

## Interim update of the GEO Cloud Credits Programme

*This document is submitted by the Secretariat to the Programme Board for information.*

### 1 INTRODUCTION

Following the launch of GEO's Cloud Credits Programme in 2019 and the first partnership with Amazon Web Services (AWS), the programme has continued to expand by forging new partnerships with Google Earth Engine and Microsoft Planetary Computer (previously AI for Earth). Since the last report presented at the 18<sup>th</sup> Programme Board, GEO's Cloud Credits Programme now has a total of 77 projects (22 with AWS; 21 with Microsoft, divided into three calls; and 34 with Google Earth Engine).

This interim report presented to the 25<sup>th</sup> Programme Board is intended to provide an overview of the status of the projects and to continue discussion on the next steps of the Cloud Credits Programme. Given that most of the projects are in the process of being completed, it is relevant to reflect on the place of this programme within the Secretariat and the GEO Work Programme. Also, to note that the initial intention was to break down the barriers to access state-of-the-art technology at no cost to GEO members. If successful, this point would be reached when the next stage decisions would be taken with the successful projects.

### 2 STATUS OF THE PROJECTS

It is important to remember that all three partnerships were negotiated in the spirit of GEO and according to the GEO Rules of Procedure. In all three partnerships, it is stipulated that the credits are provided to the institutions subject to the conditions that all data and software developed during the project will be made available globally as open source and not owned by the vendors. All data used in the projects is to be fully documented (showing provenance and access conditions, if any), and made available in a free and open manner, according to the GEO Data Sharing and Data Management Principles and the FAIR guidelines.

Each programme began with a public call for proposals. The selection of projects was based on pre-set criteria and process.

#### 2.1 GEO-AWS Earth Observation Cloud Credits Programme

Of the 22 projects within the GEO-AWS EO Cloud Credits Programme, 6 are still in the implementation phase with the credits provided in the programme. For the remaining projects, the last credit end date has been reached. See Annex B for a detailed breakdown.

The GEO-AWS EO Cloud Credits Webinars, held from 22 to 25 March 2021, provided an opportunity for projects in the GEO-AWS Programme to share knowledge, obtain advice and expand their networks. Participants from nineteen projects in least developed countries participated in the webinars, ranging from Costa Rica to Rwanda to Nepal. The projects were thematically divided into four different sessions: Agriculture, Disaster Response and Prevention,

Ecosystems and Biodiversity, and Sustainable Development. Recordings and presentations are available on the GEO website [GEO-AWS Webinar Series \(earthobservations.org\)](https://earthobservations.org).

As this programme was the first in the series, it helped to identify the needs of grantees and to inform some early lessons learned in the design of the programmes with Google and Microsoft.

## **2.2 GEO-Google Earth Engine Programme**

This programme comprises 34 projects implemented over a period of two years, most of which ended in the year 2022 – see Annex B. The programme benefited from the technical and communication support of EO Data Science. In 2020, the EO Data Science team brought together the GEO-Google Earth Engine (GEE) Programme projects for five virtual meetups. The virtual meetups, which took place between the 1 December 2020 and 10 December 2020, enabled projects working on similar themes to exchange knowledge and network with one another. The projects were grouped by theme into five sessions: disaster management; biodiversity and climate change; water quality; land degradation; agriculture and poverty alleviation. The recordings of the meetups are available on the [EO Data Science website](#).

The GEO GEE Programme organized a side event during GEO Week 2021. The projects have also been covered by the EO Data Science newsroom in 2021 and several projects have been showcased in the GEO for Good Lightning Talks Series organized by the Google in 2022. Videos of the presentations and discussions are available on [Youtube](#).

## **2.3 GEO-Microsoft Planetary Computer Programme**

The GEO-Microsoft Planetary Computer Programme is the most recent programme. It includes a total of 21 projects selected during three calls for project proposals. The first call, co-organized with GEO-BON, comprised of five projects, all of which are still ongoing. The Secretariat is providing administrative support to these projects and has now started discussions with these projects about deliverables and will make the GEO Knowledge Hub available to researchers as a repository for the developed codes and applications. The credits will be available for a period of 3 years, and the deliverables will therefore be expected by the end of 2023.

Projects in the second call conducted jointly by the GEO Secretariat and Microsoft began in late 2021 for one year. A mid-term report was conducted in May 2022. Among the seven projects, one has been extended to 2023. The Secretariat is in discussion with these projects on the availability and utility of the GEO Knowledge Hub.

Finally, the third joint call for proposals between the GEO Secretariat and Microsoft resulted in 8 projects starting in 2022 and one project being postponed and finally starting in January 2023. These projects have a duration of one year. The GEO Secretariat provides the administrative follow up and will also provide them with insights on the availability of the GEO Knowledge Hub.

Several projects in this programme have requested an extension of the agreement. The reasons cited are varied and include the delay in project implementation due to the pandemic and the allocation of funds carried over to future events. In most cases, the duration of the credits exceeds the duration of the agreement, so the extension requests are purely formal and allow the projects concerned to continue development and participate in future events.

### **3 LESSONS LEARNED**

A key lesson learned was that the effective development, management and monitoring of the Cloud Credits Programme requires dedicated resources. For example, in the case of the GEO-AWS EO Cloud Credits Programme, the Secretariat provided administrative and scientific support, in collaboration with the AWS team on the technical side. The Secretariat supported the promotion of the programme, including during the 2021 webinars. Unfortunately, the lack of financial resources led to the cancellation of the side event planned at GEO Week 2022 as the programme beneficiaries did not have financial support for travel to the event.

On the other hand, the GEO-Microsoft Planetary Computer Programme offered a cash grant that accompanied the provision of cloud credits. Among other things, projects were able to finance their participation in various science events. In addition, the grant also allowed grantees to fund a portion of their research costs, enabling projects to develop more mature deliverables, such as application development and data and code packages.

The GEO-Microsoft Planetary Computer Programme was managed by the Secretariat for two of its three calls. However, the first call was managed by the GEO-BON secretariat on the scientific supervision aspects. This model is important because it illustrates how a GEO Work Programme activity led the management of the projects, thus allowing alignment with the GEO Work Programme. The GEO Secretariat remains in charge of the administrative follow-up of these projects.

One of the main challenges faced in the implementation of two of these three programmes is the absence of resources for communications, exchange and dissemination of project results has directly impacted project sustainability. EO Data Science and Google Earth have attempted to overcome this problem by providing resources to disseminate the results, mainly through virtual meetings and showcases. The Secretariat has a role to play in continuing discussions to make the GEO Knowledge Hub available, both to disseminate the results and to promote alignment with the GEO Work Programme, where possible.

Although many of the projects are not yet complete, an initial evaluation of the GEO Cloud Credits Programme is that it is an example of the GEO community successfully working closely with the private sector. See Annex A for a snapshot of some of these success stories. As a result of this programme, Digital Earth Africa has an agreement with AWS, Digital Earth Pacific uses the Microsoft Planetary Computer, some initial work has been done with Digital Earth Americas and Google Earth Engine and the Open Earth Alliance has partnerships with Google and Microsoft. Recently, building on the success of the AWS programme, GEOglWS is in advanced discussions to implement the use of GEOglWS in the Cloud for over a dozen countries in Africa and Latin America.

### **4 WHAT'S NEXT**

2023 will be dedicated to tracking and contacting the different research groups in order to get reports on progress and final reports of the completed and soon-to-be-completed projects. The GEO Knowledge Hub team will also consider the Hub serving as a repository of the developed codes and applications. The Secretariat will attempt to identify successful projects and continue discussions on links with, and potential integration into, the Work Programme activities, especially for programmes that have been monitored and managed by the Secretariat. The first

call of the Microsoft programme is an exception, as it is already part of the Work Programme through GEO BON.

Managing the Cloud Credits Programme has required Secretariat resources for backstopping and support. Any future efforts will need the same, including for discussions with AWS, GEE and Microsoft to consider the future and sustainability of this collaboration. All identified options will be presented to the Programme Board for its consideration.

## **Annex A**

### **Illustrative Success Stories**

#### **BRAZILIAN EARTH OBSERVATION DATA CUBE USING AWS FOR LAND USE AND COVER CHANGE**

The project "Brazilian Earth Observation Data Cube using AWS for Land Use and Cover Change" was selected from several proposals within the GEO-AWS Earth Observation Cloud Credits Programme. It received \$60,000 in Earth Observation Cloud Credits. The goal of this project is to compute, store and process large volumes of satellite images for the automatic generation of land use and cover maps of Brazil. AWS is helping INPE to archive this goal.

From January 2022, the Earth observation data cubes produced by the Brazil Data Cube project are available on AWS (Amazon Web Service) as Open Data. These data cubes are produced from Analysis-Ready Data (ARD) of CBERS-4, Sentinel-2 and Landsat-8 satellite images for the entire region of Brazil.

More info :

[Brazil Data Cube – Plataforma para Análise e Visualização de Grandes Volumes de Dados Geoespaciais](#)

[Earth Observation Data Cubes for Brazil - Registry of Open Data on AWS](#)

#### **MONITORING DISASTERS IMPACTS ON LAND COVER IN COASTAL ZONES OF EGYPT WITH GEOSPATIAL ANALYSIS TOOLS AND OFFICIAL STATISTICS**

The ESCWA project on "Monitoring Disasters' Impacts on Land Cover in Coastal Zones of Egypt" was selected for funding among the GEO-Google Earth Engine Programme. The project, submitted in cooperation with the Central Agency for Public Mobilization and Statistics in Egypt (CAPMAS), "responds to the urgent need to integrate disaster measurements with other statistics and, in turn, to provide better data and measurements to improve disaster risk reduction in Egypt and the Arab region," said Wafa Aboul Hosn, Chief of Economic Statistics at ESCWA. The project provides the required data and a replicable methodology to assess damage caused by disasters in a local context. It also links the use of remote sensing data to traditional statistical data, which will improve geospatial analysis in the region and increase the effectiveness of Sustainable Development Goals (SDG) monitoring.

More info:

[UNESCWA Initiative for Monitoring Disasters Impacts on Land Cover in Coastal Zones of Egypt with Geospatial Analysis Tools and Official Statistics](#)

### **AI FOR THE BELIZE NATIONAL MARINE HABITAT MAP**

Since late 2020, Belize’s Coastal Zone Management Authority & Institute (CZMAI), supported by GRH Consulting Ltd., has been implementing the “AI for the Belize National Marine Habitat Map” project. Via this work, Belize’s 1997 30m Landsat-based National Marine Habitat Map was updated, using a combination of Microsoft Azure’s cloud computing power in conjunction with field surveys, 3m PlanetScope imagery, supplementary 10m Sentinel-2 imagery, and Machine Learning techniques. As such, the data is used to provide updated estimates of the status of Belize’s major coastal and marine ecosystems. In addition to helping inform Belize’s Nationally Determined Contribution (NDC) to the Paris Agreement, the data will now be used to support the country’s implementation of Sustainable Development Goal 14 and will be integrated into the revision of the National Integrated Coastal Zone Management Plan. Additionally, these ecosystems are recognized for their blue carbon focus and potential to contribute to Belize’s climate change mitigation efforts.

More info:

[GEOBON-AI for the Belize National Marine Habitat Map project – final report](#)

## Annex B

### Status of all Cloud Credits Projects

**Table 1: Status of GEO-AWS Earth Observation Cloud Credits Programme**

Project Title	Status	Credit end date	Institution
AWS4AgriSAR-Crop inventory mapping from SAR data on cloud computing platform	Ended	7/30/2020	Centre of Studies in Resources Engineering (CSRE) Indian Institute of Technology Bombay
agriBORA - Geodata for actionable farm intelligence	Ended	12/31/2022	Kenya Agricultural and Livestock Research Organization (KALRO)
AfriCultuReS Decision Support System (ADSS) Community Version	Ongoing	3/31/2023	South African National Space Agency
Mapping National-Scale Agricultural Practices	Ended	2/28/2022	University of Maryland, USA
Monitoring rice paddy and flood in the lower mekong basin	Ended	10/31/2022	HCMC Space Technology Application Centre
Filtered Alert Hub Toolset	Ended	9/30/2022	Alert-Hub.Org CIC / Brazil Meteorological Institute (INMET)
Fire Monitoring Service	Ended	12/31/2022	Tsinghua University/China
Global Mobile Tsunami Warning System using Amazon Web Sever— A Life-Saving Platform	Ongoing	9/30/2023	Ikatan Ahli Tsunami Indonesia, Tsunami Research Foundation / NASA Jet Propulsion Laboratory Pasadena University of ChileSantiago / Instituto Geofisico, Escuela Politecnica Nacional, Quito-Ecuador
Air Quality Forecasting for Africa	Ended	12/31/2021	Kigali Collaborative Research Center (KCRC)
South Asian drought monitoring and outlook system to support agricultural advisory processes	Ended	9/30/2022	ICIMOD , Nepal
Brazilian Earth Observation Data Cube using AWS for Land Use and Cover Change	Ended	12/31/2022	National Institute for Space Research (INPE) , Brazil
Extracting semantic features from for OSM using deep leering and Sentinel 1&2 data for land use classification to support GEO wetland monitoring	Ended	3/31/2022	Department of Remote Sensing and GIS, Faculty of Geography, University of Tehran Geoinformatics - Department of Geography, University of Babylon GIScience Heidelberg

Project Title	Status	Credit end date	Institution
Spatial Agricultural Intelligence	Ended	10/31/2020	African Regional Institute for Geospatial Information Science and Technology (AFRIGIST)
Automation of processes in the cloud, for the generation of mosaics of annual satellite images free of clouds, to contribute in the generation of information on changes in forest cover.	Ongoing	n/a	National Programme for the Conservation of Forests for the Mitigation of Climate Change of the Ministry of the Environment of Peru
A Global Modelling Tool for Nature's Contributions to People in Sustainable Development	Ended	7/31/2022	Costa Rica - Ministry of Environment and Energy
Capacity Building on Monitoring of SDGs	Ended	8/31/2022	Remote Sensing and Climate Center, Ghana Space Science and Technology Institute
India Datacube (Integrating Earth Observation Data with Censuses and Sample Surveys to Estimate Development Indicators for India)	Ended	9/30/2022	Indian Institute for Human Settlements
EO for sustainable development	Ongoing	2/28/2023	National Institute of Statistics and Geography (INEGI) National Commission for the Knowledge and Use of Biodiversity (CONABIO), Mexico City
Methodology for SDGs indicators assessment	Ended	8/31/2022	Space Research Institute NAS Ukraine and SSA Ukraine
Deep Learning for Satellite Monitoring of Illegal Amber Mining in Ukraine	Ended	10/31/2021	Kharkiv National University
FAO Sen2-Agri	Ongoing	8/31/2023	FAO
Operational monitoring system of ground deformations in Nigeria	Ongoing	n/a	Department of Geoinformatics and Surveying, University of Nigeria



**Table 2: Status of GEO-Google Earth Engine Programme**

Project Title	Status	Institution
Paddy Watch	Ended	Sydney Institute of Agriculture, The University of Sydney
Remap		College of Science and Engineering, James Cook University
Alert System for Algal Bloom		Federal University of Pelotas, Brazil (UFPeI)
Land Degradation Neutrality		Institute of Remote Sensing and Digital Earth, Chinese Academy of Sciences
BioModelos		Instituto Alexander von Humboldt
Multi-temporal Change Detection		Profesional Especializado GIT.
		Administración de la información geodésica, cartográfica y geográfica. Instituto Geográfico Agustín Codazzi - IGAC
Coastal Erosion and Mangrove Ecosystems		Institute of Marine and Coastal Research
Ecological Integrity Index		Humboldt Institute, National Parks office, Conservation International, and The Nature Conservancy in Colombia
Deforestation / Forest Degradation		National Center for Geoenvironmental Information (CENIGA) of the Ministry of Environment and Energy (MINAE) of Costa Rica
Identification of Vulnerable Areas and / or Climatic Risks		Ministerio del Ambiente (Ecuadorian Ministry of Environment)
Urban Agricultural Intensity with SAR and optical RS		Faculty of Hydraulic and Water Resources Engineering, Institute of Water Technology, Arba Minch University
Analysis Ready Data for Water Security		Pacific Community (SPC), Australian National University (ANU)
Coastal Ecosystems		German Aerospace Center (DLR)
Marine Coastal Eutrophication		Institute for Space-Earth Environmental Research, Nagoya University
Natural Resources Management	Kenya Space Agency	
Ice Shelf Monitoring	Department of Geoscience & Remote Sensing	

Project Title	Status	Institution
		Delft University of Technology
i) Multi-scale Flood Monitoring and Assessment Services for West Africa (MiFMASS)		African Regional Centre for Space Science & Technology Education-English
ii) UK Space Agency – International Partnership Programme: Strengthening Public Policy from Space (SPPS): Satellite-enabled Data Services		
Flood Monitoring		Institute and Observatory of Geophysics, Antananarivo (IOGA). University of Antananarivo
Large-Scale High-Resolution Detection of Vulnerable Settlements		National Institute of Statistics and Geography (INEGI, Mexico)
Fire Danger Warning System		Eversis
Sustainable water management for agriculture		Laboratoire de Télédétection Appliquée (LTA) and Centre de Suivi Ecologique (CSE)
Vegetation monitoring - Cape Floristic Region		South African Environmental Observation Network (SAEON),  Fynbos Node
Multidimensional Poverty Data - Africa		Department of Sociology and Work Science, University of Gothenburg and Center for Population and Development Studies, Harvard University.
Global environmental change monitoring		KTH Royal Institute of Technology  Director, Division of Geoinformatics  Department of Urban Planning & Environment
Sustainable Water Management		Observatoire du Sahara et du Sahel (OSS)
Deep Learning Methods for Land Cover and Land Use Classification		Space Research Institute NAS Ukraine and SSA Ukraine
Essential Biodiversity Variables - ScaleUp		University of Florida and Florida Museum of Natural History and  German Centre for Integrative Biodiversity Research (iDiv)
AquaWatch		University of Wisconsin-Madison  Space Science and Engineering
Trends.Earth - Supporting Land Degradation Neutrality		Ecosystem Analysis

Project Title	Status	Institution
		Moore Center for Science, Conservation International
Ecological Integrity Index		Northern Arizona University SICCS
Disaster Forecasting, Mitigation, Response		ImageCat, Inc
Monitoring Disasters Impacts on Land Cover in Coastal Zones of Egypt		United Nations Economic and Social Commission for Western Asia
Environment and Climate Stress Index		UN Environment Programme

**Table 3: GEO-Microsoft Planetary Computer Programme**

Project Title	Status	Institution
AMAZECO: Covering the Amazon with an Ecosystem Structure EBV product combining satellite and airborne LIDAR	Ongoing	Bangor University, UK Universidade Federal dos Vales do Jequitinhonha e Mucuri, Brazil University of Florida, USA
AI for the Belize National Marine Habitat Map	Ongoing	Coastal Zone Management Authority and Institute, Belize, C.A GRH Consulting, LLC, Alabama, USA
Extracting the signal of change in community-composition EBVs from big unstructured species-occurrence datasets through Azure-enabled spatiotemporal analytics	Ongoing	CSIRO, Australia
Bioacoustics and Machine Learning for Automated Avian Species Monitoring in Global Biodiversity Hotspots	Ongoing	Future Generations University Asociación Armonía, USA
Using AI to validate and downscale ecosystem-related Essential Biodiversity Variables (EBVs) in mountain environments	Ongoing	EURAC Research, Italy U.S. Geological Survey, USA Mountain Research Initiative, Switzerland ISAC-CNR, Italy
Open Earth Alliance Earth Analytics Hub	Ongoing	Open Earth Alliance
PD (Phylogenetic Diversity) in the cloud	Ongoing	Global Biodiversity Information Facility, Copenhagen, Denmark University of New South Wales Sydney, Australia
India Flood Monitoring and Impact Assessment Portal (IFMIAP)	Ongoing	Indian Institute for Human Settlements, India
Global mapping and monitoring of coconut plantations and the assessment of their biodiversity impacts using deep learning	Ongoing	Durrell Institute of Ecology and Conservation, University of Kent, UK Stellenbosch University, South Africa Borneo Futures/IUCN Oil Crops Task Force, Brunei Darussalam Autonomous University of Barcelona, Spain Liverpool John Moores University, UK
Global Near-Real Time Drought Monitoring Using High-Resolution Satellite Precipitation Datasets	Ongoing	North Carolina Institute for Climate Studies/North Carolina State University (NCICS/NCSU), Asheville, NC, USA National Centers for Environmental Information (NCEI), Asheville, NC, USA NASA Goddard Space Flight Center (GSFC), Greenbelt, MD, USA

Project Title	Status	Institution
EXTENT –wetland habitat and extent mapping powered by Planetary Computer	Ongoing	DHI GRAS, Denmark
Near-real-time monitoring of tropical forest disturbance by fusion of Landsat, Sentinel-1, and Sentinel-2 data	Ongoing	Department of Earth & Environment, Boston University, USA
GEODE: A Genomic Observatories Diversity Explorer	Ongoing	Pennsylvania State University, USA
Development of Cloud Computing and Machine Learning Tools to Identify Combined Heat and Flood Exposure Worldwide	Ongoing	CIESIN, USA
Monitoring Deforestation and Degradation in Brazilian Amazonia with Planetary Computer	Ongoing	Logos GEO R&D and INPE-Brazil, Brazil
Optimizing the Microsoft Planetary Computer for Emergency Observation and Mapping (EO/M)	Ongoing	Manilla Observatory, Philippines
Machine listening to monitor climate change impacts on neotropical amphibians	Ongoing	Universidad Autónoma de Madrid, Spain Instituto de Investigación de Recursos Biológicos Alexander von Humboldt, Colombia Pontificia Universidad Javeriana Cali, Colombia Universidade Federal de Goiás, Brazil
IPEAR: Intelligent Planning of Electrification for Agriculture using Renewables	Ongoing	ESPOL University Guayaquil, Ecuador
GEO for NAPs	Ongoing	Michigan State University, USA
Remote sensing of structural diversity as an open-source tool for monitoring forest ecosystem function	Ongoing	University of Texas at El Paso, USA
Azure4GEO -Deep learning based crop characterization with synergistic use of SAR and optical data on cloud computing platform	Ongoing	Indian Institute of Technology Bombay, India