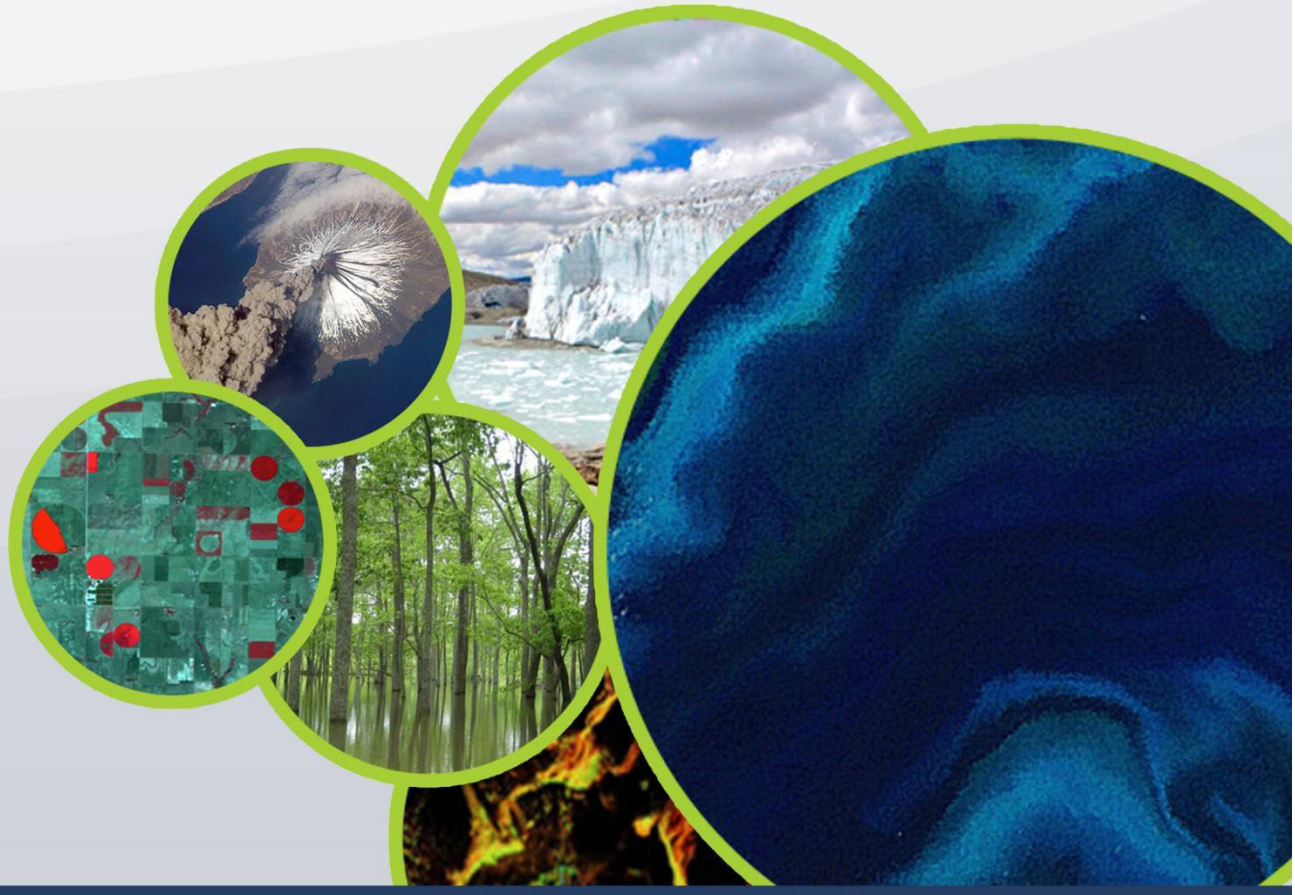
Committee on Earth Observation Satellites



2023-2025 Work Plan

March 2023 v1.1

Contents

Acronyms

AC-VC	CEOS Atmospheric Composition Virtual Constellation
CEO	CEOS Executive Officer
CEOS	Committee on Earth Observation Satellites
CEOS-ARD OG	CEOS Analysis Ready Data Oversight Group
CGMS	Coordination Group for Meteorological Satellites
COAST AHT	CEOS Coastal Observations Applications Services and Tools a*d hoc* Team
COVERAGE	CEOS Ocean Variables Enabling Research and Applications for GEO
EETT	CEOS Ecosystem Extent Task Team
GEO	Group on Earth Observations
LSI-VC	CEOS Land Surface Imaging Virtual Constellation
NSTT	CEOS New Space Task Team
OCR-VC	CEOS Ocean Colour Radiometry Virtual Constellation
OST-VC	CEOS Ocean Surface Topography Virtual Constellation
OSVW-VC	CEOS Ocean Surface Vector Winds Virtual Constellation
P-VC	CEOS Precipitation Virtual Constellation
SDG CG	CEOS Sustainable Development Goals Coordination Group
SEC	CEOS Secretariat
SEO	CEOS Systems Engineering Office
SIT	CEOS Strategic Implementation Team
SST-VC	CEOS Sea-Surface Temperature Virtual Constellation
UN	United Nations
VC	CEOS Virtual Constellation
WG	CEOS Working Group
WGCapD	CEOS Working Group on Capacity Building and Data Democracy
WGClimate	Joint CEOS – CGMS Working Group on Climate
WGCV	CEOS Working Group on Calibration and Validation
WGDisasters	CEOS Working Group on Disasters
WGISS	CEOS Working Group on Information Systems and Services

1. Introduction and Overview

The *2023-2025 CEOS Work Plan* has been developed by the CEOS Executive Officer (CEO) under direction of the CEOS Chair (Geo-Informatics and Space Technology Development Agency, GISTDA), in consultation with the CEOS Strategic Implementation Team (SIT) Chair (European Space Agency, ESA), CEOS Secretariat (SEC), CEOS Working Groups (WGs), CEOS Virtual Constellations (VCs), CEOS *ad hoc* Teams, the CEOS Systems Engineering Office (SEO), CEOS Agencies at large and external stakeholders.

The purpose of this document is to present near-term objectives and deliverables identified by CEOS in support of the mission and goals outlined in the *CEOS Strategic Guidance* document. It includes a description of CEOS activities to be executed in the current calendar year (2023) and summarises anticipated activities for the subsequent two years (2024-2025). Additional documents contributing information to this plan are located on the CEOS website (https://ceos.org/) and include: the *2022-2024 CEOS Work Plan*; the terms of reference for the CEOS Virtual Constellations and Working Groups; and several thematic observation strategies adopted by the CEOS Plenary. This Work Plan is revised annually as current activities are completed, planned activities are executed, and new initiatives are projected. However, many of the priorities and activities outlined herein are expected to remain consistent from year to year.

CEOS Mission Statement:

CEOS ensures international coordination of civil space-based Earth observation programs and promotes exchange of data to optimize societal benefit and inform decision making for securing a prosperous and sustainable future for humankind.

The primary objectives of CEOS are:

- To optimise the benefits of space-based Earth observation through cooperation of CEOS Agencies in mission planning and in the development of compatible data products, formats, services, applications, and policies.
- To aid both CEOS Agencies and the international user community by, among other things, serving as the focal point for international coordination of space-based Earth observation activities, including the Group on Earth Observations (GEO) and entities related to global change.
- To exchange policy and technical information to encourage complementarity and compatibility among space-based Earth observation systems currently in service or development, and the data received from them, as well as address issues of common interest across the spectrum of Earth observation satellite missions.

Achievement of these three objectives requires significant internal and interagency coordination, and external consultation and coordination of outputs to respond to the needs of key stakeholders. These stakeholders consist of national governments, including the Group of Seven (G7) and the Group of 20 (G20), the intergovernmental Group on Earth Observations (GEO), and organisations participating in treaties and global programs affiliated with the United Nations (UN)[1].

[1] These treaties, international organisations, and international programs include United Nations Framework Convention on Climate Change (UNFCCC), UN 2030 Agenda for Sustainable Development (the SDGs), UN Office for Disaster Risk Reduction (UNDRR), UN Convention to Combat Desertification, and UN Convention on Biological Diversity (CBD), among others.

2. CEOS Priorities

This Work Plan has been developed in the context of long-term CEOS priorities as described in the CEOS Governing Documents, and specific priorities identified in the *Kyoto Statement* issued at the 29th CEOS Plenary Meeting held in Kyoto, Japan in 2015. In this Statement, CEOS Agencies affirmed their intent to work together to:

- Ensure that climate observation requirements identified by the Global Climate Observing System (GCOS) – and implications of the Paris Climate Agreement – are addressed.
- Ensure, in the context of the *Sendai Framework for Disaster Risk Reduction 2015-2030*, that CEOS Agency data are made available in support of disaster risk reduction and that CEOS continues engagement with UN agencies and authorities.
- Ensure that space-based Earth observations support the success of the next decade of the Group on Earth Observations (GEO), and that CEOS engagement in GEO governance and leadership is enhanced.
- Proactively engage in global discussions on the critical challenges that face society, including attaining the *2030 Agenda for Sustainable Development.*

The 36th CEOS Plenary meeting was held in Biarritz, France, in 2022. The meeting reviewed the progress made in the priority areas of the outgoing CEOS Chair, the Centre National d'Etudes Spatiales (CNES). In 2022, CNES's priority theme was "*Paths to Sustainability: from Strategy to Practical Measures*". The aim was to put an emphasis on the evolution of R&D and demonstration activities to applications and services by identifying key suitable activities across the CEOS structure. This evolution had the target to engage with key stakeholder agencies through the GEO mechanisms, and with the goal of establishing operational services. The Working Group on Disasters (WGDisasters) Recovery Observatory and the Space Climate Observatory initiatives and projects were examples of great successes towards this goal in 2022. The support to the United Nations Framework Convention on Climate Change (UNFCCC) Global Stocktake (GST) was, and continues to be, an important theme for CEOS. In 2022, the AFOLU (Agriculture, Forestry and Other Land Use) roadmap and the CEOS Biomass Protocol uptake and engagement with GEO-TREES (Forest Biomass Reference System from Tree-by-Tree Inventory Data; a GEO community activity), were key foci. Increased support to calibration and validation (cal/val) initiatives was also encouraged throughout 2022, with specific emphasis on cross-calibration of thermal infrared measurements from future CEOS Agencies' missions - in particular those missions identified as key for Surface Biology and Geology (SBG) - and the development of multi-thematic cal/val sites based on capacity pooling as much as possible, to develop international synergies between CEOS Agencies. The overall focus for the 2022 effort was to ensure attention to the Paris Agreement, to establish policy drivers and frameworks as appropriate, to continue to work on relevant SDGs, and to respond to the *Sendai Framework for Disaster Risk Reduction 2015-2030*.

At the 36th CEOS Plenary, CEOS Principals endorsed the AC-VC white paper "*Monitoring Surface PM2.5: An International Constellation Approach to Enhancing the Role of Satellite Observations*" and some updates to the *WGCV Terms of Reference* (now v1.1). The Terms of Reference for two new task teams were also endorsed by CEOS Principals at Plenary. The first is a task team that will focus on 'New Space', which is a SIT Chair priority. The New Space Task Team (NSTT) was endorsed for one-year and will explore collaboration opportunities in New Space that bring mutual benefit to all parties, including the identification of concrete initiatives that will drive the agenda forwards. The second task team that was endorsed is on 'Ecosystem Extent', which is a priority for the incoming CEOS 2024 Chair (Canadian Space Agency, CSA). The Ecosystem Extent Task Team (EETT) was endorsed for a two-year

period and will assess the utility for mapping Ecosystem Extent using current and new space-based observations that will become available in the next 10 years. CEOS Principals also endorsed the extension of the Ocean Coordination Group for a further six months, and the extension of the COAST *ad hoc* team for one-year, to allow more time to coordinate ocean-related activities across CEOS membership, and to further consider CEOS's consolidated response to related external stakeholders and programmes.

The incoming CEOS 2023 Chair (GISTDA) presented the priorities for 2023 at the 36th CEOS Plenary under the banner "*Earth Observation for a Better Environment, Economy, and Humanity*". This theme focuses efforts around two main priorities for 2023: to support CEOS preparations and inputs to the GST, the first of which is due to be delivered this year, and to support the exploration of new geometries for CEOS Agencies within the 'New Space' agenda. A focus for the GST will be to support the AFOLU and Greenhouse Gas (GHG) roadmaps, to ensure that the CEOS GST Portal is up-to-date, and to support a workshop on Ocean Carbon from Space. The second priority, related to 'New Space', is a very important topic to GISTDA, and the CEOS Chair will work closely with the SIT Chair in 2023 to develop recommendations based on the shared experiences of CEOS Agencies.

The 2022-2023 CEOS SIT Chair is ESA, supported by JAXA as the SIT vice-chair. ESA continues to specifically focus on global challenges with strong UN mandates, providing support through GEO as appropriate and where there is high relevance for satellite Earth observation (EO). An important emerging activity of potential interest to CEOS is the new and fourth GEO priority on *Resilient Cities and Human Settlements*, which is a response to the UN's New Urban Agenda (2016). Improving CEOS support to global challenges through consideration of new geometries for space agencies, and how CEOS engages with New Space entities in both the space observation (upstream) and the downstream space sectors, including the necessity to address new mission and new user requirements as they emerge, should hopefully translate into opportunities for CEOS to engage a wider user audience. It is important for CEOS to keep a watching brief on new activities in EO in both Government and commercial sectors, which may have implications for the current thematic observation strategies, taking advantage of the complementarities between public and commercial assets and services.

Noting the adoption of the United Nations Office for Outer Space Affairs (UNOOSA) "Space2030 Agenda" in 2021 as a forward-looking strategy for reaffirming and strengthening the contribution of space activities and space tools to the achievement of global agendas, CEOS will continue to support more effective societal decision-making in the areas of climate monitoring and research; carbon observations, including observations to support the effective monitoring and management of the world's forested regions; food security; disaster risk management; oceans; biodiversity; capacity building; and data availability and access. Satellite mission coordination will be strengthened, particularly through the CEOS Virtual Constellation activities. CEOS Working Groups and Virtual Constellations will expand their technical and scientific coordination to support these priorities and improve the overall level of complementarity and compatibility of CEOS Agency Earth observation and data management systems for societal benefit.

For subsequent years (2024-2025), this document summarises planned CEOS activities more broadly; details regarding these future activities will be established in forthcoming updates of this document. Virtual Constellations, Working Groups, and *ad hoc* Teams may prepare separate, more detailed, Work Plans that complement this overall guiding Work Plan.

3. Expected Outcomes for 2023-2025

The expected outcomes for 2023-2025 reflect the ongoing and emerging priorities of CEOS, as characterised by its internal decision-making and external commitments. They are intended to focus on improved Earth observation (EO) systems coordination and enhanced data access for key global programmes and initiatives. The main outcomes are described for the following areas:

The projected outcomes for each thematic area are summarised in short introductory paragraphs that list the objectives / deliverables to be pursued in the three-year period of the Work Plan. A table indicating Objective / Deliverable Number, Title, Projected Completion Date (indicated by quarter of the calendar year) and Responsible CEOS Entity(ies) concludes each section.

This Work Plan is expected to be a companion document to the CEOS Deliverables Online Tracking Tool, which captures the most current information available for each Objective / Deliverable, including detailed descriptions of the Objective / Deliverable, background information, status, projected outcomes, connections to other CEOS external partners and entities, and other important information.

CEOS operates on a best-efforts basis. Responsible CEOS Entities are expected to accomplish the Objectives / Deliverables identified in this document and the Online Tracking Tool to the best of their abilities. The CEOS Deliverables Online Tracking Tool (accessible via https://ceos.org/tracking/), captures significantly more information than presented in this Work Plan. It is particularly important for CEOS Deliverables to have an identified external link, i.e., to a particular GEO Work Programme Flagship / Initiative / Community Activity[1] or UNFCCC / UNCBD / etc. activity. As of March 2023, there are 132 active CEOS Deliverables, which includes 53 newly created in 2023.

[1] https://www.earthobservations.org/documents/gwp23_25/geo_work_programme_2023_2025_summary_document_v3_20221214.pdf

3.1. Climate Monitoring, Research, and Services

CEOS and the Coordination Group for Meteorological Satellites (CGMS) work together, through the Joint CEOS/CGMS Working Group on Climate (WGClimate), to facilitate climate measurements, science and monitoring from space through the coordinated planning, tracking, production, improvement, sustainment and availability of space-based climate data records. This work is focused on implementation of the *Strategy Towards an Architecture for Climate Monitoring from Space* (hereafter referred to as the *Architecture*) developed and endorsed by CEOS, CGMS and the World Meteorological Organization (WMO). Further, in 2018 WGClimate chartered a Greenhouse Gas (GHG) Task Team focused on supporting the Global Stocktakes required by the *UNFCCC Paris Agreement*, signed in 2015 under the United Nations Framework Convention on Climate Change (UNFCCC).

The following sections summarise activity from the perspective of CEOS contributions to the joint effort, as well as CEOS-specific activities in the climate domain.

During **2023**, WGClimate will:

- Update and exploit the comprehensive Essential Climate Variable (ECV) Inventory (Version 4) of Climate Data Records (CDRs) and implement coordinated actions arising from an Inventory gap analysis. The gap analysis identifies opportunities for improvement of data records and their usage along the climate information value chain outlined by the *Architecture*.
- Complete the Version 4 Gap Analysis Report, and deliver it to the AFOLU Team, GHG Task Team, and CEOS Ocean community to incorporate into their respective plans and deliverables.
- Examine the ECV Inventory to identify issues in the future availability of measurements for the Global Climate Observing System (GCOS) ECVs as described in the 2022 GCOS Implementation Plan. As issues are found, WGClimate will initiate mitigation actions by improving coordination on long-term mission planning. Additionally, WGClimate will leverage the ECV Inventory to communicate progress of the satellite coordination community within the United Nations system and more broadly.
- Coordinate CEOS and CGMS activities towards the definition and implementation of an integrated operational global carbon observing system, including a system for monitoring the column concentrations of CO_2, CH_4 and other greenhouse gases from space. In 2020, CEOS and CGMS endorsed the Greenhouse Gas Roadmap (v2.4). Together with the GHG Task Team, WGClimate will coordinate progress on and provide updates to tasks stated in its Annex. This involves collaborative work with the UNFCCC Subsidiary Body of Scientific and Technological Advice (UNFCCC/SBSTA) and GCOS in support of the Paris Agreement.
- Continue the activity on demonstration of use cases for climate data records to encourage wider application of the use of satellite observation. This activity effectively validates the *Architecture* and fosters usage of satellite-derived CDRs. Some use cases may leverage the global carbon observing system contributed by UNFCCC Parties and therefore support the Parties' user engagement process. Other use cases may demonstrate CEOS and CGMS capacity-building and training activities and likely foster further usage.
- Complete a CDR Definitions manuscript, conduct review with peer organisations (e.g., GCOS and WGCV) and submit for publication. Providing a common and coherent set of definitions will help improve communications among Agencies, organisations and technical teams.

- Develop and provide the Space Agency Response to the 2022 GCOS Implementation Plan. This routine deliverable provides status and future plans on IP recommendations for space observations and climate products.
- Provide oversight to continuing implementation of GHG monitoring activities (2018 Coordinated Action Plan: Actions 11 (coordinate CO2 CDRs), 13 (plan for stratospheric CH4 profiles) and 14 (coordinate CH4 CDRs).

For **2024-2025**, significant outputs will be:

- Updated versions of the ECV Inventory, Gap Analysis Report and Coordinated Action Plan.
- Continued and enhanced engagement with UNFCCC/SBSTA to better facilitate CEOS contributions beyond atmospheric CO2 monitoring, including AFOLU.
- The publication of use cases on the ECV Inventory web portal (https://climatemonitoring.info).

Number	Objective/Deliverable Title	Projected Completion	Responsible CEOS Entity(ies)
CMRS-19-05	Update definitions for FCDR, CDR, ICDR (Coordinated Action 1)	2023 Q2	WGClimate
CMRS-19-06	Implement Coordinated Actions 5 on FCDR Inventory, 6 on nomenclature document for CDRs, 10 on meta data standards	2024 Q2	WGClimate
CMRS-22-02	Provide condensed feedback from the Gap Analysis to the GHG task team and AFOLU allowing refinement of their work plan	2023 Q3	WGClimate
CMRS-22-03	Provide condensed feedback from the Gap Analysis in support of the Ocean community within CEOS in support of the CEOS GST Strategy	2023 Q3	WGClimate
CMRS-23-01	Provide COP-27 SBSTA Statement for CEOS Chair Delegation	2023 Q3	WGClimate
CMRS-23-02	Provide COP-28 SBSTA Statement for CEOS Chair Delegation	2024 Q3	WGClimate
CMRS-23-03	Provide COP-29 SBSTA Statement for CEOS Chair Delegation	2025 Q3	WGClimate
CMRS-23-04	Provide Agency Response to GCOP IP	2023 Q4	WGClimate

3.2. Carbon Observations in support of Climate Science and Policy

I. Coordinate space-based observations to support the effective monitoring and management of the world's forested regions in support of international climate agreements and the Space Data Component of the GEO Global Forest Observations Initiative (GFOI).

Through the LSI-VC Forests and Biomass (LSI F&B) Team, CEOS is coordinating the implementation of the CEOS Strategy for Space Data for GFOI (endorsed by CEOS Plenary in 2011) for the provision of satellite observations in support of the development of national forest monitoring and measurement, reporting and verification (MRV) systems. This strategy will evolve to reflect changes in relevant CEOS Agency mission plans, and to include coordination of the missions contributing to estimation of above-ground biomass (AGB). This new generation of missions, amounting to an investment of more than $US4bn by CEOS Agencies, are of significant interest to countries and institutions seeking to estimate avoided carbon emissions through incentive schemes such as REDD+. The LSI F&B Team proposes to

support the accelerated policy relevance of the data from these missions by facilitating interaction between the GFOI community and technical CEOS communities, such as those pioneering the CEOS Biomass Protocol in the Working Group on Calibration and Validation (WGCV)'s Land Product Validation (LPV) subgroup, as well as the outreach and engagement defined and implemented through the anticipated CEOS AFOLU Roadmap.

2023-2024: Further work is expected in relation to the promotion and implementation of the GEO-TREES initiative, which seeks to develop a Forest Biomass Reference Network (FBRN) proposed by the WGCV LPV Biomass team as promoted through the SIT Chair Team and others via CEOS partners in GFOI and GEO. Priorities of 2023 are to finalise the establishment of a trust fund, intensify the outreach activities, implement the first two GEO-TREES sites and to get additional funding partners on board.

The LSI F&B Team will continue to steward the updated GFOI Space Data Strategy and to progress the priority initiatives identified in relation to the policy relevance of AGB estimation missions. Further activities are anticipated in relation to:

- A new phase for the GFOI R&D programme.
- Analysis Ready Data (ARD) trials and pilots in the GFOI community, to be done in collaboration with LSI-VC.
- Emergence of a GFOI Early Warning Module.
- Prototyping as requested, e.g., with GFOI countries working with Digital Earth Africa.
- Advocacy for a space data role in future updates of the GFOI Methods and Guidance Document (MGD).

The LSI F&B Team will seek to ensure that the work of CEOS in support of GFOI is consistent with, and supportive of, the broader CEOS Carbon Strategy activities, including the *CEOS Strategy to Support the Global Stocktake of the UNFCCC Paris Agreement*.

II. Progress implementation of the CEOS Strategy for Carbon Observations from Space

In 2014, CEOS endorsed the *CEOS Strategy for Carbon Observations from Space* in response to the *GEO Carbon Strategy* (CARB). The CEOS strategy addresses three domains — atmospheric, oceanic and terrestrial — and their interfaces, and identifies a number of recommended actions to be completed by space agencies.

At the 30th CEOS Plenary Meeting, CEOS determined several targeted initiatives to advance the implementation of the *CEOS Strategy for Carbon Observations from Space*. These initiatives are crosscutting in nature and address numerous actions in the strategy. The initiatives cover a broad range of CEOS WGs and VCs and are addressed by the CARB objectives/deliverables.

In 2018, an expert CEOS team published a White Paper on a GHG monitoring constellation, which provided a blueprint for CEOS and CGMS Agencies to address the needs for GHG observations, driven by the Paris Agreement, over the next decade. Based on the GHG Constellation White Paper, WGClimate provided a roadmap and planning document, as approved by the CEOS and CGMS plenaries in 2020, to help coordinate the implementation of the GHG Constellation, including delivery of prototype GHG inventory products in late 2021 in support of the first Global Stocktake (GST). In parallel, the LSI F&B team delivered a number of Agriculture, Forestry and Other Land Use (AFOLU) products, in support of the GST, in time for promotion at COP-26 in November 2021. Both the GHG and AFOLU products were provided through the CEOS GST Portal (https://ceos.org/gst) along with technical explanations and user guidance.

2023-2024: The GHG and AFOLU roadmaps foresee a long-term commitment to the further refinement of CEOS Agency data products in support of the GST process. Further implementation actions can be expected, including efforts to promote, educate and build capacity as we approach the first GST in 2023. The WGClimate GHG task team will summarise the lessons learned from the CEOS pilot CO_2 and CH_4 product delivered to UNFCCC for the first GST, which will help the CEOS community in perfecting the product to better suit the user needs in the succeeding products for future GSTs. The GHG task team will also work with space agencies and private partners to ensure GHG product continuity from future satellite missions. A set of standards for uncertainty reporting of flux estimation will also be developed to facilitate future product intercomparison. Calibrated and validated harmonised products from multiple sensors and multiple agencies can provide seamless long-term, frequent and intense global data for GHG monitoring. The WGCV hopes to work in the coming years with the GHG community to perform intercomparison of both radiance and retrieved GHG density levels, undertake calibration and validation (cal/val) campaigns, and provide common standard cal/val datasets. The GHG task team, together with the WGCV, will continue to secure and support sustainability, quality of, and timely access to HGH ground networks in support of the CO2 MVS, such as TCCON, COCCON and ICOS.

Depending on the outcomes of the CEOS GST Strategy discussion, further thematic coordination plans might be expected to emerge including those in relation to ocean carbon.

III. Pursue an integrated carbon cycle interface between CEOS and the UNFCCC

The SIT Chair has asked that CEOS consider the opportunities provided by the UNFCCC Global Stocktake (GST) process to demonstrate the policy relevance of EO satellite data and to plan for dataset inputs to the first and second global stocktakes (in 2023 and 2028 respectively) that will support the policy process. Building on the important connections established by WGClimate, this activity will explore the enhancement of the relationship between space data providers and the policy needs of conventions and the parties to the conventions. The objective is to ensure an integrated process that assures policy relevance of CEOS data and links to the space agency planning processes from conventions and parties.

2023: A number of measures can be expected in relation to the planning and provision of space-based datasets for use in the GST process, including results from the work of the GHG and AFOLU Roadmap activities, related measures recommended by the GST Strategy paper, and GFOI support from the LSI F&B team. Specific GST recommendations and deliverables are set out in Section 3.3.

Number	Objective/Deliverable Title	Projected Completion	Responsible CEOS Entity(ies)
CARB-17-05	Cal/Val and production of biomass products from CEOS Agency missions	2023 Q4	WGCV
CARB-19-02	Phase II R&D Program for GFOI	2024 Q1	LSI-VC F&B Team CEOS GFOI Lead
CARB-19-03	Early Warning Module for GFOI	2023 Q2	LSI-VC F&B Team CEOS GFOI Lead
CARB-19-04	Forest Biomass measurements for GFOI countries	2023 Q4	WGCV LSI-VC F&B Team CEOS GFOI Lead

Number	Objective/Deliverable Title	Projected Completion	Responsible CEOS Entity(ies)
CARB-20-01	Develop a CEOS AFOLU roadmap	2023 Q2	LSI-VC F&B Team SIT Chair LSI-VC GEOGLAM Team WGClimate GHG Task Team
CARB-20-02	Integrated Carbon Cycle interface between CEOS and the UNFCCC	2023 Q1	WGClimate WGClimate GHG Task Team SIT Chair CEOS GFOI Lead LSI-VC GEOGLAM Team
CARB-20-04	Space Data support to GFOI Capacity Building component	2023 Q4	LSI-VC F&B Team
CARB-20-05	Support and encourage space data uptake in GFOI countries	2023 Q4	LSI-VC F&B Team
CARB-21-01	GST1 Prototype Products and Guidance	2023 Q4	LSI-VC F&B Team WGClimate GHG Task Team SIT Chair
CARB-21-03	Forest Biomass Reference Network (GEO-TREES)	2023 Q4	WGCV LPV LSI-VC F&B Team CEOS GFOI Lead SIT Chair
CARB-22-01	Production of harmonised biomass products from CEOS Agency missions	2023 Q4	WGCV LPV
CARB-23-01	Lessons learnt from pilot CO_2 and CH_4 products	2023 Q2	WGClimate GHG Task Team
CARB-23-02	Standards for uncertainty monitoring of flux estimates	2023 Q3	WGClimate GHG Task Team
CARB-23-03	GCOS IP response for GHG-related activities	2023 Q3	WGClimate GHG Task Team
CARB-23-04	Update GHG Roadmap	2023 Q2	WGClimate GHG Task Team
CARB-23-05	New Space and GHG product development and standards setting	2023 Q3	WGClimate GHG Task Team

3.3. Observations in Support of the Global Stocktake of the UNFCCC

Article 14 of the 2015 Paris Agreement among Parties to the *United Nations Framework Convention on Climate Change (UNFCCC)* sets out the concept of the Global Stocktake (GST) to evaluate global progress towards the goals of the Agreement. The outcome of the GST will inform the preparation of subsequent Nationally Determined Contributions (NDCs) to allow for increased ambition and climate action to achieve the purpose of the Paris Agreement and its long-term goals. For CEOS Agencies to coordinate their efforts to support the first GST (due in 2023) and subsequent GSTs (due every five years thereafter), a GST Strategy Paper (*A CEOS Strategy to Support the Global Stocktake of the UNFCCC Paris Agreement*, v3.1) was endorsed by CEOS Principals at the 35th CEOS Plenary in 2021. The GST strategy paper covers the specific modalities of the GST and proposes where and how CEOS Member Agencies can support its implementation.

The substantive elements of the GST of particular interest to CEOS are:

- Mitigation, i.e., reporting, measurement and tracking the progressive decrease in national GHG emissions,
- Adaptation to ongoing climate change and its consequences and impacts,
- Finance of mechanisms to support the Paris Agreement, and
- Equity among Parties for implementation (this last being implicit in the process).

The GST strategy paper sets out a series of recommendations for action to support the 2023 GST, taking into account CEOS capabilities and interests, and building on existing efforts where appropriate. The recommendations are as follows:

1. WGClimate and WGClimate GHG Task Team should consult with the relevant elements of CEOS, including Associates such as ISC, WCRP and GCOS, together with modelers, to check the GHG Implementation roadmap on completeness concerning requirements for terrestrial observation (SIF, NPP, land cover, biomass, etc.) for supporting mitigation actions through the development of Monitoring and Verification System (MVS). The actions in Annex C of the roadmap shall be complemented as needed.

2. The need for parallel inputs to ocean models deemed necessary for the support of MVS and for a wider validation of carbon flux estimates globally should be considered and appropriately combined into the actions in Annex C of the GHG roadmap.

3. The results of the actions from the above recommendations should inform (a) the report of CEOS to UNFCCC (e.g., SBSTA/RSO (Research and Systematic Observation) discussion on observation to support the implementation of the Paris Agreement) and should pro-actively flow (b) into the consultation process of the *ad hoc* group for the Synthesis Report on Observations for the GST.

4. CEOS should consider, in conjunction with modelers, setting up one or more focused observational campaigns in the areas suggested above, or others, as a major contribution to the understanding of the trends of GHG emissions from natural sources in key areas.

5. The AFOLU roadmap team should continue the work it has started for CEOS, reflecting the decisions taken at CEOS Plenary 2020. The AFOLU roadmap team and WGClimate GHG Task Team should work together to ensure consistency between data for emissions reported via AFOLU and for prior biogenic terrestrial emissions, and those due to changing land use, in implementing monitoring and verification systems. These need to be consistent on both temporal and spatial scales. The WGClimate GHG Task Team should ensure that their Roadmap is consistent with the outcomes of this discussion.

6. It is recommended that, to help in ensuring the take-up of satellite-based methods for AFOLU (and indeed in the context of MVS), CEOS should work with a few selected demonstrator countries to assist them in their national reporting under AFOLU (the model of GFOI can be compared). USGS through its SilvaCarbon programme would be well placed to lead this.

7. CEOS should work with the various partners set out above to identify data requirements and actions for CEOS in relation to adaptation, including participation of relevant CEOS groups such as WGClimate and WGDisasters. Case studies might be of value to demonstrate competence and relevance. Partnership with specific countries in implementing their National Adaptation Plans (NAPs) could be of value, as in the case of AFOLU above, both to demonstrate worked examples and to strengthen support for this approach at UNFCCC, including at COPs.

8. CEOS should maintain a watch over the implementation of projects funded through climate fund mechanisms to ensure that all appropriate assistance is given by agencies in their implementation and governance.

9. CEOS must continue all efforts to provide the necessary climate data records that support the

assessment of the actual status of the climate and the prediction and projection of future climate change, its response to changing GHG emissions and other drivers, and the impacts of climate change.

Number	Objective/Deliverable Title	Projected Completion	Responsible CEOS Entity(ies)
GST-22-01	Provide ongoing coordination, oversight and external communications for the GST Strategy deliverables	2023 Q4	SIT Chair SIT Vice-Chair
GST-22-02	Ensure that the products from terrestrial observations needed to derive biogenic emissions as priors for Monitoring and Verification System (MVS) such as CO2MVS are considered in the GHG TT Roadmap Annex C.	2023 Q2	WGClimate GHG Task Team LSI-VC
GST-22-03	Ensure that the products from oceanic observations needed to derive biogenic emissions as priors for Monitoring and Verification System (MVS) such as CoMVS are considered in the GHG TT Roadmap Annex C.	2023 Q4	COAST AHT OCR-VC SST-VC WGClimate
GST-22-04	Deliver results of GST Strategy actions to key meetings in the UNFCCC Calendar, including SBSTA and COP, and meetings of the GST Ad hoc group for the Synthesis Report on Observations for the GST.	2023 Q4	WGClimate WGClimate GHG Task Team
GST-22-06	GHG TT and AFOLU Roadmap Team to ensure their plans are consistent with each other in treatment of relevant areas.	2023 Q4	LSI-VC F&B Team WGClimate GHG Task team
GST-22-07	Establish National Inventory Test User Group and channels for country feedback on CEOS products and their application.	2023 Q3	LSI-VC F&B Team
GST-22-09	As part of a GST Strategy update, provide periodic updates at Plenary and SIT meetings on CEOS actions relevant to Finance and Equity aspects of the GST	2023 Q4	SIT Chair
GST-22-10	Ongoing use of the ECV Inventory and the related analyses to address the climate data record requirements.	2023 Q4	WGClimate

3.4. Observations for Agriculture

The GEO Global Agricultural Monitoring Initiative (GEOGLAM) aims to enhance agricultural production estimates using Earth observations to address concerns raised by the G20 Agricultural Ministers about market volatility for the world's major crops, as well as to provide early warnings of crop shortages and failures in countries most at risk of food insecurity. The work described in the following paragraphs will be carried out in 2023.

I. Respond to the Group on Earth Observations Global Agricultural Monitoring (GEOGLAM) community's articulation of satellite data requirements for monitoring agriculture.

In 2018-2019, GEOGLAM completed its Requirements Refresh, which provided a more holistic view of needs beyond acquisition and into accessibility and utilisation. An important component of this is GEOGLAM's Essential Agricultural Variables (EAV), which are articulations of user-oriented key agricultural products for assessing state and change in agricultural land use and productivity; CEOS deliverable AGRI-19-04 reflects this. From this EAV definition, several public-facing GEOGLAM documents will be updated to reflect these needs, including:

- GEOGLAM Community Research and Operationalization Agenda**.** First published in 2018, this

sets out key priorities for GEOGLAM with respect to its operational R&D activity – JECAM – as well as identifying barriers in implementing EO in operational systems. Part of the EAV articulation is a gap analysis, i.e., a data-to-information lifecycle analysis, which seeks to identify the drivers of gaps in operationalisation utilising EO (e.g., EO data coverage, EO access, EO utilisation, training data and validation, computing infrastructure and training).

- GEOGLAM EO Data Requirements. Very minor adjustments are expected to the GEOGLAM EO Data Requirements to ensure harmonisation between the EAVs and the EO data. Most changes will be in "Target Product" names, with some small adjustments in target resolutions anticipated. A new CEOS Response to GEOGLAM Requirements should then be completed (AGRI-22-02).

Out of the GEOGLAM Requirements Refresh, there were additional opportunities identified for GEOGLAM to interface with CEOS as CEOS seeks to advance adoption of EO data. None of these have been approved by CEOS but are proposed to the sub-working group as items of value to the agricultural community. These include:

- A White Paper Produced by CEOS LSI-VC GEOGLAM on Data Quality Control & Assessment**.** In light of the recent proliferation of data streams and associated products from CEOS Agency missions, many users expressed uncertainty about which products were appropriate for their applications as well as how to gain access to them. Interoperability between sensors was consistently referenced as of utmost importance. A white paper explainer on which data sources and space agency funded products are suitable for which applications would be valuable.
- Analysis Ready Data (ARD) and Application Ready Data (ARD+). The CEOS Analysis Ready Data for Land (CARD4L) is useful to highly trained remote sensing technicians with adequate computational infrastructure or access to cloud-based data processing modalities (e.g., CEOS Data Cube). There was agreement that, with the rapidly expanding volumes of data from new missions, increased attention to data access, continuity, and quality is needed. The GEOGLAM community should be continually apprised of the work of the CEOS-ARD Oversight Group to maintain open lines of communication.

II. Soil Organic Carbon Stock and Flux estimates for Agricultural Land Uses: Input to GST AFOLU, Nationally Determined Contributions, and National Adaptation Planning

Estimates of Soil Organic Carbon (SOC) stocks and fluxes are an important yet poorly constrained component of the global climate system. Accurate quantification and error budgeting of SOC stocks and fluxes is needed to study and understand the effects of human activities on the carbon-climate system. These measurements help policymakers assess progress in meeting high-level policy goals, such as Nationally Determined Contributions (NDCs), as well as providing important input to the Global Stocktake of carbon emissions and sequestration in Agriculture, Forestry and Other Land Uses (AFOLU) as linked to the Paris Accords and Glasgow Agreement. Further, this information is critical in the development of realistic and scientifically guided national adaptation plans. CEOS LSI-VC has adopted an Global Stocktake of Emissions from AFOLU, and has developed an impressive protocol for utilising EO to quantify forest biomass, but to-date has not developed a system for emissions and sequestration accounting in agriculture.

To better inform stakeholders and priority applications, the CEOS SEO is supporting a project in the context of GEOGLAM to utilise Earth observation (EO) data, best-in-class machine learning approaches, and existing soil samples to create a global digital SOC stock and flux data product that will provide

gridded data at 0.25-degree resolution on SOC stocks, pH, Cation Exchange Capacity (CEC) and fluxes in the form of soil heterotrophic respiration. Soil pH and CEC are key indicators of soil fertility and its ability to sequester soil carbon, an important part of utilising agriculture to mitigate climate change. SOC stocks and fluxes are needed to compute carbon budgets over agricultural lands. These products will be representative of soil properties over the last 5 years and, most importantly, the project is developing a free, open, and accessible workflow/pipeline that can be replicated at multiple scales using new soil samples and EO data by stakeholders around the world.

Number	Objective/Deliverable Title	Projected Completion	Responsible CEOS Entity(ies)
AGRI-19-04	Iteratively respond to GEOGLAM EO Data Coordination team's definitions of "Applications Ready Data" (ARD+) and "Essential Agricultural Variables for GEOGLAM"	2024 Q4	LSI-VC GEOGLAM Team
AGRI-22-02	CEOS Response to GEOGLAM Requirements	2024 Q4	LSI-VC GEOGLAM Team
AGRI-22-03	Soil Organic Carbon Stock and Flux estimates for Agricultural Land Uses: Input to GST AFOLU, Nationally Determined Contributions, and National Adaptation Planning	2023 Q2	CEOS SEO

3.5. Observations for Disasters

The CEOS Working Group on Disasters (WGDisasters) ensures the sustained coordination of disaster-related activities undertaken by the CEOS Agencies and acts as an interface between CEOS and the community of stakeholders and users involved in risk management and disaster risk reduction.

Increased impacts of global climate change bring more frequent and extreme hydro-meteorological events, often leading to consequences such as landslides, flooding, drought, wildfires, or rising sea levels. These hazards and other traditional non climate hazards such as volcanoes present enhanced opportunities for the EO community to demonstrate the unique scope and reach of satellites in support to the full cycle of risk management.

The primary objectives of the WGDisasters are:

- to support the efforts of Disaster Risk Management authorities in protecting lives and safeguarding property by means of satellite-based EO and science-based analyses,
- to foster increased use of EO in support of Disaster Risk Management,
- to support the implementation of the *United Nations Sendai Framework for Disaster Risk Reduction* (focusing on its Priority 1 "Understanding Risk"), and
- to raise the awareness of politicians, decision-makers, and major stakeholders (e.g., GEO, UN Agencies, donor institutions like the Asian Development Bank, World Bank/Global Fund for Disaster Risk Reduction, scientific communities, national resource management agencies, civil protection agencies, local decision makers, and others) of the benefits of using satellite EO in all phases of Disaster Risk Management.

In **2023** and **2024** the WGDisasters will support the ongoing work of international initiatives, including GEO, to strive to increase the awareness of decision-makers of the critical role of satellite EO (including a new joint activity with CEOS WGCapD directly related to this), and reinforce the need for enhanced satellite EO Programs to better address Disaster Risk Management (DRM) needs. The WGDisasters has highlighted the importance of moving from technical demonstrations to sustained application of

EO for improved risk management. A new cross-cutting reflection has been initiated in this regard, with a view to bringing forward the best practices in past WGDisasters successes. Such reflection will include an analysis of possible links and synergies with the SCO (Space for Climate Observatory), to take the increasing impact of climate change on disasters into account, and the usefulness of EO data to help reduce risks and vulnerability of territories. The final report on this reflection will be made to CEOS Plenary in 2023.

With this objective in mind, the WGDisasters expects to initiate plans for sustainable activities with partners outside of CEOS for mature "Demonstrators" over the next two years. Three key Demonstrators will reach critical milestones in 2023: the Recovery Observatory, the Volcano Demonstrator, and the Landslide Demonstrator. A fourth Demonstrator covering Seismic Hazards was completed and discontinued in 2022. Sustainable application of EO is achievable with increased visibility within donor communities and a strong appeal for support from committed end users. This effort is well underway with the three demonstrators listed above.

In 2022, the WGDisasters reviewed the GEO activity it leads (EO4DRM) and expanded the scope of that work with GEO. The three demonstrators previously mentioned fall under this scope. EO4DRM has several key thematic demonstrators reaching maturity; each demonstrator presents specific sustainability challenges and requires a dedicated approach.

- *Recovery Observatory*. A report will present financing plan and next steps, the need for increased awareness and dissemination of successes, a vision for 2-3 Recovery Observatories (Ros) globally per year and propose CEOS as a contributing partner but likely no longer the lead. The Recovery Observatory was recently recognised by the UN General Assembly in the framework of the Space 2030 Agenda as "a means to increase the contribution of satellite data to recovery from natural disasters" and to contribute to Sendai framework priority 4: Build Back Better. The WGDisasters intends to build on this recognition by engaging new partners to support this critical phase of risk management.
- *Virtual Volcano Observatory*. An incremental approach for global monitoring with scalable options for implementation will be presented. As a result, financing could accelerate.
- *Operational Landslide Monitoring and Next-generation Landslide Science*. Targeted local applications at commercial maturity with private partners but that have a global approach requires renewed science commitment.
- The WGDisasters Data Coordination Team will continue to support the Geohazards Supersites and Natural Laboratories (GSNL) GEO initiative with data and/or resources for infrastructure maintenance (e.g., via the Network of Resources of ESA) and will work with GSNL to prepare a GSNL Evolution Feasibility Study.
- The *GEO/LEO/SAR Flood Pilot* will report on effective best practices and value of data and methodologies shared by pilot team members to CEOS Member Agencies. It will also explore how to effectively improve flood risk management with the use of Earth observation from satellites.
- The *Wildfire Pilot* will complete its study of user needs and the definition of the final pilot deliverables geared towards integrating satellite based EO observations in support of global fire monitoring. All Demonstrator activities produce reports in accordance with specified WGDisasters Deliverables.

Number	Objective/Deliverable Title	Projected Completion	Responsible CEOS Entity(ies)
DIS-15-04	Implementation of data coordination for the GEO GSNL initiative	2030 Q4	WGDisasters
DIS-20-01	CEOS Contribution to GEO GSNL Initiative for DRR	2024 Q4	WGDisasters WGCapD WGISS
DIS-20-02	GNSL evolution feasibility study	2024 Q4	WGDisasters
DIS-20-04	Landslide demonstrator showing value of combining optical and radar data for multi and cascading hazard disaster risk prediction and assessment products (maps and models in areas of high known risk due to activity, exposure and vulnerability), with report on effective practices, key data and practices	2024 Q4	WGDisasters
DIS-20-05	RO Demonstrator Proposal (3 to 5 PDNA over two years)	2023 Q4	WGDisasters
DIS-22-01	Flood Pilot with GEO-LEO-SAR "Understanding Flood Risk from Space"	2024 Q4	WGDisasters
DIS-22-02	Volcano Demonstrator Sustainability Report	2023 Q4	WGDisasters
DIS-22-03	Use cases for the Operationalization of EO at the local level	2023 Q3	WGDisasters
DIS-22-04	Wildfire Pilot Final Report	2024 Q4	WGDisasters

3.6. Observations for Water

The CEOS Working Group for Information Systems and Services (WGISS) and Land Surface Imaging Virtual Constellation (LSI-VC) have been working with GEO AquaWatch to develop a suspended sediment regional Aquatic Analysis Ready Data (ARD) product. An ARD product is generated from raw data and processed so that it can be used without the need for further processing to be applied by users. In the context of water quality, ARD is defined as the systematic radiometric, atmospherically, geometrically, and spatially corrected full archive EO datasets of normalised water leaving radiance or reflectance. Through participation in the COAST *ad hoc* Team, GEO AquaWatch will leverage and benefit from the CEOS Earth Analytics Interoperability Lab (EAIL) to compare the ARD implementation approaches. This comparison will be about developing an aquatic ARD like the existing CEOS ARD for Land (CARD4L) approach in which 1) definitions are established for all criteria, operations, functions that are applied to top of the atmosphere (TOA) EO data, and 2) the various ARD approaches will then be compared in every step they perform to produce ARD data over inland and coastal waters. WGISS and LSI-VC will collaborate with GEO AquaWatch to:

- Define the Product Family Specifications (PFS) for aquatic ARD through discussions with the aquatic community,
- Ensure the interoperability of multi-sensor ARD data and data cubes through communication of best practices to the global water quality community, and
- Assist in scoping of a potential cloud-based processing of ARD which could be versioned so that downstream users can select alternatives and versioning of Analysis Ready Data.

Deliverables related to the above activities are detailed in sections 3.10 and 3.11.

3.7. Data Quality

The CEOS Working Group on Calibration and Validation (WGCV) continues to evaluate and recommend best practices for the characterisation/calibration of satellite-based sensors, and the validation of satellite-based Earth observation (EO) data products. The results of this work are the calibration and validation building blocks for data and tools that underpin the work of the Virtual Constellations and other Working Groups. For these underpinning activities, different tasks are focused within subgroups focused on specific areas of interest.

The WGCV supports six Subgroups that operate as individual entities and focus on specific technical areas related to calibration and validation as follows:

- Atmospheric Composition (ACSG)
- Infrared Visible Optical Sensors (IVOS)
- Land Product Validation (LPV)
- Microwave Sensors (MSSG)
- Synthetic Aperture Radar (SAR)
- Terrain Mapping (TMSG)

I. Coordinate and contribute to the development of suitable methodologies for the on-ground characterisation of satellite-based EO sensors, the on-orbit calibration of EO missions, and the validation of satellite-based Level 1 and Level 2 products.

2023-2025: The calibration of missions in the thermal infrared domain is becoming increasingly important with several CEOS agencies working on future missions in this area. This includes SBG (Surface Biology and Geology; NASA), Copernicus LSTM (Land Surface Temperature Monitoring) (ESA/COM) and Trishna (CNES/ISRO). A team of experts from the IVOS and LPV subgroups has been formed to carry out a study in 2023/2024 to determine the necessary characteristics of sites and their instrumentation to produce a derived brightness temperature signal at top of atmosphere with the highest possible accuracy while minimising any associated uncertainties. The team will also identify an inventory of potential sites that fulfil, or could fulfil, these criteria and provide a roadmap toward the establishment of what is being called TIRCALNET, following the past example of RADCALNET.

There is a growing number of public and commercial providers offering high resolution space-borne Earth observation data. In order to effectively utilise this data, it is important to have an understanding of its characteristics, calibration methods, and quality and technical capabilities. Interoperability between satellites and products will expand the opportunities for global applications including agriculture, assessment of the water cycle, forest and vegetation monitoring, pollution monitoring and climate. Data can be used together only if it is sufficiently characterised, therefore, harmonisation of calibration and validation approaches is fundamental. The WGCV is supporting the CEOS New Space Task Team on these types of matters and will contribute to the Task Team's white paper planned for completion at the end of 2023. In particular, the Cal/Val Maturity Matrix, which is currently used by both NASA and ESA to assess the characteristics of commercial missions, will be proposed as a potentially useful tool for CEOS to adopt to facilitate quality assessment of New Space missions in a consistent manner.

In 2023, WGCV will propose an approach for assessing Cal/Val measurements as Fiducial Reference Measurements (FRMs). FRM measurements should ideally have documented SI traceability (e.g., via round-robin characterisation and regular pre-and post-deployment calibration of instruments) using metrology standards or community recognised best practices. The uncertainty budget for all FRM

instruments and derived measurements must be available and maintained. FRM measurement protocols, procedures and community-wide management practices like measurement, processing, archive, documents, etc., are defined, published and adhered to by FRM instrument deployments. The assessment process could follow the example of the CEOS-ARD assessment framework by first defining a self-assessment process which would be reviewed by a panel of WGCV members. After endorsement, the results would be published on the CEOS Cal/Val Portal.

Also in 2023, the population and maintenance of the CEOS WGCV Cal/Val portal will continue, with a particular focus on greenhouse gas (GHG) data products. Efforts will be made to communicate and develop a set of standards for CO_2 and CH_4 products such as radiance spectra, densities and flux that are suitable for inter-comparisons across multiple missions. Whilst it is paramount to secure the continuity of the existing Cal/Val infrastructure, the system also needs to be expanded urgently to better cover the globe and future Cal/Val of (smaller-scale) flux estimates, like point sources and cities. The WGCV will also collaborate with WGClimate and the AC-VC to contribute to the calibration and validation efforts of CEOS GHG initiatives, and with the AC-VC to contribute to the coordination of validation efforts for the Geostationary Air Quality Constellation (GEO-AQ) and for the tropospheric ozone assessment initiative of IGAC/TOAR-II. A joint AC-VC and WGCV/ACSG meeting should be organised by Q3 2023.

II. Continue cooperation with GEO, Global Space-based Inter-calibration System (GSICS), and WMO and ground-based networks in the provision of high quality EO data products.

2023-2025: The WGCV will continue to strengthen its cooperation with GSICS on the topic of sensor calibration. A joint workshop on pre-flight calibration and characterisation will be organised by the end of 2023 or 2024. Additionally, a joint task team between WGCV and GSICS is being proposed to ensure the coordination and interoperability of the forthcoming SI-Traceable Satellites (SITSATs). SITSATs aim to be the foundation for a future 'international climate and calibration observatory' and this new generation of explicitly designed satellites will help enable a new epoch in climate quality observations of the Earth. The proposed joint task team will build on the workshop "SI-Traceable Space-based Climate Observing System: a CEOS and GSICS Workshop" held in London in September 2019. The goal of the workshop was to assess the benefits and requirements of a space-based climate observing system, summarising current measurement capabilities, climate-based needs and future implementation plans.

The WGCV will continue working with the GEO Secretariat, including work to support relevant GEO activities, mainly by encouraging the widespread adoption of quality assurance principles. The development of calibration and validation infrastructure and comparison campaigns within the frame of the WGCV will be used to promote these principles and best practices. The WGCV will continue to foster cooperation with WMO, ground-based networks and CEOS WGs and VCs through dedicated presence during WGCV meetings and by reaching out to science users and data product providers in the atmosphere, terrestrial and ocean communities.

Number	Objective/Deliverable Title	Projected Completion	Responsible CEOS Entity(ies)
CV-14-03	Workshop on state of the art for pre-flight calibration techniques	2023 Q4	WGCV
CV-17-01	L1 top-of-atmosphere interoperability	2023 Q2	WGCV

Number	Objective/Deliverable Title	Projected Completion	Responsible CEOS Entity(ies)
CV-20-01	Surface Reflectance measurements Intercomparison exercise for vegetation (SRIX 4Veg)	2023 Q4	WGCV
CV-20-02	Biomass Retrieval Intercomparison eXercise (BRIX-2)	2023 Q4	WGCV
CV-20-03	DEMIX	2023 Q3	EC ESA
CV-22-01	Validation protocols for atmospheric aerosol and cloud profiles	2024 Q1	WGCV
CV-22-02	CEOS Terms and Definitions Wiki	2024 Q4	WGCV
CV-23-01	Develop an FRM Assessment Framework	2023 Q4	WGCV
CV-23-02	SARCalnet: Establishment of initial SARCalnet processes and network initiation	2024 Q1	WGCV SAR Subgroup
CV-23-03	TIRCALNET: Establishment of initial TIRCALNET processes and network initiation	2025 Q4	WGCV IVOS Subgroup WGCV LPV Subgroup
CV-23-04	Launch of a GCP Intercomparison Exercise	2024 Q4	WGCV TMSG
CV-23-05	Retrieval and validation of high winds with combined active-passive microwave measurements	2025 Q2	WGCV MSSG
CV-23-06	Retrieval and validation of sea surface atmospheric pressure with microwave remote sensing	2025 Q2	WGCV MSSG

3.8. Capacity Building and Data Democracy

The CEOS Working Group for Capacity Building and Data Democracy focuses and unifies CEOS efforts towards providing intensive Earth observation awareness-raising, capacity building, education and training in multiple formats; promoting wider and easier access to Earth observation data; increasing the sharing of software tools such as the use of open-source software and open systems interface; and increasing data dissemination capabilities, aiming at transferring relevant technologies to end users.

2023: WGCapD will continue to increase its efforts at the global, regional and national level by building upon activities carried out in 2022. This will be done by delivering trainings in different formats (e.g., in-person, virtual), collaborating with other CEOS working groups, and developing new activities in support of GEO and the global agendas. New resources will be made available on the WGCapD webpages. For the first time, the WGCapD annual meeting will be held jointly with UN-Space, the United Nations interagency coordination mechanism for space. This meeting has as objective to capture the needs and barriers on the use of Earth observation in the United Nations System and to provide the opportunity to United Nations Member States to express their needs and barriers. In addition, the Earth Observation Training, Education, and Capacity Development Network (EOTEC DevNet), which aims to improve coordination among different space-based asset providers and training providers, will continue pursuing greater engagement of its regional communities of practice and will continue developing the network of networks.

2023-2024: WGCapD will continue to address a global need for the identification and coordination of the world's diverse and often disparate capacity building and training resources related to satellite Earth observations. It is expected that EOTEC DevNet will enter a self-sustaining phase. WGCapD also plans to continue collaborating with GEO to strengthen AmeriGEO and AfriGEO through training contributions at their respective meetings/workshops.

WGCapD divides its work into support to global, regional, national and infrastructure activities:

1. For **global work**:
   - Focus on on-line learning through e-learning, MOOCs, webinars, and blended learning approaches.
   - EOTEC DevNet will continue connecting CEOS WGCapD with other global networks and will seek to achieve self-sustainability.
   - Development of a curriculum using WGCapD produced resources is under preparation.
   - Deliverables: CB-22-06, CB-22-07, CB-23-01, CB-23-03, CB-23-04, CB-23-06, CB-23-07
2. For **regional work**:
   - Focus on support to regional GEOs: AfriGEO and AmeriGEO.
   - Support trainings in conjunction with regional societies and other meetings.
   - Leverage single-agency regional activities as possible.
   - Deliverables: CB-20-21, CB-22-08, CB-23-02, CB-23-05
3. For **national work**:
   - Support national trainings where fitting.
   - Strengthen our understanding of national needs in other thematic areas.
   - Strengthening inclusiveness and support to underrepresented communities.
   - Deliverable: CB-20-14
4. For **infrastructure**:
   - Enablers, with a focus on sharing of best practices and resources, convening key stakeholders, and addressing users' needs.
   - Joint work with WGISS
   - Deliverables: CB-20-07, CB-22-10, CB-22-11, CB-22-12, CB-22-13, CB-22-14, CB-22-15

Number	Objective/Deliverable Title	Projected Completion	Responsible CEOS Entity(ies)
Global Deliverables			
CB-22-06	Webinar on joint applications for land and climate	2023 Q3	WGCapD
CB-22-07	Open-Source Science Outreach Plan and Training	2023 Q4	WGCapD
CB-23-01	ARSET-Agricultural Crop Monitoring with Synthetic Aperture Radar and Optical Remote Sensing	2023 Q1	WGCapD
CB-23-03	Guidance Document for Conducting Needs Assessments for Capacity-Building	2024 Q1	WGCapD
CB-23-04	Open-Source Science Outreach Plan and Training in support of NASA's Transform to Open Science (TOPS) Initiative	2024 Q2	WGCapD
CB-23-06	Recovery observatory for decision-makers	2023 Q4	WGCapD
CB-23-07	UN/Austria Symposium 2023 Space Systems &Technology for Climate Action	2023 Q3	WGCapD
CB-23-08	Recommendations on learning objects joint repositories and metadata standards for learning objects	2024 Q3	WGCapD
Regional Deliverables			
CB-20-21	Copernicus User Uptake in Africa	2023 Q4	WGCapD
CB-22-08	Copernicus training of trainers in Africa	2024 Q4	WGCapD
CB-23-02	ESA/NASA Trans-Atlantic Training 10	2023 Q3	WGCapD
CB-23-05	Digital Earth Africa online courses: Water resources (English and French), Agriculture (English, French)	2023 Q4	WGCapD

Number	Objective/Deliverable Title	Projected Completion	Responsible CEOS Entity(ies)
National Deliverable			
CB-20-14	Indigenous Peoples-focused In-Person Training (Australia)	2023 Q2	WGCapD SEO
Infrastructure Deliverables			
CB-20-07	Best Practice Guide to E-Learning	2023 Q2	WGCapD
CB-22-10	Sentinel Selected Applications: practical training with Jupyter Notebooks on the ESA EO Platform	2023 Q4	WGCapD
CB-22-11	EOTEC DevNet Pilot Phase 2 Report	2023 Q1	WGCapD
CB-22-12	EOTEC DevNet Multi-Stakeholder Network Analysis	2023 Q1	WGCapD
CB-22-13	Jupyter Notebooks Foundations Webinar	2023 Q3	WGCapD WGISS
CB-22-14	EO Capacity Building Curriculum	2023 Q4	WGCapD
CB-22-15	Third Vietnam School of Earth Observation (VSoEO 3)	2023 Q4	WGCapD

3.9. Data Discovery, Access, Preservation, Usability and Exploitation: approaches, systems, tools and technologies

Through the CEOS Working Group on Information Systems and Services (WGISS), CEOS Agencies will continue to foster the enhancement of the WGISS Connected Data Assets Infrastructure to support not only the CEOS entities, but also the external entities like GEO, UN, WMO, etc., by enabling discovery and access capabilities to mature data services provided by CEOS Agencies.

The **WGISS Data Discovery and Access Interest Group** will support adoption of supported WGISS standards (e.g., Open Geospatial Consortium, Catalogue Service for the Web and CEOS OpenSearch Best Practices) and definition of new ones, with the aim of connecting as many CEOS agencies as possible into the federated system. The Interest Group will also make the services and tools developed and operated by CEOS agencies discoverable by endorsing the application of "Service Metadata and Discovery Best Practices" issued in 2022. With the increased request for federated collaborative environment to access data and services, the Interest Group intends to explore scenarios for a federated authentication and authorisation mechanism.

Earth observation data represent a unique, valuable, independent, and strategic resource that needs to be preserved, managed and curated throughout its lifecycle to make sure it continues to provide essential information on our planet and the changes which are affecting it. The **WGISS Data Preservation and Stewardship Interest Group** continues to accomplish its data preservation and curation efforts through addressing space data and associated information archiving, preservation, consolidation and valorisation aspects, including efforts to recover heritage data currently not accessible or at preservation risk. A "Data Management and Stewardship Maturity Matrix" will be issued to help data managers and curators to accomplish their tasks. All the guidelines and best practices produced by the group will be reviewed and adjourned with latest findings and shared within and outside of CEOS (e.g. CGMS and New Space companies) to enable the maximum benefit of EO data for science, society and economic growth.

The **WGISS Technology Exploration Interest Group** will survey cutting edge technologies related to the Earth observations. Survey results will be summarised and issued as guidelines and best practices. The "Jupyter Notebook Best Practices" is to be issued in 2023 by collaborating with WGCapD, UN, GEO, etc. Use cases of Artificial Intelligence / Machine Learning (AI/ML) focusing on EO research and applications will be investigated and summarised in a white paper in 2024.

WGISS will coordinate the CEOS Interoperability Framework to discuss the vision of its activity and a way forward for CEOS-ARD, on-line dictionary, etc., with its numerous components distributed across many CEOS entities. WGISS will begin this process by developing an interoperability roadmap to present to SIT-38. Further, investigations on Data Integrity and Authenticity, STAC implementation, and Systems Federation will be investigated in 2024-2025.

Number	Objective/Deliverable Title	Projected Completion	Responsible CEOS Entity(ies)
DATA-22-01	Jupyter Notebook Best Practice	2023 Q4	WGISS
DATA-22-02	Discovery and Access for Data Analytics and Processing Tools and Services	2023 Q3	WGISS
DATA-22-04	Data Management and Stewardship Maturity Matrix	2023 Q1	WGISS WGCV
DATA-22-05	Feasibility Study for Common Guidelines for the STAC Implementations	2023 Q2	WGISS
DATA-22-06	Archive Technologies White Paper	2023 Q2	WGISS
DATA-23-01	AI/ML White Paper	2024 Q4	WGISS
DATA-23-02	CEOS Interoperability Framework Roadmap	2023 Q1	WGISS

3.10. Advancement of the CEOS Virtual Constellations

CEOS seeks to characterise the Virtual Constellations in the context of both the development of the space segment for GEOSS and of the multitude of outcomes and deliverables that CEOS seeks to provide for GEO and other users and frameworks.

2023-2025: Ensure that the Virtual Constellations (VCs) — Atmospheric Composition (AC- VC), Land Surface Imaging (LSI-VC), Ocean Colour Radiometry (OCR-VC), Ocean Surface Topography (OST-VC), Ocean Surface Vector Wind (OSVW-VC), Precipitation (P-VC), Sea Surface Temperature (SST-VC) — are accomplishing the outcomes and deliverables associated with the activities documented in the *CEOS Virtual Constellations Process Paper* and their respective terms of reference and implementation plans.

I. AC-VC

The CEOS Atmospheric Composition Virtual Constellation (AC-VC) exists to sustain a systematic capability to provide essential observations of atmospheric composition from space. Key objectives include coordination of the collection and delivery of data to improve predictive capabilities for changes in ozone layer, monitor air quality, and monitor climate forcing associated with changes in atmospheric composition.

Activities for **2023** focus on first-ever intercomparisons of tropospheric ozone datasets and on harmonised validation plans for the three geostationary air quality missions now in development. AC-VC climate activities focus on the development and delivery of atmospheric Greenhouse Gas (GHG) Inventories and Observing System Simulation Experiments (OSSEs) to support the GHG Task Team within the Working Group on Climate. Following the endorsement of the PM2.5 whitepaper, it is envisaged to write a roadmap on activities responding to the whitepaper recommendations.

II. LSI-VC

The CEOS Land Surface Imaging Virtual Constellation (LSI-VC) is guided by a vision of sensor agnostic land surface data from all missions, achieving observations that enable users to characterise change on the Earth's surface through time.

LSI-VC championed the concept of CEOS Analysis Ready Data (CEOS-ARD) and continues to develop specifications for land surface products. It is also a key contributor to the CEOS-ARD Oversight Group, the CEOS-ARD Strategy (due to be updated in 2023), and the new Open Geospatial Consortium (OGC) ARD Standards Working Group, which will use CEOS-ARD as a basis for broader geospatial ARD Standards. CEOS-ARD is a first step towards increasing the interoperability of Earth observation datasets. In 2022, LSI-VC described the concept of a CEOS Interoperability Framework to address the fact that interoperability of EO datasets requires numerous advancements across a variety of areas and CEOS groups. This work will now be led by WGISS and the LSI-VC will be a key contributor.

Cloud computing is now central to the use of EO data. It is both convenient for users and increasingly a necessity in the age of 'Big Data'. With CEOS-ARD, the aim is to provide data that allows immediate analysis with a minimum of additional user effort. With this in mind, LSI-VC will work over the coming years to better understand the state of CEOS-ARD in the cloud and seek to optimise its representation. This will include understanding and documenting user experiences and working with WGISS on technical topics, e.g., formats, accessibility, discoverability, metadata standards, authoritative data, etc.

The Forests & Biomass and GEOGLAM subgroups of LSI-VC specifically focus on topics related to forests and agriculture respectively. The CEOS AFOLU Roadmap, being led by the Forests & Biomass Subgroup, will define the 2035 observing system required to address the AFOLU information needs of society. Once finalised, the LSI-VC and its subgroups will respond to the recommendations presented in the Roadmap, undertaking activities such as mission continuity, observation gap assessment and other technical topics. LSI-VC will also respond to the updated GEOGLAM observation requirements and consider the needs of the Essential Agricultural Variables (EAVs).

III. P-VC

The CEOS Precipitation Virtual Constellation (PC-VC) exists to sustain and enhance a systematic capability to observe, measure and validate global precipitation. These observations are essential to understand the distribution and characteristics of precipitation, its role in the hydrological/water cycle, and its impact on the climate system. Importantly, the accurate and timely knowledge of global precipitation is needed to improve the prediction of high-impact weather events such as hurricanes, floods, droughts and landslides, as well as the management of freshwater resources and the interconnectivity with the Earth System (for example, crop yields and fire susceptibility). The spatial and temporal variability of precipitation necessitates the utilisation of data from multiple sensors on multiple satellites to ensure sufficient observations are available to provide representative sampling across the range of scales (spatially and temporally) as required by the research, operational and application-driven user communities.

The P-VC has the following strategic objectives to address this aim:

1. Provide a coordination mechanism to harmonise precipitation-capable satellite systems, data collection, processing and delivery, retrieval algorithms, and calibration/validation infrastructures,

2. Serve as a programmatic point of contact for precipitation measurements, addressing issues which go beyond the individual mission programmes,
3. Coordinate activities to develop and improve the knowledge and understanding of precipitation (rain and snow) processes, the distribution of precipitation and the changes in precipitation over time on a global basis, and
4. Support and engage the scientific and operational user communities.

IV. SST-VC

The CEOS Sea Surface Temperature Virtual Constellation (SST-VC) provides a forum for collaboration on the production and coordination of sea surface temperature products across the international spectrum of remote sensing instruments, including infrared and microwave sensors on polar orbiting and geostationary platforms working closely with science team members from the Group for High Resolution Sea Surface Temperature (GHRSST) Project.

2023-2024: The SST-VC will continue to participate in and support the CEOS ARD Oversight Group and its related activities, including the emerging Open Geospatial Consortium (OGC) ARD Standards Working Group, and CEOS Interoperability initiatives. This will include working with the SIT chair and other CEOS-ARD interests to continue to evolve and improve the CEOS ARD Framework and Product Family Specification (VC-22-05 and VC-22-06). The SST-VC will also continue participation in the Ocean Coordination group to bring expertise from the GHRSST project in data formats and metadata for marine products, remote sensing requirements in high latitude regions and other related activities. The SST-VC also intends to support Level 4 (merged) ocean data product validation in a South Africa regional pilot project in collaboration with the COVERAGE initiative.

V. OST-VC

The goal of the CEOS Ocean Surface Topography Virtual Constellation (OST-VC) is to implement a sustained, systematic capability to observe the surface topography of global oceans. OST-VC links CEOS Agencies, the Ocean Surface Topography Science Team (OSTST) and the altimetry user community. It is suited to discuss constellation-wide programmatic issues and high-level constellation user requirements.

2023: OST-VC activities for 2023 will focus on the OST-VC white paper “A Coordinated International Satellite Altimetry Virtual Constellation: Toward 2050”. This paper will provide an update to the previous one dated 2009 and will integrate new user needs as expressed by the OST user community. It will also analyse the gaps in space missions to cover user needs and to make some relevant recommendations to international space Agencies. The OST-VC will also participate to the Ocean Coordination group to report on the needs and gaps discussed within the OSTST community.

2024-2025: In 2024-2025, the OST-VC will seek to strengthen multi-mission collaboration, continue its yearly community meetings (OSTST meetings) where information about current and future missions will be shared.

VI. OCR-VC

The focus of the CEOS Ocean Colour Radiometry Virtual Constellation (OCR-VC) is the monitoring and forecasting of Earth’s living aquatic environments. OCR provides information in three major application areas: Climate, Carbon and Water Quality.

2023: OCR-VC activities for 2023 will focus on starting the development of the Aquatic Carbon roadmap as a follow-on to the 2022 Aquatic Carbon related activities (the Ocean Carbon from Space workshop, the white paper and the Earth Science Reviews special issue). Carbon-related activities will also include the organisation of a Blue Carbon Workshop to take place early in 2024 and whose outputs will feed into the Roadmap. OCR-VC activities for 2023 will also include the organisation of the International Ocean Colour Symposium (IOCS) that will take place in November 2023 in the USA. In 2023, the OCR-VC will also support the Ocean Coordination Group as it moves forward to improve coordination and activities related to aquatic environments. Finally, the OCR-VC will contribute to the Aquatic Reflectance Product Family Specification for CEOS-ARD to extend it to all water types including seas and open oceans.

2024-2025: OCR-VC activities for 2024-2025 will include the continuation of developing a coordinated multi-mission basis for OCR cal/val, including System Vicarious Calibration infrastructures and protocols for bio-optical *in situ* measurements. OCR capacity building will also continue to provide new resources and training to users.

All OCR-VC activities and deliverables support the implementation of the International Network for Sensor InTercomparison and Uncertainty Assessment for Ocean Colour Radiometry (INSITU-OCR).

VII. OSVW-VC

The CEOS Ocean Surface Vector Wind Virtual Constellation (OSVW-VC) encourages the provision of high-quality ocean surface vector wind data for various applications through active international collaborations and scientific innovation. It aims to achieve more active engagement and coordination between nations involved in the development of satellite ocean surface vector wind sensors and the international wind vector community to discuss requirements and advocate the importance of ocean wind measurements. To this end, the OSVW-VC acts as the formal link between CEOS and the scientific community, represented by the International Ocean Vector Winds Science Team (IOVWST). The OSVW-VC is engaging the concerned parties to coordinate and optimise the ocean surface vector winds missions. A particular challenge is to coordinate the sampling of the wind measurements at the time scales which are required for a large variety of applications.

ISRO successfully launched its third scatterometer mission onboard Earth Observation Satellite - 06 (EOS-06) on 26th November 2022. The scatterometer (SCAT-3) follows the heritage of its precursors OSCAT (2009) and SCATSAT-1 (2016) in design, except for the larger diameter (1.4m) antenna for better spatial sampling. The local equatorial crossing time at descending node is 12 noon. The data products are being generated with nominal spatial sampling of 25km and 12.5km. Quality of the products is normal and the payload is currently undergoing it's In Orbit Testing (IOT) phase. Once the IOT phase is over, the data will be made available for the calibration-validation exercises. This is going to be an important ISRO contribution to the OSVW-VC.

Number	Objective/Deliverable Title	Projected Completion	Responsible CEOS Entity(ies)
VC-14-09	Implementation of the International Network for Sensor InTercomparison and Uncertainty Assessment for Ocean Colour Radiometry (INSITU-OCR)	2026 Q4	OCR-VC
VC-19-06	Update of CEOS OST-VC User Requirements Document	2023 Q4	OST-VC
VC-20-01	Tropospheric ozone dataset validation and harmonization	2023 Q4	AC-VC
VC-20-02	Air quality constellation validation coordination	2024 Q4	AC-VC WGCV

Number	Objective/Deliverable Title	Projected Completion	Responsible CEOS Entity(ies)
VC-20-03	Air quality constellation validation coordination: validation plans	2023 Q2	AC-VC WGCV
VC-20-04	Air quality constellation validation coordination: announcements of opportunity	2023 Q4	AC-VC WGCV
VC-20-10	CEOS–Industry ARD Workshop	2023 Q4	CEOS-ARD OG LSI-VC SIT Chair
VC-20-18	New version IMERG	2023 Q1	P-VC
VC-20-24	Aquatic Carbon From Space Special Issue	2023 Q2	OCR-VC
VC-20-26	System Vicarious Calibration (SVC) infrastructures in support of Climate-quality OCR data records	2026 Q4	OCR-VC
VC-20-27	Development of protocols for bio-optical in situ measurements	2026 Q4	OCR-VC
VC-20-28	Capacity building summer schools and online resources	2024 Q4	OCR-VC
VC-22-01	CEOS ARD Product Family Specifications (PFSs) for land products	2024 Q4	LSI-VC
VC-22-02	CEOS ARD product assessments for land products	2024 Q4	LSI-VC
VC-22-04	Mission continuity timelines for land domain CEOS-ARD PFS	2023 Q4	LSI-VC
VC-22-05	CEOS-ARD Strategy 2021 Implementation	2023 Q4	SIT Chair CEOS-ARD OG All VCs
VC-22-06	CEOS-ARD Strategy 2023	2023 Q4	SIT Chair CEOS-ARD OG All VCs
VC-23-01	Aquatic Carbon roadmap	2025 Q4	OCR-VC
VC-23-02	Blue Carbon Workshop	2024 Q2	OCR-VC
VC-23-03	Aquatic reflectance ARD	2024 Q1	OCR-VC
VC-23-04	Ocean Coordination Group	2023 Q3	OCR-VC
VC-23-05	CEOS-ARD Impact Case Studies	2025 Q4	CEOS-ARD OG LSI-VC
VC-23-06	CEOS-ARD in the Cloud	2025 Q4	CEOS-ARD OG LSI-VC WGISS
VC-23-07	CEOS-ARD PFS Template v2	2023 Q2	CEOS-ARD OG All VCs
VC-23-08	CEOS Representation to the Open Geospatial Consortium (OGC) Analysis Ready Data (ARD) Standards Working Group (SWG)	2025 Q4	CEOS-ARD OG SEO WGCV WGISS LSI-VC
VC-23-09	CEOS-ARD Community Building	2025 Q4	CEOS-ARD OG LSI-VC
VC-23-10	Expansion of the Aquatic Reflectance CEOS-ARD PFS to Cover Oceans	2023 Q4	CEOS-ARD OG OCR-VC LSI-VC
VC-23-11	LSI-VC Response to the Observation Requirements of the CEOS AFOLU Roadmap	2025 Q4	LSI-VC LSI-VC GEOGLAM Team LSI-VC F&B Team
VC-23-12	CEOS-ARD Product Family Specifications (PFSs)	2024 Q4	CEOS-ARD OG All VCs
VC-23-13	CEOS-ARD Product Assessments	2024 Q4	CEOS-ARD OG WGCV All VCs

3.11. Support to Other Key Stakeholder Initiatives

I. Facilitate the use of satellite data in the 2030 Agenda for Sustainable Development

At the 35th CEOS Plenary in 2021, after five years of successful activities, the CEOS SDG *ad hoc* Team transitioned to a new permanent and coordinated home for the management of all CEOS activities related to the UN Sustainable Development Goals (SDGs). The **CEOS SDG Coordination Group**, which includes representatives from the CEOS Strategic Implementation Team (SIT), the CEOS Systems Engineering Office (SEO), the CEOS Executive Officer (CEO), a CEOS-GEO liaison on SDG matters, and other key members from the former SDG *ad hoc* Team. The CEOS SIT Chair leads the overall strategic oversight and delegates the technical implementation to the CEOS Systems Engineering Office (SEO). The SEO coordinates SDG deliverables and CEOS Work Plan activities by liaising with lead experts responsible for each SDG deliverable. The lead experts organise their technical capacity and support using a pool of experts (internal and/or external) connected to each SDG topic (e.g., current SDG indicator sub team members), CEOS entities (WG, VC, AHT) and SDG-related GEO Work Programme activities.

The former CEOS SDG *ad hoc* team focused its activities on four SDG indicators: 6.6.1 on water extent, 11.3.1 on urbanisation, 14.1.1 on coastal eutrophication/marine pollution, and 15.3.1 on land degradation. CEOS agreed to focus on continuing support to GEO SDG efforts to advance the uptake of EO data (including GEO Federated approach in EO4SDG, GEO Toolkits, responding to UN requests, etc.), analysing satellite data requirements and supply for key Indicators, and liaising with other CEOS groups on capacity building, ARD strategy, EO-enabling infrastructure, etc., to harness CEOS collective expertise and to maximise benefits for CEOS Agencies and for SDG stakeholders.

2023-2024: At the Plenary 2022, the CEOS SDG Coordination Group (SDG CG) indicated the completion of 8 of 9 deliverables and outlined a list of future deliverables for 2023 and beyond. Work will continue on the 4 indicators listed above, including their annual review. Other options and SDG contributions have been explored to maximise CEOS expertise in support of international sustainability efforts.

At the two face-to-face meetings held late 2022 (SIT Technical Workshop and Plenary), the SDG CG reviewed their progress within the new mechanism and presented to CEOS members. They realised and highlighted the need of such a coordinating body to ensure CEOS provides satellite data expertise to stakeholders and to support GEO effectively in achieving one of their strategic priorities. Whilst recognising internal coordination should be further developed across CEOS entities, the SDG CG also agreed to maintain activities for end-users, while exploring other activities aligning with CEOS strategic priorities.

For 2023 and beyond, the Group will:

- Ensure continuity of some activities:
  - *EO Support Sheets Review*: as key CEOS technical resources useful for SDG stakeholders, the first versions were published on the SDG website in 2022. It is important to ensure that these resources remain up-to-date, so annual reviews will be undertaken by CEOS experts to ensure users can refer to it to meet their needs. These updates will consider new missions and new tools and resources relevant to SDGs.
  - *Broad contributions to SDGs/Communications*: leveraging the new SDG webpage displaying technical resources and background information and communications channels (social media, video, etc.), the SDG CG will continue and expand its effort to promote CEOS work in this domain by highlighting key internal efforts across different groups and activities.

- Respond to external requests and refine specific data needs:
  - *LDN Task*: the GEO Land Degradation Neutrality works closely with UNCCD (UN Convention to Combat Desertification) and has requested the help of CEOS to address specific needs with regards to satellite data and decision tree (see the Good Practice Guidance).
  - Future work associated with other SDG indicators will be considered through normal CEOS governance processes in line with the *CEOS External Requests Process Paper* and the *CEOS New Initiatives Process Paper*.
- Explore how CEOS can support country sustainability efforts to achieve their goals beyond the level of indicators (Global SDG Indicators Framework):
  - *Open Data Cube Application for SDGs*: this activity would be a demonstrator of how CEOS tools and services can directly support the SDGs (not necessarily at the SDG Indicators' level).

2024-2025: Additional ideas and activities are already discussed but will require further strategic and resources refinement. While CEOS aims to support GEO and its members to improve the use of EO satellite data in the SDG Framework, CEOS also relies on GEO's support to increase its visibility and promote its expertise to UN Agencies and other potential users (as detailed in two Engagement papers shared with GEO in 2022). This includes:

- Exploring ways to support and deliver a Wetland inventory. The Ecosystem Task Team will prepare a "white paper" on ecosystem extent in 2023, which will likely reference wetland inventories.
- The creation of an SDG Dashboard: a visualization tool similar to the NASA-ESA-JAXA EO dashboard, to help show how CEOS datasets can be used in the SDG context.
- Explicit links with the New Space Task Team and the potential for a future demonstration project targeted on SDGs with links to specific data for end-users requiring CEOS and/or GEO's help to get access to data that only industry would provide, e.g. high resolution data for islands, Radar data in other regions, etc.

II. Continue CEOS contributions and maintain leadership role in the GEO Blue Planet Initiative.

2023-2024: CEOS Agencies will continue to develop and distribute experimental and operational data, products and services, along with the further evolution of the COVERAGE model and initiatives undertaken within the CEOS COAST *ad hoc* Team, and likewise operational satellite oceanography activities (EUMETSAT, NOAA) to facilitate distributed access to collocated, synergistic datasets with fit-for-purpose latency, quality, coverage and content for applied, commercial and research utilisation.

III. Further develop CEOS contributions to meet biodiversity observation requirements.

2023-2024: Essential Biodiversity Variables (EBVs) are a collection of (currently) 20 biological variables that capture key dimensions of biodiversity and how they are changing. They are of particular importance for monitoring biodiversity change and are intended to be the feedstock for a variety of important derived products, especially for indicators used by international conventions such as the Convention on Biological Diversity (CBD) and the UN Sustainable Development Goals (SDGs). Remotely sensed data play a primary role in many EBVs and a supportive role in most of them.

While some further refinement of the EBVs is planned, one component of this next phase will be to advance the observation and particularly the production requirements for selected EBVs and derived

products; this is intended to support the longer-term goal to operationalise production of key products. The EBV Data Portal, still under development and hosted by iDiv in Leipzig, is starting to provide access to data relevant to the EBVs. Further development of workflows that provide important data products such as indicators and tying these into GEO BON's Biodiversity Observation Networks (BONs) is also planned. One aspect to this could be to identify related or common variables relevant to other areas or policy conventions, particularly climate.

Discussion on an ambitious concept for a global observation system for biodiversity will continue. Key areas needing exploration include but are not limited to overall scope; users and their priority needs; connection to existing systems; integration of remotely sensed and *in situ* data; scalability; and growth plan. Partnerships will be essential and exploring ideas with potential collaborators will continue as the concept develops further.

An additional and ongoing task is outreach to the broader biodiversity and ecosystem communities because many in these communities do not utilise remote sensing data despite its value in addressing biodiversity- and ecosystem-relevant issues. One aspect of this is the continued enhancement of the "BON-in-a-Box" toolkit that facilitates access to and utilisation of data; it also eases the pathway for a government or other entity to set up a Biodiversity Observation Network. Among other capabilities, these tools will make it possible to generate certain products such as indicators that may not yet be available but that are needed to support CBD and SDG Goals and Targets at the national level.

At the 36th CEOS Plenary in 2022 an **Ecosystem Extent Task Team** (EETT) was established for a two-year period to assess the utility for mapping Ecosystem Extent using current and new space-based observations that will become available in the next 10 years. As a forum for national and international organizations focused on space-based EO, CEOS is uniquely positioned to explore how the capabilities that current and forthcoming missions can bring can support user needs for mapping ecosystem extent. CEOS can further assist by coordinating leadership on the use of these capabilities relevant to biodiversity measurement from space.

The Ecosystem Extent Task Team's objectives are to:

1. Develop a white paper that will provide an integrated international perspective on how space-based Earth observations can be used to support ecosystem mapping and monitoring with a focus on ecosystem extent.
2. Develop specific ideas to further the concepts in the white paper.
3. Explore and propose an initiative to demonstrate the use of EO for ecosystem extent mapping and monitoring.

IV. CEOS Ocean Variables Enabling Research and Applications for GEO

COVERAGE (CEOS Ocean Variables Enabling Research and Applications for GEO) is a CEOS initiative, proposed by NASA and endorsed at the SIT-32 meeting in Paris in 2017 as a collaborative pilot project involving CEOS Agency and international stakeholder participation. It seeks to provide improved access to a coherent set of interagency data products from the four Ocean VCs and to implement a technology platform providing value-added data services in support of marine GEO initiatives, including the Marine Biodiversity Observation Network (MBON) and Blue Planet. COVERAGE development is comprised of four phases (A-D).

The COVERAGE phase A (technical scoping) activity officially kicked off with NASA support in November 2017 and has been successfully completed. COVERAGE Phase B (COV-17-04) successfully concluded in Q4 2020. This 1-year activity involved technical development of a prototype COVERAGE system

demonstrating core functionality for a limited range of data types, with an emphasis on collocated, multi-parameter satellite products from the 4 Ocean VCs that are integrated with select *in situ* datasets in support of a pilot ecosystem thematic application. Phase B included implementation of COVERAGE's distributed architecture with satellite nodes on NASA-AWS and EUMETSAT-WEkEO cloud platforms and connectivity to select CSIRO, NOAA and IMOS *in situ* data repositories accessible via prototype Web portal capabilities accessible at https://coverage.ceos.org. COVERAGE Phase C commenced in June 2021 as a planned 18-month activity and concluded successfully in December 2022. Technical work involved enhancements to the prior prototype capabilities based on community comments received to develop a more mature and fully featured COVERAGE system. Further development and expansion of thematic application use cases as proof-of-concept demonstrations was also undertaken with project partners. Continued stakeholder engagement was also integral to Phase-C, including with our advisory board of agency representatives, the CEOS VCs and in the context of the advancement of the COVERAGE concept to the UN Decade of the Oceans for Sustainable Development in coordination with CEOS.

2023: The final phase of COVERAGE (D) is expected to last 6 months through Q1-2023 (COV-18-02) and will involve evaluation of the COVERAGE system. Central to this activity will be the demonstration of capabilities amongst key COVERAGE stakeholders, including agency partners GEO-BON and GEO-Blue-Planet, with a view to potential future operationalisation. COVERAGE will additionally continue to contribute to coordination activities among the various CEOS ocean-related entities and initiatives through the CEOS Ocean Coordination Group.

V. CEOS Coastal Observations, Applications, Services and Tools *ad hoc* Team

The COAST (Coastal Observations, Applications, Services and Tools) *ad hoc* team (AHT) is a dedicated coastal-focused *ad hoc* team helping bridge land and ocean observations within CEOS and, given its cross-cutting nature, helping to integrate across multiple CEOS entities and domains, both thematic (e.g., Disasters, SDGs, and Capacity Development) and technical (e.g., Ocean, Land and Atmosphere, Biodiversity, WGISS, cal/val, and COVERAGE). The COAST AHT is advancing two pilot projects that leverage the CEOS- ARD framework already demonstrated for terrestrial applications. The COAST AHT is well-positioned to highlight the broader utilisation of Earth observations for greater societal benefit within coastal zones (e.g., Blue Economy; SDG-14), and demonstrates a specific mechanism for CEOS to engage with external stakeholders such as GEO, IOC/GOOS, UN Environment and high visibility activities such as the *UN Decade of Ocean Science for Sustainable Development (2021-2030)*.

In 2022 the COAST AHT successfully transferred technology for the Coastline Mapping Product developed by Geoscience Australia to the EAIL for Chesapeake Bay. The Digital Earth Africa effort for the West Coast pilot region was so successful that it has been implemented Africa-wide. ISRO hosted a successful outreach and demonstration event with regional stakeholders for the Bay of Bengal pilot region and NOAA hosted several successful demonstration sessions for the coastal bathymetry, coastline mapping, and flooding/inundation products for the Chesapeake Bay pilot region. Talks to expand demonstrated products into Blue Carbon, likely in partnership with the GEO Blue Planet and the GEO MBON initiatives, have been held.

2023: the COAST AHT expects to complete product co-design and demonstration, training, validation of the initial products, and capacity development of pilot products in initial geographical regions. Efforts are underway to find a way to sustain COAST activities in this final year as an *ad hoc* Team.

VI. CEOS and the 'New Space' Agenda

Across CEOS Agencies, there is significant interest in how best to engage companies in 'New Space' that may bring an important added value to the public upstream and downstream sectors, for which the ultimate beneficiaries are data users. In several countries represented in CEOS, national public institutions are exploring avenues for facilitating this innovative and rapidly expanding industry (the New Space sector) and for fostering partnerships with next-generation non-governmental entities that are closely linked to Earth observation (EO) from space, either in the procurement of satellites (upstream) or in the exploitation of EO data. There is growing consensus in CEOS that sharing experience acquired by the national space agency at the country-level can be useful and beneficial to other CEOS Agencies (Members and Associates).

There is also robust interest among CEOS membership in exploring ideas for future initiatives between CEOS and the commercial sector. This potential new direction is consistent with the *CEOS Strategic Guidance Document* (Section 3 - Goals) in which the CEOS organisation recognises that it must remain flexible and forward-thinking to respond to the emerging needs of its stakeholders and the global community. Forging partnerships with the increasingly diverse Earth observation user community presents both opportunities and challenges for CEOS to remain true to its mission statement:

> *"CEOS ensures international coordination of civil space-based Earth observation programs and promotes exchange of data to optimize societal benefit and inform decision making for securing a prosperous and sustainable future for humankind."*

The topic of New Space was introduced by the 2022-2023 CEOS SIT Chair (ESA) as one of the strategic priorities of its two-year term as SIT Chair. At the 2022 CEOS Plenary, a **New Space Task Team** (NSTT) was established for one-year to explore collaboration opportunities in New Space that could potentially bring mutual benefit to all parties, including the identification of concrete initiatives to drive the agenda forward.

The **2023** planned activities of the New Space Task Team consist of:

- Organising dedicated sessions at each CEOS meeting attended by CEOS Principals (SIT Meeting, SIT Technical Workshop and CEOS Plenary).
- Commencing with an assessment of the areas and issues that are common among CEOS Agencies and that are expected to impact public EO programmes in the future. These may include, e.g., the impact on ground and space architectures; the need for more effective data interoperability and integration to combine more data streams; collaborative efforts on major datasets in support of CEOS priorities; and calibration and validation of small satellites and calibration transfer.
- Developing a White Paper with Findings and Recommendations. This document shall be based on both the information collected during the experience sharing sessions and the specific relevant activities undertaken across the CEOS entities. The White Paper will highlight topics determined to be the most productive for CEOS to pursue and topics found to be less productive, out of scope or problematic.
- Developing a series of objectives and activities that will guide CEOS in fostering the combined use of data from public and private EO small satellite missions.
- Defining and implementing actions within the CEOS framework that aim to enhance the outcomes of CEOS entities engaging with New Space companies. Those activities shall also foster the partnership at the national level between individual CEOS members and their national New Space sector.

Number	Objective/Deliverable Title	Projected Completion	Responsible CEOS Entity(ies)
BON-22-02	Develop the next level of detail for the Global Biodiversity Observation System (GBiOS) concept so that implementation approaches can be explored.	2023 Q4	CEOS Biodiversity Expert
BON-23-01	Ecosystem Extent White Paper	2023 Q4	EETT
BON-23-02	Ecosystem Extent Demonstrator	2024 Q4	EETT
COV-18-02	COVERAGE system evaluation (Phase D)	2023 Q1	COVERAGE
OUT-23-01	New Space sessions at CEOS meetings	2023 Q4	NSTT
OUT-23-02	CEOS New Space White Paper	2023 Q4	NSTT
OUT-23-03	Data licensing in partnership between Public and New Space sectors	2023 Q4	NSTT
OUT-23-04	Method and result sharing for performing evaluations of commercial data	2023 Q4	NSTT
OUT-23-05	ESA – NASA Earth Observation Mission Quality Assessment Framework - Optical Guidelines	2023 Q4	NSTT
OUT-23-06	ESA – NASA Earth Observation Mission Quality Assessment Framework - SAR Guidelines	2023 Q4	NSTT
SDG-23-01	EO Support sheet for SDG Indicator 6.6.1 (Water) 2023 Review	2023 Q4	SDG CG SEO
SDG-23-02	EO Support sheet for SDG Indicator 11.3.1 (urbanisation) 2023 Review	2023 Q4	SDG CG SEO
SDG-23-03	EO Support sheet for SDG Indicator 14.1.1 (Marine Pollution) 2023 Review	2023 Q4	SDG CG SEO CEOS AHT
SDG-23-04	EO Support sheet for SDG Indicator 15.3.1 (Land degradation) 2023 Review	2023 Q4	SDG CG SEO
SDG-23-05	Land Degradation Neutrality (LDN) Task	2023 Q4	SDG CG SEO
SDG-23-06	Open Data Cube Applications for SDGs	2023 Q4	SDG CG SEO
SDG-23-07	Communications packages to demonstrate broad contributions to SDGs for a variety of CEOS groups and initiatives	2023 Q4	SDG CG SEO
WAT-22-01	Provide inputs for coastal sediment, coastal eutrophication and Blue Carbon pilot projects being co-designed and co-developed on a regional basis in concert with GEO Blue Planet, GEO AquaWatch, MBON and associated downstream stakeholders	2023 Q4	COAST AHT

3.12. CEOS Services

This section describes services provided by CEOS to the international Earth observation community. These are ongoing functions, which serve space agency "core business" such as data discovery and calibration/validation, the CEOS Missions, Instruments and Measurements (MIM) database, the WGISS Connected Data Assets or Radiometric Calibration Network (RadCalNet). As ongoing functions, these services are presented in the Work Plan, but are not monitored in the same way as other Work Plan Deliverables.

I. Accessibility of CEOS Agencies Datasets

Full representation and accessibility of CEOS Agencies' datasets through WGISS Standards and Connected Data Assets Infrastructure (i.e., International Directory Network [IDN], CEOS WGISS Integrated Catalogue [CWIC], Federated EO Gateway [FedEO]). As the IDN contains OpenSearch endpoints for data access and is also the CEOS Data Collections access point for the GEOSS Platform (formerly GEOSS Common Infrastructure-GCI) and GEOSS Portal, it is essential that all CEOS Agencies keep information on their data collections, including Analysis Ready Data, up-to-date in the IDN according to its metadata model (DIF-10). This requires interaction with CEOS Agencies and data providers.

Responsible CEOS Entity: WGISS

II. Radiometric Calibration Network (RadCalNet)

The CEOS WGCV RadCalNet service provides all satellite operators (agencies and commercial) with access to 'free and open' SI-traceable Top-of-Atmosphere (TOA) spectrally-resolved reflectances to aid in the post-launch radiometric calibration and validation of optical imaging sensor data (www.radcalnet.org). This is an essential pre-requisite to achieving sensor-to-sensor harmonisation and subsequent data interoperability. RadCalNet provides the means to derive and correct for biases between sensors in a robust and consistent manner resulting in the information needed to assign the quality metrics increasingly required for many Analysis Ready Data (ARD) products.

Following an initial developmental period with four sites, and an opening to the community in 2018, a fifth site was added (July 2020) following a peer review of the site against the membership criteria. Over the next few years, we anticipate small evolutions in documentation and procedures both at individual sites and at network level to account for improvements in technology, methodology and feedback from users. Whilst continuing to expand the range and number of users, we also anticipate and encourage membership of new sites. Additional sites will increase the geographical and temporal availability of data while providing different spectral radiometric properties. The continued improvements by WGCV's RadCalNet Working Group to RadCalNet processing and distribution, evaluation of test site protocols and hardware, and new test sites will facilitate the evaluation of a range of new sensor characteristics expected in the coming years.

Responsible CEOS Entity: WGCV

III. Collection, Incorporation, and Quality Control of New and Updated Climate Information from Data Providers

Update and verify the content of the ECV Inventory based on contributions by data providers and publish the annual version on cimatemoniroing.info. Completion date is recurrent: Q4 every year from 2019 onward.

Responsible CEOS Entity: WGClimate

IV. Essential Climate Variable (ECV) Inventory Gap Analysis

Perform gap analysis work that always provides incremental updates to the year before in terms of improvements on the compliance to GCOS requirements and a report in focus areas addressing needs of CEOS and CGMS. The gap analysis is coordinated by the WGClimate Chair with support from several expert teams that will perform the gap analysis in parallel. Completion date is recurrent: Q4 every year from 2019 onward.

Responsible CEOS Entity: WGClimate

V. Coordinated Action Plan – Climate

The action plan identifying agreed actions that CEOS and CGMS Members and Associates intend to take to address priority gaps will be updated once a year. The actual action plan will be endorsed and released to the CEOS community at a suitable meeting. Completion date is recurrent: Q4 every year from 2019 onward.

Responsible CEOS Entity: WGClimate

VI. Space Agencies Statement to UNFCCC/SBSTA

The WGClimate Chair drafts the annual "Space Agencies Statement" to the autumn season SBSTA/COP and presents this for endorsement to CEOS and CGMS Plenaries (mostly done in virtual endorsement mode). The statement is presented at SBSTA by the country chairing CEOS. Completion date is recurrent in Q3/Q4 every year from 2019 onward.

Responsible CEOS Entity: WGClimate

VII. Maintain the Missions, Instruments and Measurements (MIM) database as a key tool to enhance understanding of Earth observations from space missions and data.

The CEOS Database (a.k.a., the Missions, Instruments and Measurements Database, or MIM) is the only official consolidated statement of CEOS Agency programs and plans. Each year, the database will be updated based on survey inputs provided by all CEOS Agencies to reflect the current status of CEOS Agency missions and instruments. The European Space Agency (ESA) and the SEO have developed a number of analysis and visualisation tools to apply this information in support of gap assessments and the database is used by the SEO as the basis for missions, instruments and measurements references in the ECV Inventory.

Together, these resources represent the cornerstone of CEOS capabilities to undertake informed coordination decisions. CEOS will continue development of these resources each year, with a particular focus on engaging them for ECV development and observational gap analyses. New enhancements for advanced search capabilities will be added, as well as links to other CEOS

resources (e.g. COVE, CWIC and IDN) or to external information systems, such as WMO's Observing Systems Capability Analysis and Review Tool (OSCAR) and the Global Change Information System (GCIS, http://data.globalchange.gov/lexicon/ceos).

Annually, the ESA CEOS MIM Database team will continue work on the development and promotion of new tools for, and in collaboration and coordination with, the community to discover and browse the information contained in the MIM, including content on GCOS, carbon, water, and other CEOS thematic activities.

Responsible CEOS Entity: ESA

VIII. Publish the CEOS Newsletter

CEOS, through contributions of JAXA, will continue the publication of this valuable, long-standing communication tool. The CEOS Newsletter articles are posted once a month in a timely manner on its webpage and the annual Newsletter is issued once a year.

Responsible CEOS Entity: JAXA

IX. Maintain the CEOS Website and Enhance Currency and Relevance of Content

CEOS, with coordination through the SEO, will build on the "content management" approach underpinning the CEOS website to promote more up-to-date and relevant information for users. For example, the website will be proactively used to promote CEOS Agency launches.

Responsible CEOS Entity: SEO

X. Engage, attend, be strategically involved (where appropriate), report on CEOS achievements, and present at key meetings.

CEOS desires to increase and improve the connections between CEOS and its stakeholders during deliverable development. CEOS leadership and the national delegations of CEOS Agencies will expand links with stakeholders to inform ministers of CEOS Earth observation products and coordination efforts and to enlist appropriate G20/G8 support for enhanced Earth observation coordination. CEOS should highlight CEOS achievements in global change monitoring and the significance of long-term satellite observation capabilities in statements at key high-level meetings.

Responsible CEOS Entity: CEOS Chair, SIT Chair, CEO, All CEOS Agencies and Entities

This CEOS Work Plan will be updated annually by the CEOS Executive Officer (CEO) under the guidance of the CEOS Chair, and in consultation with the CEOS Strategic Implementation Team Chair, CEOS Secretariat, CEOS Working Groups, Virtual Constellations, Ad Hoc Teams, the CEOS membership at large, and external stakeholders. This document shall be consistent with and mutually supporting of other CEOS guiding documents.