortunately, the GEO-GEE Cloud Credits Programme has empowered small research groups to make strides in satellite image processing. With this capacity, they have developed over the last two years a methodology that leverages in situ measurements and the Normalized Difference Chlorophyll-a Index (NDCI) derived from satellite imagery (Sentinel-2 MSI).

This initiative has yielded the AlgaeMAP: Algae Bloom Monitoring Application for Inland Waters in Latin America, which currently provides data spanning from 2016 to 2023 for over 100 water bodies in Argentina, Brazil and Peru.

AlgaeMAP represents a pioneering development, being the first large-scale water quality application of its kind in Latin America. Initially tailored for water bodies in São Paulo, Brazil, it expanded into other key regions like Cordoba, Argentina, and Arequipa, Peru, due to its success. Responding to high demand, AlgaeMAP is now extending its coverage to north-eastern Brazil, an area facing severe water quality issues.

Notably, AlgaeMAP's outputs have been embraced by diverse institutions, including academic researchers, hydropower companies, and water department services. They rely on the application's spatial and temporal analyses to enhance water management practices across various fronts. This innovative tool is facilitating more proactive responses to algae blooms, safeguarding both aquatic ecosystems and communities reliant on these water bodies.

A near-real-time global rice growth monitoring and yield forecasting platform



PROJECT:
GEO-Google Earth
Engine Programme

LOCATION:
Malaysia
and global rice
production area

Rice is an essential staple food for nearly half of the global population, with significant importance in Asia. In the last few decades, Malaysian rice production and self-sufficiency has suffered challenges due to extreme weather conditions, poor soil fertility and urban development that continues to jeopardize crop growth.

To attain self-sufficiency in rice production, it is crucial to have precise spatial data on rice cultivation area and its yield in real time. Currently, there is no global standard for monitoring rice growth. The existing process for rice yield estimation in Malaysia and most parts of the world relies on field surveys that are time-consuming and inefficient.

The Paddy Watch team, Climate Trace, and IADA Barat Laut Selangor (BLS) – a significant granary region in Malaysia – joined forces through the GEO-GEE Cloud Credits Programme. Together, they developed a powerful algorithm and application for real-time rice fields monitoring throughout the world.

The application is capable of mapping and tracking rice growth stages at a 10-metre spatial resolution across the world. Paddy Watch application can detect how much rice is grown, predict yield, inform water use, and make decisions that help Malaysia reach the Zero Hunger target set out in the United Nations 2030 Agenda for Sustainable Development. The application can also be used to protect rice fields from being repurposed for other uses, such as crop farming or urban development, which play an active part in jeopardizing food security.

Additionally, the Paddy Watch team developed the first worldwide rice field map for estimating methane production, which can potentially support national programmes to track, verify, and reward adoption of methane-reducing techniques in rice production.

In the future, the team plans to broaden its collaboration with other Malaysian government agencies, such as the Malaysian Space Agency, and extend its reach to additional granary regions to enhance the app's functionality and influence.

Furthermore, at the international level, the team intends to collaborate with researchers from China Agricultural University on a joint research project between China and the Association of Southeast Asian Nations (ASEAN) focused on crop mapping using AI and sophisticated data analysis.

Measuring poverty through Earth observation and machine learning



PROJECT:
GEO-Google Earth Engine
Cloud Credits Programme

LOCATION:
Africa
and India

Despite notable progress, about 300 million people in Africa still live in extreme poverty. The global community has collectively committed to implementing the Sustainable Development Goals (SDGs) to further advance human living conditions and combat poverty. However, a significant data challenge hampers the efforts of researchers and policymakers, as they lack the necessary information to deepen their understanding of poverty's root causes and far-reaching consequences.

In response to this challenge, the team of AI and Global Development Lab embarked on a mission to train and adapt an Earth observation and machine learning (EO-ML) algorithm to detect multidimensional poverty in African communities using Landsat satellite images spanning from the 1990s to 2020. This innovative algorithm has given rise to a new dataset, now hosted on Google Earth

Engine as an accessible application. This dataset offers valuable insights into poverty metrics, paving the way for a wide array of downstream applications. For instance, leveraging this dataset, forecasts have been generated regarding the trajectory and pace at which African communities are lifting themselves out of multidimensional poverty. Additionally, it enables assessments of their likelihood to achieve the SDGs by 2030. Recognizing that India is another country with a portion of the population living in poverty, the team conducted a pilot study, extending their approach to this vast sub-continent. While many current EO-ML applications have concentrated

on Africa, predominantly predicting a limited set of asset-based indicators related to human well-being, this application took a different approach. They georeferenced village-level census data representing 40 percent of India's population, employing it to train a distinct EO-ML model capable of predicting 16 variables associated with material conditions using Landsat 7 imagery.

Employing principles of transfer learning, the team utilised the census-based model to extract valuable insights, subsequently fine-tuning this model to predict an even broader spectrum of developmental variables—over 90 in total—derived from two rounds of the National Family Health Survey (NFHS). The overall outcomes clearly indicate that the fusion of satellite data with Indian Census data yields a wealth of information for training ML models. These models provide an unprecedented level of detail in tracking and analysing human development across diverse geographical locations and through time.

Modernizing the national marine habitat map in Belize



PROJECT:
GEO-Microsoft Planetary
Computer Programme

LOCATION:
Belize

In collaboration with GRH Consulting, the Coastal Zone Management Authority & Institute (CZMAI) embarked on a transformative initiative to modernise Belize's long-standing National Marine Habitat Map (NMHM 1997). This ambitious undertaking harnessed the power of high-resolution satellite imagery, field survey data, and cutting-edge mapping techniques supported by Microsoft's Azure platform. The primary focus of this project was to examine Belize's coastal and marine ecosystems, with particular emphasis on coral reefs and seagrass beds, integral components of the nation's climate change mitigation efforts.

The result of this endeavour was the creation of a more comprehensive and precise NMHM for the year 2021, which offered critical insights into the extent of major coastal and marine ecosystems in Belize.

The updated map became a critical input to the InVEST Habitat Risk Assessment (HRA) model, which identified potential threats to these vital ecosystems as outlined in Belize's 2016 Integrated Coastal Zone Management (ICZM) Plan. This provided solid evidence for management interventions and adaptation strategies to strengthen the resilience of both ecosystems and people who rely on them for their livelihoods, such as tourism and fishing.

Both the updated NMHM and the HRA results were seamlessly integrated into the Interim ICZM Plan for 2020-2025. They also inform the development of Belize's Marine Spatial Plan which is expected to be complete by November 2025.

Partnerships and collaboration are essential in achieving successful outcomes for complex national projects. The updated NMHM is an excellent example of how data, technology, partnerships, and collaboration can contribute to national adaptation and sustainable development efforts. It provides policymakers and stakeholders with the necessary data to improve planning and make informed decisions.

Machine listening to monitor climate change impacts on neotropical amphibians



PROJECT:
GEO-Microsoft Planetary
Computer Programme

LOCATION:
Brazil, Colombia

Tropical amphibians such as frogs and toads require specific temperature and humidity conditions to survive. As temperatures are rising and droughts are increasing, driven by climate change, these animals are increasingly threatened with extinction. As a result, there is an urgent need to understand how these animals cope with our changing planet. One solution is to leverage technologies to monitor species activity and support conservation efforts.

The machine listening team made use of autonomous devices to record the sounds of frogs and toads in nature for extended periods. The results of monitoring correspond to 1,733 days, 147,832 audio files, and 8,722,088 detections in 4 sites since 2019. It would have taken experts decades to process these detections manually. With the cloud computing support from the GEO-Microsoft Planetary Computer Programme, the team developed an artificial intelligence system that listens and identifies each species' activity based on their unique sounds. The processing of these detections in the cloud platform took less than a week and resulted in recognizing the calls of 42 distinct species in two tropical conservation hotspots - the Atlantic Forest and Cerrado biomes.

The vast dataset of frog and toad sounds was compiled to create the intelligent system that is now publicly available. With this resource, other scientists and developers will be able to build upon this work and improve the accuracy and efficiency of monitoring methods for these species. The technology developed in this project will allow for more reliable data to be implemented in amphibian monitoring programmes, promoting actions for policies in climate change mitigation in Brazil and Colombia, and reinforcing their leadership in biodiversity monitoring.

PARTNERS: Instituto de Investigación de Recursos Biológicos Alexander von Humboldt (IAVH), K. Lisa Yang Center for Conservation Bioacoustics, Universidad Autónoma de Madrid, Universidade Federal de Goia and Universidad Javeriana



photo: Unsplash / Diego Jimenez

Regional GEOs Development



Establishing a GEO national coordination mechanism across Africa

PROJECT: AfriGEO



The AfriGEO Secretariat, in collaboration with South Africa GEO and the Kenya Space Agency, responded to the AfriGEO Steering Committee's call to develop a guidance document for establishing National GEOs in multiple African countries.

While GEO provides some guidance on national coordination, it primarily draws from experiences in developed countries, which may not fully reflect the unique challenges faced by African nations. Notably, South Africa and Nigeria have already demonstrated leadership in establishing their National GEOs, and Kenya and Ghana show promise in establishing theirs.

National GEOs are pivotal in supporting GEO's global mandate and facilitating regional GEO activities. The concept of "National Coordination Mechanism (NCM)" is a government-led process supported by GEO and AfriGEO that aims to unite Earth observation practitioners from both the public and private sectors. It is anchored in open data and open knowledge, adhering to GEO's values.

Key aspects of the NCM encompass the establishment of legal instruments to support data sharing, data governance, data security, and data collection. Inclusivity is a core element of the NCM, involving all stakeholders and defining what role they have to play. Gender integration and youth inclusion are essential considerations that also need to be addressed.

Financial support and budgeting are vital for NCM implementation in each fiscal year, while defining activities both in the short-term and the long-term. It will also be necessary to establish priority communities of practice at the national level, where stakeholders can regularly exchange what they are working on, share data, and collaborate.

The guidance document will also document use cases of NCMs that exist within the continent to advise on best practices, playing a role in catapulting other countries into setting up National GEOs.

AfriGEO has played a significant role in supporting the establishment of national GEOs. Notably, it assisted Nigeria and South Africa in launching and actively participated in Kenya's Stakeholder engagement process that was spearheaded by the Kenya Space Agency to catalyse the NCM process.

Strengthening regional response to oil spills in the Americas



PROJECT: AmeriGEO

Oil spill incidents pose ongoing challenges for countries in the Caribbean and the Americas.

In response to these pressing concerns, AmeriGEO launched the “Collaboration for the Monitoring of Oil Satellites in the Americas” (COSTA) program during AmeriGEO Week 2022 in Asunción, Paraguay. With the valuable support of NOAA’s Satellite Analysis Branch (SAB), COSTA seeks to facilitate coordinated efforts with national GEOs and enhance regional oil spill monitoring capabilities. It also advocates for individual countries to establish Operational Early Warning Programmes for oil spills.

Since the inception of COSTA, significant progress has been made. In 2022, AmeriGEO stepped in to support Peru in coordinating the response to a devastating Repsol oil spill, which incurred a cleanup cost exceeding US\$ 65 million. In Peru, 16 operators and technical staff from key organisations like the National Commission for Aerospace Research and Development (CONIDA), the Agency for Environmental Assessment and Enforcement (OEFA), and the Ministry of the Environment have received training and certification. CONIDA now spearheads a 7-day operational monitoring system for oil spills.

In Colombia, 11 operators from the National Maritime Authority (DIMAR) and the Oceanographic and Hydrographic Research Center of the Pacific are on track to complete their training and certification by the end of 2023.

In Trinidad and Tobago, following an initial effort in 2021, 17 operators from the Environmental Management Authority, the Ministry of Energy (MEEI), and the Institute of Marine Affairs (IMA) underwent training. IMA and MEEI have since established a 7-day operational monitoring system for the East Caribbean portion of the Atlantic.

Looking ahead, through the coordination of the Central American Maritime Transport Commission (COCATRAM), the maritime authorities of the Central American countries including Panama, Costa Rica, the Dominican Republic, Nicaragua, Honduras, El Salvador, and Guatemala have committed to participate in the COSTA programme in 2024.

The impact of the COSTA programme within the AmeriGEO region is noteworthy from various perspectives, but perhaps the most crucial aspect is the empowerment it offers to GEO member countries. Through COSTA activities, these nations fortify their institutional capabilities in oil spill detection and early warning Programs. This strategic endeavour marks a significant stride toward achieving national autonomy and fostering sustainable development.

Advancing earth observations for the Asia-Oceania region

PROJECT: AOGEO



The Asia-Oceania region, home to two-thirds of the world's population, is grappling with environmental changes spurred by climate change and rapid socioeconomic growth. In response to these challenges, the Asia-Oceania Group on Earth Observations (AOGEO) has taken the initiative to foster effective regional cooperation. Their goal is to enhance Earth observations capacity, effectively addressing the unique challenges confronting countries in Asia-Oceania.

AOGEO's focus extends to nine critical challenges, encompassing water cycles, biodiversity, greenhouse gas emissions, oceans, coasts, islands, agriculture, food security, drought, the environment, and disaster management. AOGEO employs a diverse range of approaches, including annual symposia, workshops, training activities, and webinars. These approaches are aimed at capacity development and engagement with targeted stakeholders, drawing the participation of over 800 attendees from the region over the last two years.

The 15th AOGEO Symposium held in 2022 underscored the growing demand for access to high-resolution and near real-time observation data, as well as the need for continuous capacity development in science and technology. The Integrated Priority Studies, such as those focused on the Mekong River Basin, Pacific Island Countries and Territories (PICTs), and the Himalayan Mountains, were prominently discussed. These studies showcased evidence-based tools designed to support decision-making processes.

The 6th AOGEO Workshop successfully trained 580 practitioners and young professionals in Earth observation for climate monitoring. In alignment with GEO's Post-2025 strategy, AOGEO is committed to engaging the youth, recognizing their pivotal roles in promoting scientific endeavours, catalysing sustainable development, and serving as ambassadors for science within their communities.

Furthermore, the Oceania Geospatial Symposium in 2022 revealed a strong willingness among Pacific Island Countries and Territories to collaborate closely with GEO and the Committee on Earth Observation Satellites (CEOS) for increased access to satellite data across the Pacific region. Consequently, it has led to heightened active involvement and leadership from the Pacific Island Advisory Group, signifying a positive step toward addressing regional challenges through collective action.

Leveraging Copernicus programmes for global challenges

PROJECT: EuroGEO



Launched in 2017, EuroGEO represents Europe's contribution to GEO, with its primary objective being the promotion of Earth observations (EO) in addressing global challenges effectively. In the past years, EuroGEO has focused on securing a coherent European contribution to the GEO initiatives. The new EuroGEO implementation plan aligns its activities to address the interconnected challenges, including climate change, biodiversity loss, and pollution at a global scale.

Copernicus data and services have become integral tools in the GEO community, supporting diverse domains such as marine, land, atmosphere, and climate. EU-funded programmes such as Horizon Europe have contributed significantly to set up new EO systems to better use and exploit the Copernicus data, and to establish services which address issues within and outside of Europe. GEO Work Programme activities have also been supported in various Horizon Europe Partnerships like AgriData, Biodiversa+, PARC, and projects of the Digital Europe Programme. Through the e-shape project, EuroGEO has contributed to consolidating EO resources based on Copernicus for the global community. The 37 pilots conducted under the e-shape project have proven to be a significant resource for the GEO Community. The methodologies and findings from e-shape are now accessible through the GEO Portal and the GEO Knowledge Hub. These methodologies, along with the partnership of e-shape, also support the ongoing incubator process, which is currently being tested on the

Global Ecosystem Atlas and the Global Heat Resilience Service, serving as precursors to post-2025 activities.

A great example of how Copernicus data is being used today is the European Ground Motion Service (EGMS), implemented by the European Environment Agency as part of the Copernicus Land Monitoring Service. EGMS was launched in 2021 enabling users to identify ground motion with millimetre precision across Europe. Specifically, it is being used to improve landslide risk management. Companies like Detektia rely on EGMS for their services. Detektia uses EGMS to provide early warnings of infrastructure deformation. Notably, it was instrumental in assessing risk in the case of the Fereggiano Flood Diversion Tunnel in Genoa, where significant ground surface deformation above the tunnel was detected early enough to inform action. Additionally, EU projects like RASTOOL are working to transform EGMS products into cross-border landslide risk assessment information, ultimately benefiting people living in landslide-prone areas.

The recent launch of the new Copernicus Data Space Ecosystem marks a significant development for the GEO community. It provides immediate access to vast quantities of open and free Earth observation data from the Copernicus Sentinel satellites, encompassing both new and historical Sentinel images, as well as data from Copernicus Contributing Missions. EuroGEO is poised to leverage its projects and initiatives, including the GPP Project, e-shape, and JRC EuroGEO Digital Ecosystem, to facilitate the evolution of a GEO infrastructure that fully harnesses the benefits of these investments.



Table **of Acronyms**

Table of Acronyms

Acronym	Name
AAFC	Agriculture and Agri-Food Canada
ACCESS	Alliance for Collaboration on Climate and Earth Systems Science
AFAD	Turkish Disaster Management Agency
AGRHYMET	Agriculture, Hydrology, Meteorology Regional Centre
AIR	Atlantic International Research Centre
AMIS	Agricultural Market Information Systems
ANSO	Alliance of International Science Organizations
ASEAN	Association of Southeast Asian Nations
AWS	Amazon Web Services
BKG	Federal Agency for Cartography and Geodesy Germany
BMEL	Federal Ministry of Food and Agriculture of Germany
BMKG	Agency for Meteorology Climatology and Geophysics of Indonesia
BMZ	Federal Ministry for Economic Cooperation and Development of Germany
BNU	Beijing Normal University
CABI	Centre for Agriculture and Bioscience International
CAS	Chinese Academy of Sciences
CBD	Convention on Biological Diversity
CBFEWS	Malawi's Community-Based Flood Early Warning System
CNES	Centre national d'études spatiales
CNR	National Research Council
CONAE	Comisión Nacional de Actividades Espaciales
COCATRAM	Central American Maritime Transport Commission
CZMAI	Coastal Zone Management Authority & Institute of Belize
DCCMS	Department of Climate Change and Meteorological Services of Malawi
DEFRA	Department for Environment Food and Rural Affairs of United Kingdom
DIMAR	Dirección General Marítima Colombiana
DODMA	Department of Disaster Management Affairs of Malawi
DOST	Department of Science and Technology of the Philippines

Acronym	Name
DPWH	Department of Public Works and Highways of the Philippines
DRSRS	Directorate of Resources Surveys and Remote Sensing
DWR	Department of Water Resources of Malawi
ECMWF	European Centre for Medium-Range Weather Forecasts
EEA	European Environmental Agency
EGS	EuroGEO Surveys
ESA	European Space Agency
FAO	Food and Agriculture Organization
FCPF	Forest Carbon Partnership Facility
GAD	Gobierno Autonomo Descentralizado de Azuay
GBIF	Global Biodiversity Information Facility
GEE	Google Earth Engine
GeoSAS	Geospatial Analytical Services
GIZ	German Agency for International Cooperation
HKU	University of Hong Kong
IADA	Integrated Agriculture Development Area in Malaysia
IAVH	Instituto de Investigación de Recursos Biológicos Alexander von Humboldt
ICHARM	International Center for Water Hazard
ICIMOD	International Centre for Integrated Mountain Development
IFI	International Flood Initiative
IHE	IHE Delft Institute for Water Education
IIASA	International Institute for Applied Systems Analysis
IMAA	Institute of Methodologies for Environmental Analysis
INAMHI	Instituto Nacional de Meteorología e Hidrología
IOCARIBE	Intergovernmental Oceanographic Commission of UNESCO for Caribbean and Adjacent Regions
IWUMD	Irrigation and Water Utilization Management Department of Myanmar
JAMSTEC	Japan Agency for Marine-Earth Science and Technology
JAXA	Japan Aerospace Exploration Agency
JPL	NASA Jet Propulsion Laboratory
KMGBF	Kunming-Montreal Global Biodiversity Framework
KRB	Kenya Roads Board
KSA	Kenya Space Agency
LiU	Linköping University

Acronym	Name
MMU	Manchester Metropolitan University
MOi	Mercator Ocean International
MOST	Ministry of Science and Technology of the People's Republic of China
MRCS	Malawi Red Cross Society
MRI	Mountain Research Initiative
NASA	National Aeronautics and Space Administration
NASK	National Academy of Sciences of Tajikistan
NASU	National Academy of Science of Ukraine
NATESC	National Agro-Tech Extension and Service Center
NFGA	National Forestry and Grassland Administration of China
NICFI	Norway's International Climate and Forest Initiative
NOAA	National Oceanic and Atmospheric Administration
NRSCC	National Remote Sensing Center of China
NSP	Plant Production and Protection Division of FAO
OSS	Observatoire du Sahara et du Sahel
RAINFOR	Amazon Forest Inventory Network
RCMRD	Regional Centre for Mapping of Resources for Development of Kenya
RIIS	Research Institute for Innovation and Sustainability
SACEE	Satellite Application Center for Ecology and Environment of China
SANSA	South African National Space Agency
SAON	Sustaining Arctic Observing Networks
SatCen	European Union Satellite Centre
SEE	Sustainable Eco Engineering Pvt. Ltd
SIA	Scoulia di Ingegneria Aerospaziale
STRI	Smithsonian Tropical Research Institute
SYSU	Sun Yat-sen University
TmFO	Tropical managed Forests Observatory
UAM	Universidad Autónoma de Madrid
UEM	Eduardo Mondlane University
UFG	Universidade Federal de Goiás
UFRJ	Federal University of Rio de Janeiro
UG	University of Ghana
UMT	Universiti Malaysia Terengganu
UNCCD	United Nations Convention to Combat Desertification

Acronym	Name
UNDP	United Nations Development Programme
UNEP-IEMP	United Nations Environment Programme - International Ecosystem Management Partnership
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNOSAT	United Nations Satellite Center
UONBI	University of Nairobi
UPLB	University of Philippines Los Banos
UR	University of Rwanda
USAID	United States Agency for International Development
USRA	Universities Space Research Association
UT	University of Tokyo
WFP	World Food Programme
WHU	Wuhan University
WOCAT-CDE	World Overview of Conservation Approaches and Technologies - Center for Development and Environment



GEO GROUP ON
EARTH OBSERVATIONS