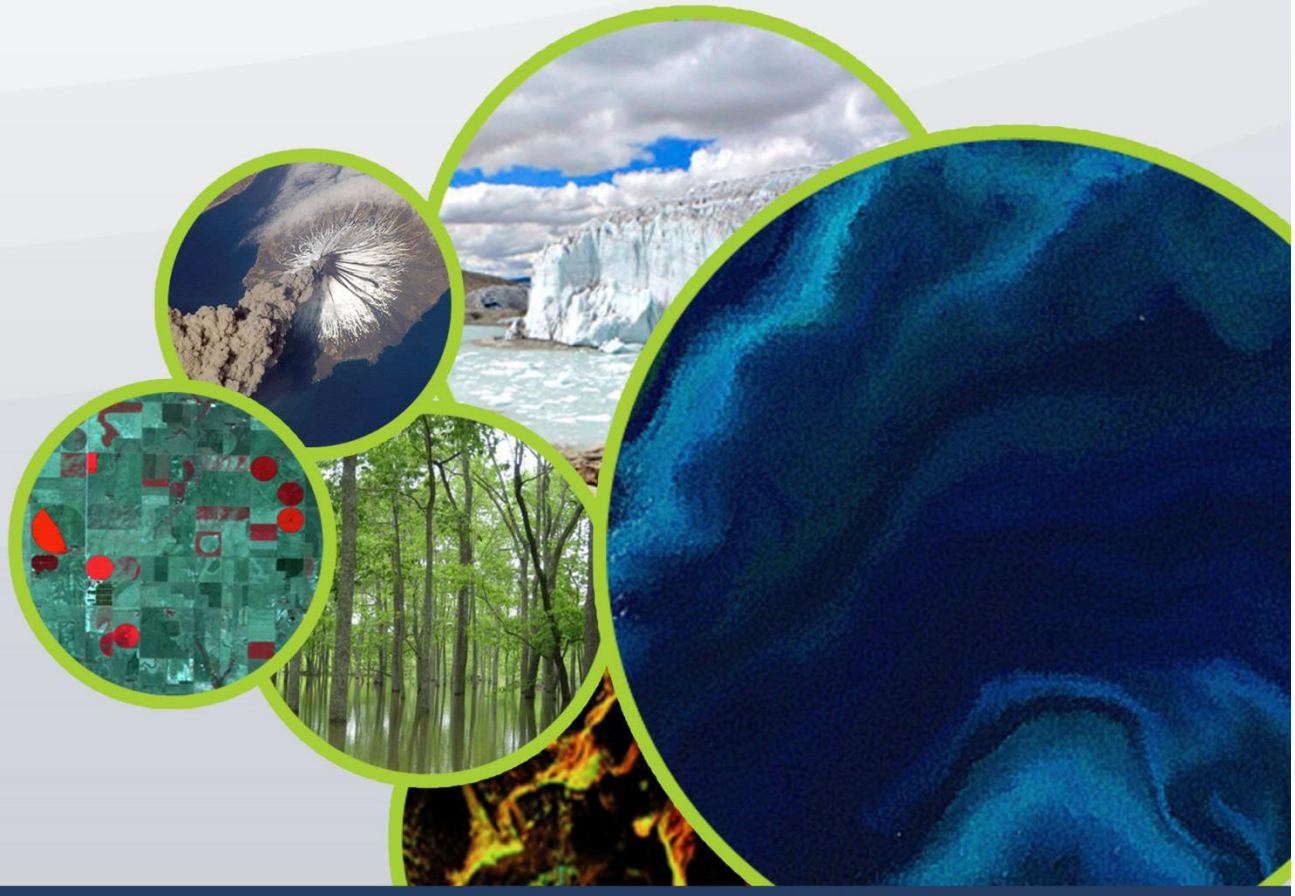
Committee on Earth Observation Satellites



2024-2026 Work Plan

May 2024

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
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 *2024-2026 CEOS Work Plan* was developed by the CEOS Executive Officer (CEO) under the direction of the Canadian Space Agency (CSA) as the CEOS Chair for 2024, in consultation with the Japanese Aerospace and Exploration Agency (JAXA) as the CEOS Strategic Implementation Team (SIT) Chair, the 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 (2024) and summarises anticipated activities for the subsequent two years (2025-2026). Additional documents contributing information to this plan are located on the CEOS website (https://ceos.org/) and include the CEOS *2023-2025 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.

Two characteristics of CEOS particularly influence the work plan cycle: first, the very nature of CEOS as a "best-efforts" collaborative organisation; and second, the leadership rotations (yearly for the CEOS Chair and every two years for the CEOS SIT Chair). The best-efforts context calls upon the organisation to periodically re-examine its activities for their continued relevance and that it be mindful of the demand on its collective and individual resources. The leadership rotations bring Chair and SIT Chair priorities every year and every two years respectively while ensuring continuity and completion of the previous work plan, as well as previous priorities. Although the Work Plan is officially updated and approved on an annual basis, CEOS agencies, Working Groups, and Virtual Constellations, and ad hoc Teams are encouraged to communicate changes throughout the year. New tasks can therefore be acknowledged and incorporated into the next edition of the Work Plan in an efficient way.

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 the cooperation of CEOS Agencies in mission planning and 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 activities that have an environmental or socioeconomic impact.
- 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), GEO, and organisations participating in treaties and global programmes affiliated with the United Nations (UN)[1].

2.CEOS Priorities

This Work Plan was 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 37th CEOS Plenary meeting took place in Chiang Rai, Thailand, on November 14-16, 2023. The meeting reviewed the progress made in the priority areas of the outgoing CEOS Chair, the Geo-Informatics and Space Technology Development Agency (GISTDA), and progress on the full range of CEOS remote sensing activities. The 37th CEOS Plenary further underscored the vital role of space-based Earth observation in addressing existing and emerging global challenges and the CEOS role in international collaboration on remote sensing for data users and decision making worldwide.

In the context of CEOS contributions to the UNFCCC Global Stocktake process under the 2015 Paris Agreement, the first priority under GISTDA's term as CEOS Chair, CEOS released the 2023 Earth Observation Handbook, "Space Data for the Global Stocktake", in advance of the

[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.

UNFCCC 28th Conference of the Parties (COP 28) held in Dubai, United Arab Emirates, on November 30 - December 12, 2023. CEOS also delivered the Joint CEOS-CGMS Space Agency Statement to the UNFCCC Subsidiary Body for Scientific and Technological Advice (SBSTA) for COP 28. In support of future UNFCCC Global Stocktakes, CEOS completed the multi-year effort to develop and formally endorse the Agriculture, Forestry, and Other Land Use (AFOLU) Roadmap, which now includes an Action Supplement to monitor and track its implementation in the coming years. In 2023, CEOS participated in the development of the WMO Global Greenhouse Gas Watch (G3W) and is actively contributing to its Implementation Plan. CEOS gave high priority to its collaboration with the UNFCCC Secretariat, with calls for regular meetings and consistent messaging among key observation bodies.

In support of GISTDA's second priority"New Space", CEOS completed the two-year effort that yielded the New Space Task Team white paper and recommendations, both of which include follow-on activities in this CEOS 2024-2036 Work Plan. While CEOS Principals gave their approval to disband the New Space Task Team following the completion of its mandate, they also acknowledged that New Space remains a focus area for CEOS as resources allow.

Two additional 2023 milestones were the updating of the CEOS Greenhouse Gas (GHG) Roadmap and the development of the dedicated GHG Satellite Mission Portal. CEOS endorsed the Interoperability Framework and Roadmap, and Principals approved the proposal for CEOS to develop an Aquatic Carbon Roadmap to complement the multi-year efforts that yielded the CEOS GHG Roadmap and CEOS AFOLU Roadmap. The Ecosystem Extent Task Team completed the white paper on ecosystem extent mapping, provided recommendations, and briefed the CEOS community on the demonstrator efforts that will be a key focus in 2024. The 2023 CEOS Plenary also agreed to disband the Ocean Coordination Group and accepted the initial proposal from the CEOS Coastal Observations Applications Services and Tools (COAST) *Ad Hoc* Team to transition to a CEOS Virtual Constellation. The COAST mandate was extended to allow time for the development of a full proposal for review and potential endorsement at the SIT-39 conference in April 2024, guided by the applicable governing document, i.e., the CEOS Virtual Constellation Process Paper.

In 2023, a comprehensive review by the CEOS executive officer highlighted CEOS engagement in multiple facets of the GEO Work Programme, with the CEOS collective and CEOS Agencies providing crucial open-source data and products that constitute the backbone of many GEO activities. CEOS held Observer status on the 2023 GEO Executive Committee and was elected to the GEO Programme Board for the 2023-2025 term. The scope and scale of CEOS remote sensing contributions and expertise to GEO are integral to what GEO seeks to accomplish. As both entities move forward, the synergy between CEOS and GEO remains important in the global effort to leverage space-based Earth observation data and products for the benefit of humanity, our planet, and its biodiversity.

Recognizing the significance of the United Nations Office for Outer Space Affairs (UNOOSA) "Space2030 Agenda" adopted in 2021 as a forward-looking blueprint for bolstering the role

of space activities and tools in advancing sustainable development, in 2023, CEOS reaffirmed its commitment to accessibility and interoperability of well curated data resources and tools that advance global understanding of the Earth as an integrated system and further inform decision and policy making across a spectrum of critical domains.

The 2023 CEOS Plenary endorsed the nomination of the United Kingdom Space Agency (UKSA) for the role of 2025 CEOS Chair, and the nomination of the National Aeronautics and Space Administration (NASA) for the role of SIT Vice Chair (2024-2025) and SIT Chair (2026-2027). As incoming SIT Chair for 2024-2025, the Japan Aerospace Exploration Agency (JAXA) proposed priorities for Climate Policy Impact and Greenhouse Gas Observations from Space, which the CEOS community strongly welcomed. The Canadian Space Agency (CSA) assumed the role of 2024 CEOS Chair and showcased the theme of its chairmanship, which will further elevate the CEOS focus on Biodiversity from Space and associated stakeholder engagement. This proposal was also welcomed. The 2023 CEOS Plenary endorsed and welcomed Environment and Climate Change Canada (ECCC) as a new CEOS Associate. Finally, the CEOS community adopted the proposed CEOS Communications Strategy outlining campaigns for 2024-2025.

This three-year work plan covering the years 2024-2026, provides a high-level summary of planned CEOS activities by the relevant entities, as well as crosscutting efforts that are part of the unique value CEOS international coordination delivers to the remote sensing community, stakeholders, and data users. It is an integral part of the transparency and accountability of CEOS to itself, partner organisations, and stakeholders. More detailed implementation plans are developed and tracked at the technical level in the CEOS Working Groups, Virtual Constellations, and Ad Hoc Teams.

3.Expected Outcomes for 2024-2026

The expected outcomes for 2024-2026 reflect the ongoing and emerging priorities of CEOS, in consideration of its internal decision making, resources, and stakeholder commitments. They are intended to focus on improved Earth observation systems coordination and enhanced data access for key global programmes and initiatives. The main outcomes are described for the following areas:

3.1. Climate Monitoring, Research, and Services
3.2. Carbon Observations in Support of Climate Science and Policy
3.3. Observations in Support of the Global Stocktake of the UNFCCC
3.4. Observations for Agriculture
3.5. Observations for Disasters
3.6. Observations for Water
3.7. Data Quality
3.8. Capacity Building and Data Democracy

3.9. Data Discovery, Access, Preservation, Usability and Exploitation: approaches, systems, tools and technologies
3.10. Advancement of the CEOS Virtual Constellations
3.11. Support to Other Key Stakeholder Initiatives
3.12. CEOS Services

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 Entities 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. CEOS Deliverables need to have an identified external link, i.e., to a particular GEO Work Programme Flagship / Initiative / Community Activity[2] or an activity connected to UNFCCC / UNCBD / UNCCD etc.

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.

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

As part of its sustained annual activities, WGClimate will:

- Deliver the annual Space Agency Statement to the UNFCCC Subsidiary Body of Scientific and Technological Advice (UNFCCC/SBSTA). The Statement is provided to the CEOS Chair Team for submission to the SBSTA meeting at the COP. WGClimate will also provide a summary version for oral presentation to SBSTA.

- Leverage its comprehensive Essential Climate Variable (ECV)) Inventory of Climate Data Records (CDRs) and implement coordinated actions arising from ECV Inventory gap analyses. The gap analyses identify opportunities for improvement of data records and their usage along the climate information value chain outlined by the *Architecture*.
- Examine the ECV Inventory to identify issues in the future availability of measurements for the Global Climate Observing System (GCOS) ECVs as described in GCOS Implementation Plans. 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, $CH_{4,use}$ and other greenhouse gases from space. In 2020, CEOS and CGMS endorsed the Greenhouse Gas Roadmap. 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 (SBSTA) and GCOS in support of the Paris Agreement.
- Continue to publish online use cases for climate data records to encourage wider utilisation of satellite Earth observations. This activity effectively validates the *Architecture* and fosters the use of satellite-derived CDRs.
- Provide oversight to the continuing implementation of GHG monitoring activities.

During **2024**, WGClimate will also:

- **Continue development of the Space Agency Response** to the 2022 GCOS Implementation Plan. Per the plan and 2023 schedule, WGClimate has already responded to nearly half of the GCOS IP recommendations to the GCOS Secretariat. The Space Agency Response provides status and plans on IP recommendations for space observations and climate products.
- **Update the ECV Inventory** with approximately 50 previously submitted CDRs.
- Continue **restructuring of the ECV Inventory** architecture and processes, including population, review and gap analyses protocols. This overhaul will reduce the complexity, maintenance costs and the submission and reviewing burdens on the

providers and the community.

- Submit an updated **Gap Analysis Report** to CEOS and CGMS Principals. This Report will encapsulate information gleaned from the prior two Gap Analyses as well as update information gathered through the current development of the Space Agency Response to the 2022 GCOP IP.
- Submit an updated **Coordinated Action Plan** to CEOS and CGMS Principals. This Plan will leverage information in the 2024 Gap Analyses Report and the current development of the Space Agency Response to the 2022 GCOP IP.
- Submit a **CDR Definitions manuscript** for publication in a peer-reviewed journal. Providing a common and coherent set of definitions will improve communications among Agencies, organisations and technical teams.

For **2025-2026**, significant outputs beyond the annual activities listed above will include:

- Submit the completed **Space Agency Response to the 2022 GCOS IP** to CEOS and CGMS Principals.
- Release the **restructured ECV Inventory** and complete the first Inventory record update with the new structures.

Number	Objective/Deliverable Title	Projected Completion	Responsible CEOS Entity(ies)
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-23-04	Provide Agency Response to GCOP IP	2024 Q4	WGClimate
CMRS-24-01	Update and align WGClimate website instances (CEOS, CGMS, climatemonitoring.info)	2024 Q4	WGClimate
CMRS-24-02	Update ECV Inventory content with previously-submitted records (~50)	2024 Q4	WGClimate
CMRS-24-03	Restructure ECV Inventory architecture and processes for population, review, gap analysis	2025 Q3	WGClimate
CMRS-24-04	Submit manuscript with updated definitions of FCDR; CDR; ICDR	2024 Q4	WGClimate
CMRS-24-05	Submit Merged Gap Analysis Report to CGMS and CEOS Principals for approval	2024 Q3	WGClimate
CMRS-24-06	Submit 2024 Coordinated Action Plan to CGMS and CEOS Principals for approval	2024 Q3	WGClimate
CMRS-24-07	Provide inputs on lessons learned from GST1 process to support SIT Chair update of the CEOS GST Strategy	2024 Q3	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 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 estimations of above-ground biomass (AGB). This new generation of missions, amounting to an investment of more than $US4bn by CEOS Agencies, is 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) Land Product Validation (LPV) subgroup, as well as the outreach and engagement defined and implemented through the CEOS AFOLU Roadmap.

2024-2025:

The LSI-VC Forest and Biomass subgroup will develop an action plan under the CEOS AFOLU Roadmap (endorsed at the 2023 CEOS Plenary in Chaing Rai, Thailand) to support the second UNFCCC Global Stocktake process (GST2 in 2028). The team will also ensure that CEOS products support the AFOLU sector in a harmonized way through four thematic product teams, including Above Ground Biomass (AGB), Land Cover, Wetlands and Mangroves. It will continue to steward the updated GFOI Data Strategy and to advance the priority initiatives identified concerning the policy relevance of AGB estimation missions.

The LSI-VC Forest and Biomass subgroup 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. Implementation progress 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 CEOS 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-VC Forest and Biomass subgroup 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. In 2023, the GHG Task Team re-examined Annex C with actions of the CEOS GHG Roadmap. This Annex was updated.

2024-2025: The CEOS GHG and AFOLU Roadmaps foresee a long-term commitment to the further refinement of CEOS Agency data products in support of the GST process. Given emerging new stakeholders and an evolving community, the GHG Roadmap will be fully updated and issue 2 will be generated in 2024. This update will highlight the role of CEOS and other stakeholders and how the multilateral effort is expected to evolve during the implementation phase of new entities like WMO's Global Greenhouse Gas Watch (G3W) and UNEP's International Methane Observatory (IMEO) with its related Methane Alert Response System (MARS). Further implementation actions are anticipated, including efforts to promote, educate and build capacity as we learn from the first GST and move toward supporting the second GST. While the initial GHG Roadmap focus was to support the first Global Stocktake, the updated version of the GHG Roadmap will incorporatenew stakeholders to better understand their needs and support them with the relevant GHG data. Concretely for CO2 to reach out to policymakers at smaller spatial and temporal scales (covenant of mayors, finance sectors), and for CH4 to also reach policymakers, and stakeholders of non-oil and gas related emissions, e.g., landfills, wetlands.

The GHG task team will work with CEOS Agencies and private partners on 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 seeks 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 discussions, further thematic coordination plans may been needed, including those related to ocean carbon.

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

CEOS made significant efforts to inform and support the UNFCCC Global Stocktake (GST) process; to demonstrate the policy relevance of EO satellite data; to plan for dataset inputs for the first and second UNFCCC Global Stocktakes (GST1 in 2023 and GST2 in 2028); and to inform the policy process. Informed by the outcomes of GST1, CEOS will focus on the GST2 process, engaging the appropriate climate stakeholders. To this end, the SIT Chair set two priorities for 2024-2025:

1. Climate Policy Impact – Addressing obstacles and opportunities for CEOS Agency data, particularly AFOLU/Biomass map datasets, to have maximum impact in the key climate policy processes, notably, the successive Global Stocktakes under the Paris Agreement that will occur every five years.
2. Greenhouse Gas Observations from Space - Coordination to address data continuity challenges ahead in support of evolving global and societal needs.

2024: A number of measures are projected regarding the planning and provision of space-based datasets for use in the GST process, including results of the CEOS GHG Roadmap and AFOLU Roadmap activities; related measures recommended by the GST Strategy paper; and GFOI support from the LSI-VC Forest and Biomass subgroup. Specific GST recommendations and deliverables are listed in Section 3.3.

Number	Objective/Deliverable Title	Projected Completion	Responsible CEOS Entity(ies)
CARB-19-02	Phase II R&D Program for GFOI	2024 Q1	LSI-VC F&B Team CEOS GFOI Lead
CARB-20-01	Develop a CEOS AFOLU roadmap including actions for implementation tracking	2024 Q4	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	2025 Q4	WGClimate WGClimate GHG Task Team SIT Chair CEOS GFOI Lead LSI-VC GEOGLAM Team
CARB-20-05	Support and encourage space data uptake in GFOI countries	2025 Q2	LSI-VC F&B Team
CARB-22-01	Production of harmonised biomass products from CEOS Agency missions	2025 Q4	WGCV LPV
CARB-23-05	New Space and GHG product development and standards setting	2024 Q4	WGClimate GHG Task Team
CARB-24-01	Generate Version 2 of GHG Roadmap	2024 Q4	WGClimate GHG Task Team
CARB-24-02	Define interface between CEOS & G3W during its implementation phase	2025 Q2	WGClimate GHG Task Team

CARB-24-03	Implement interfaces between CEOS & IMEO	2025 Q2	WGClimate GHG Task Team SIT Chair
CARB-24-04	Facilitate new stakeholders with GHG data	2025 Q4	WGClimate GHG Task Team SIT Chair WGClimate
CARB-24-05	Create a governance to collaborate across GHG, AFOLU and aquatic carbon roadmap activities	2024 Q4	WGClimate GHG Task Team LSI-VC F&B Team OCR-VC SIT Chair WGClimate

3.3 Observations in support of the Global Stocktake process of the UNFCCC

Article 14 of the 2015 Paris Agreement among the Parties to the UNFCCC stipulates the concept of successive Global Stocktakes (GSTs) 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. CEOS Agencies have coordinated their efforts to support the first GST (GST1 in 2023) and CEOS needs to consider the outcomes of the first GST to inform its planning, decisions, and activities in support of subsequent GSTs (due every five years thereafter).

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, 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-22-02	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.	2024 Q4	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.	2024 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.	2025 Q4	WGClimate WGClimate GHG Task Team
GST-22-07	Establish National Inventory Test User Group and channels for country feedback on CEOS products and their application.	2024 Q4	LSI-VC F&B Team
GST-24-01	Update the CEOS GST Strategy and actions to account for lessons learned from GTS1 and changes in operating context	2025 Q4	SIT Chair WGClimate WGClimate GHG TT LSI-VC OCR-VC

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 warning of crop shortages and failures in countries most at risk for food insecurity.

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

GEOGLAM has published its Earth observation requirements three times, with each subsequent revision adding complexity and precision:

1. **2012**: First version, simplified
2. **2016**: Second version, better representation of variables and new mission capabilities
3. **2019**: A more holistic view of needs beyond acquisition and into accessibility and utilisation. An important component of this is GEOGLAM's Essential Agricultural Variables (EAVs), which are Earth observation-based "building blocks" that in combination with one another or with other non-EO information support actionable, policy-required information on the state, change, and forecast of agricultural land use and productivity. GEOGLAM has learned from the ECVs and also leverages existing

ECVs in meeting its G20+ mandate.

CEOS deliverable AGRI-19-04 reflects the 3rd update, although the second half of the action was not completed ("Production of these EAVs for GEOGLAM will require a long-term coordinated effort between GEOGLAM and the CEOS Working Group Calibration/Validation's Land Product Validation (LPV) subgroup. It is proposed that in 2020 the mechanisms for such a collaboration are characterized.")

GEOGLAM is recommending a "fresh start" and closing out AGRI-19-04 and AGRI-22-04, ("CEOS Response to GEOGLAM Requirements") and better defining the areas of work moving forward. In that vein, GEOGLAM has drafted a White Paper in advance of SIT-39 that aims to spark awareness of a discussion among members of LSI-VC and the CEOS Principals, other Working Groups, and individual agencies to identify a strategic path forward to support GEOGLAM by aligning the conditions for the production of the EAVs as products or by supporting the production of the EAVs themselves (Figure 01).

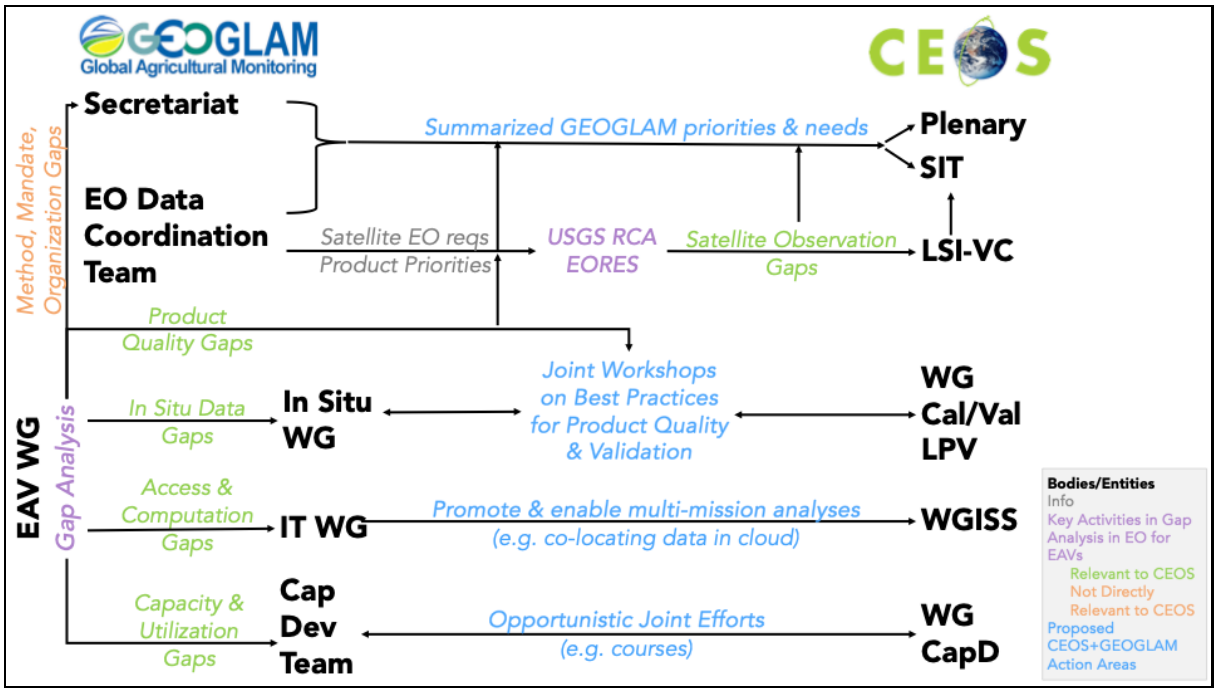


Figure 01: Possible realms of engagement between GEOGLAM and CEOS. There is additional support toward EAV production supported by multiple space agencies individually, already. CEOS involvement in these "realms" would support GEOGLAM success directly and indirectly by ensuring GEOGLAM and individual CEOS agencies are aligned (Figure source: GEOGLAM Programme Scientist Alyssa Whitcraft)

Therefore, the proposed new actions for CEOS related to GEOGLAM are:

1. Identify agency contacts for the LSI-VC Subgroup on GEOGLAM. At present, there is minimal agency representation and engagement in agriculture.
2. Discuss and characterize the role of CEOS Working Groups in supporting GEOGLAM's

implementation of the EAVs. Example areas include, but are not limited to:

a. Assess gaps in satellite Earth observation capabilities in collaboration with CEOS, e.g., **CEOS SEO, MIM Database, USGS-RCA**
b. Identify gaps and opportunities for easing access to and utilization of satellite data in the production of EAVs, e.g., **WGISS.**
c. Assess method status with respect to its quality and scalability/transferability.
d. Assess method quality, develop validation good practices via the GEOGLAM Initiative on Product Quality, e.g., through Community Workshops with **WGCV Land Product Validation subgroup**, one of which occurred in September 2023 around Good Practices for Cropland and Crop Type Mapping Validation, with support from ESA and NASA.
e. Identify the best mechanisms, timelines, and points of contact to increase harmonization between ECVs, EBVs, EAVs, and any other Essential Variables to optimize the value of space agency investments toward coordinated land monitoring.

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

3.5 Observations for Disasters

The CEOS Working Group on Disasters (WG Disasters) 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 of the full cycle of risk management.

The primary objectives of the WG Disasters are:

- To promote new scientific advancements in disaster and risk sciences
- To support the efforts of Disaster Risk Management authorities in protecting lives and safeguarding property through 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")

- 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 2024, the WG Disasters 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, and reinforce the need for enhanced satellite EO programmes to better address Disaster Risk Management (DRM) needs. The WG Disasters has highlighted the importance of moving from technical demonstrations to sustained application of EO for improved risk management. This is demonstrated by the approval by the 2023 CEOS Plenary of two activities born of CEOS WGDisasters demonstrators: G-VEWERS (Global Volcano Early Warning and Eruption Response System) and the pre-operational Recovery Observatory. The move toward a more permanent effort with regard to volcano monitoring and value-added information provision for disaster recovery is a significant step forward.

- Recovery Observatory - Beginning with a transition from a CEOS-led RO to a DRM stakeholder-led RO in 2024, the RO aims to establish 2-4 Recovery Observatories (ROs) globally per year. 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 WG Disasters intends to build on this recognition by engaging new partners to support this critical phase of risk management.
- G-VEWERS - An incremental approach for global monitoring with scalable options for implementation will be presented. As a result, monitoring for volcanoes globally could accelerate, ensuring risk reduction and improved volcano response.

In 2024, final reports are expected from the Wildfire Pilot, the Flood Pilot and the Landslide Demonstrator. In addition, the WGDisasters has kicked off a preparedness pilot in Tonga.

A further new initiative concerning Seismic Risk, including Hazard and Exposure mapping and the generation of products for immediate use by decision makers, will be started in 2024. 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.

The WGDisasters will continue to support the GEO Geohazard Supersites and Natural Laboratories initiative (GSNL) with data and/or resources data hosting or processing (e.g., via the Network of Resources of ESA). GSNL aims at improving the monitoring and management of seismic and volcanic hazards, providing access to new EO data and capacities, especially in developing countries e.g., Africa and the Latin America and Caribbean (LAC) region.

Other GEO activity is described in the EO4DRM initiative. The 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.

- 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 GEO/LEO/SAR Flood Pilot will report on effective best practices and value of data and methodologies shared by pilot team members to CEOS 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 will produce reports in accordance with specified WG Disasters 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	WG Disasters
DIS-20-01	CEOS Contribution to GEO GSNL Initiative for DRR	2024 Q4	WG Disasters
DIS-20-02	GNSL evolution feasibility study	2024 Q4	WG Disasters
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	WG Disasters
DIS-22-01	Flood Pilot with GEO-LEO-SAR “Understanding Flood Risk from Space”	2024 Q4	WG Disasters
DIS-22-04	Wildfire Pilot Final Report	2024 Q4	WG Disasters
DIS-24-01	G-VEWERS – Global Volcano Early Warning and Eruption Response System	2030 Q4	WG Disasters
DIS-24-02	Pre-operational RO	2026 Q4	WG Disasters
DIS-24-03	Tonga Preparedness Pilot	2024 Q4	WG Disasters
DIS-24-04	Data provision to the GEO GSNL initiative	2030 Q4	WG Disasters
DIS-24-05	GEO-GSNL contribution to the WGDisasters	2030 Q4	WG Disasters

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 newly established COASTVC, GEO AquaWatch will leverage and benefit from the CEOS Earth Analytics Lab (EAL; previously named the CEOS Earth Analytics Interoperability Lab) 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 good 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 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.

2024-2026: 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 is conducting a study 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 has also identified 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. The first progress meeting was held in January 2024 with CNES and JPL, the partnering agencies. They have committed to providing input data to the study from La Crau and Lake Tahoe sites respectively. There will be several deliverables during the study that will take approximately 18 to 24 months depending on progress and data availability. The most relevant deliverable would be the final report, constituting the roadmap towards an operational TIRCalNet, expected in 2026.

In the context of Synthetic Aperture Radar (SAR), the SARCalNet initiative aims to promote standardised SAR calibration and facilitate the harmonised implementation of cal/val tasks by a broad SAR community. It is crucial to have a network of curated calibration sites for SAR and well-established cal/val procedures. A team representing many SAR mission agencies has been working on documents to establish the requirements for SARCalNet. These documents include guidelines for artificial and natural targets; recommended minimum analysis of the imagery; as well as a handbook describing SARCalNet submission protocols and procedures. A subcommittee of users will actively curate the reference target submissions and produce an annual summary report. Calibration sites and targets might receive different levels of endorsement (and associated labels) depending on the completeness of provided information. Access to the SARCalNet website is currently restricted to the SARCalNet community for the testing phase and the calibration sites and targets database is evolving and populating.

There is a growing number of public and commercial providers offering high-resolution space-borne Earth observation data. To effectively utilise this data, it is important to understand its characteristics, calibration methods, and quality and technical capabilities. Interoperability between satellites and products will expand 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 will continue supporting New Space through its active participation in VH-RODA and JACIE workshops, as well as direct involvement through its various subgroup initiatives.

In 2024, WGCV will conduct pilot assessments for assessing cal/val measurements as Fiducial Reference Measurements (FRMs) based on the FRM assessment framework that has been developed and is made available on the CEOS Cal/Val Portal. 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 results of the pilot assessment will be discussed at the 2024 WGCV Plenary and will be published on the CEOS Cal/Val Portal.

The WGCV will continue to provide a framework for performing intercomparison exercises. The intercomparison frameworks have demonstrated to be successful and useful. ACIX – intercomparison of atmospheric correction scheme – is evolving towards hyperspectral using PRISMA and EnMap data. CMIX - Cloud Masking scheme intercomparison – is progressing with improvement in the validation approach using the SkyCam – ground-based sky camera network for validation on satellite-derived cloud masks. DEMIX - DEM intercomparison and impact on orthorectification process - is close to finalisation, a peer-reviewed publication has been submitted and the final report is expected in 2024. DEMIX will evolve toward GCPix aiming at providing and comparing GCP (Ground Control Point) for high resolution sensors. SRIX4VEG - Intercomparison of Surface reflectance for vegetation – the results have been presented at the 2023 November Workshop. SRIX4VEG II campaign was held in Australia in March 2024. Supported by the ACTRIS-CREGARS Research Infrastructure and under the auspices of the Network for the Detection of Atmospheric Composition Change (NDACC) the Third Cabauw Intercomparison of DOAS-like Instruments (Differential Optical Absorption Spectroscopy) with external referee (CINDI-3) will take place in the Netherlands in May-June 2024 with community-wide field intercomparison and certification of MAX-DOAS instruments, complemented by mobile-DOAS and airborne data (variability and tomography), PGN/Pandora, and a range of aerosols, ozone and other trace gases measurements. Finally, a match-up database for radiometric quality assessment is being developed that will support the quality assessment from New Space.

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

2024-2026: 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 held on 19-22 November 2024. This workshop aims to review and assess requirements against current and future application needs as well as consider innovations in state-of-the-art calibration and characterisation methods and facilities. The conclusions drawn from the workshop will lead to the publication of a CEOS WGCV and CGMS-GSICS guidance document, proposing minimal/desirable characterisation requirements and the means (methods/facilities) to achieve them for various application and instrument types. The guidance will extend to consider optimum ways to document and report calibration and characterisation information, including the associated uncertainties and traceability to International System of Units (SI)[3], in a manner that facilitates transparency to all stakeholders in a standardised manner. The guidance document, expected to be published within a year of the workshop, will primarily focus on the solar reflective domain and may include an appendix section related to the thermal infrared (TIR) domain.

Furthermore, a joint task team between WGCV and GSICS has been established to coordinate and ensure interoperability of the forthcoming SI-Traceable Satellites (SITSats). SITSats are envisioned 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 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, which assessed the benefits and requirements of a space-based climate observing system, summarising current measurement capabilities, climate-based needs, and future implementation plans. The SITSat Task team will develop a dedicated webpage on the CEOS Cal/Val Portal for SITSats. A prototype of this webpage is planned to be ready by 2024 to enhance collaboration and information dissemination within the community.

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

[3] The International System of Units, internationally known by the abbreviation SI (from French Système international d'unités), is the modern form of the metric system and the world's most widely used system of measurement.

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	2025 Q4	WGCV
CV-17-01	L1 top-of-atmosphere interoperability	2025 Q4	WGCV
CV-20-01	Surface Reflectance measurements Intercomparison exercise for vegetation (SRIX 4Veg)	2024 Q4	WGCV
CV-20-03	DEMIX	2024 Q1	EC ESA
CV-22-01	Validation protocols for atmospheric aerosol and cloud profiles	2024 Q1	WGCV ACSG
CV-22-02	CEOS Terms and Definitions Wiki	2024 Q4	WGCV
CV-23-01	Develop an FRM Assessment Framework	2024 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	2026 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
CV-24-01	Third Cabauw Intercomparison of DAOS-like Instruments (CINDI-3)	2025 Q1	WGCV ACSG
CV-24-02	Good Practices Protocol on Land Cover	2024 Q3	WGCV LPV
CV-24-03	Good Practices Protocol on Vegetation Indices	2024 Q3	WGCV LPV

3.8 Capacity Building and Data Democracy

The CEOS Working Group for Capacity Building and Data Democracy (WGCapD) 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 EO 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.

In 2024 the WGCapD will continue to increase its efforts at the global, regional and national level by building upon activities carried out in 2023. This will be done by delivering training 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 disaster, environmental and sustainability agendas. New resources will be made available on the WGCapD webpages. The WGCapD annual meeting will be held online. 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; this work includes expanding on the flood tools tracker and the work done in the EOTEC DevNet Floods working group.

2024-2026: 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.

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

1. For **global work**:
   - Focus on online learning through e-learning, MOOCs, webinars, challenges 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.
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.
3. For **national work**:
   - Support national training where fitting.
   - Strengthen our understanding of national needs in other thematic areas.
   - Strengthening inclusiveness and support to underrepresented communities.
4. For **infrastructure**:
   - Enablers, with a focus on sharing of best practices and resources, convening key stakeholders, and addressing user needs.
   - Joint work with WGISS.

Number	Objective/Deliverable Title	Projected Completion	Responsible CEOS Entity(ies)
Global Deliverables GEO to strengthen AmeriGEO and AfriGEO through training contributions at their respective meetings/workshops.			
CB-22-07	Open Source Science Outreach Plan and Training	2024 Q4	WGCapD
CB-23-03	Guidance Document for Conducting Needs Assessments for Capacity-Building	2024 Q3	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	2024 Q4	WGCapD a self-sustaining phase.
CB-23-08	Recommendations on learning objects joint repositories and metadata standards for learning objects	2024 Q2	WGCapD
CB-24-01	ESA/NASA Trans-Atlantic Training 11	2024 Q2	WGCapD
CB-24-02	ESA/ISRO PolSAR Training	2024 Q4	WGCapD
Regional Deliverables			
CB-20-21	Copernicus User Uptake in Africa	2024 Q4	WGCapD
CB-22-08	Copernicus training of trainers in Africa	2024 Q4	WGCapD
CB-23-05	Digital Earth Africa online courses: Water resources (English and French), Agriculture (English, French)	2024 Q4	WGCapD
CB-24-03	Engage & empower South African youth to use EO for Economic Empowerment	2025 Q1	WGCapD

Number	Objective/Deliverable Title	Projected Completion	Responsible CEOS Entity(ies)
National Deliverable			
Infrastructure Deliverables			
CB-20-07	Best Practice Guide to E-Learning	2024 Q2	WGCapD
CB-22-10	Sentinel Selected Applications: practical training with Jupyter Notebooks on the ESA EO Platform	2024 Q4	WGCapD
CB-22-12	EOTEC DevNet Multi-Stakeholder Network Analysis	2024 Q4	WGCapD
CB-22-14	EO Capacity Building Curriculum	2024 Q2	WGCapD
CB-22-15	Third Vietnam School of Earth Observation (VSoEO 3)	2024 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 external entities such as 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 the adoption of supported WGISS standards e.g., Open Geospatial Consortium (OGC), 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 is concerned with ensuring data users have easy and efficient ways of discovering and accessing data and associated services through the exploitation of standard protocols and the harmonizing of search and data retrieval processes.

The Interest Group will evaluate the possibility of defining a guideline/best practice for the Spatio Temporal Asset Catalog (STAC) at CEOS level and facilitate discussions on STAC integration with other CEOS groups including LSI-VC and the ARD-OG, as well as participate with external groups discussing STAC including OGC. With increased requests for a federated collaborative environment to access data and services, the Interest Group intends to explore scenarios for a federated authentication and authorization 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.

The Interest Group will begin developing a white paper on EO data collections management and governance that will address topics including management of data collections in the cloud, preservation of collections, reproducibility of previous collections versions (algorithm availability), cross-collection validation, and general interoperability and governance approaches. The Interest Group will also begin development of a white paper to address and recommend techniques to ensure preservation and reusability of software tools related to EO missions.

The WGISS Technology Exploration Interest Group will survey cutting-edge technologies related to EO. Survey results will be summarised and issued as guidelines and best practices. The “Jupyter Notebook Best Practices” will be issued in 2024 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 also in 2024.

An interoperability framework for the CEOS community is essential due to the importance of EO data in a wide range of applications, including agriculture, climate change monitoring, disaster management, and urban planning, as well as the increasing cooperation of public and commercial space actors worldwide to meet this demand. As a result, the need for interoperability of EO, and more broadly geospatial, data and related information systems has become more critical than ever before.

The WGISS Data Interoperability and Use Interest Group was re-initiated in 2023 and developed a CEOS Interoperability Framework and initial Roadmap. In collaboration with various CEOS entities, the Interest Group will continue to evolve the roadmap and develop

an Interoperability Handbook 2.0, which will lead to increased interoperability maturity for EO data.

Number	Objective/Deliverable Title	Projected Completion	Responsible CEOS Entity(ies)
DATA-22-01	Jupyter Notebook Best Practice	2024 Q4	WGISS
DATA-22-05	Feasibility Study for Common Guidelines for the STAC Implementations	2024 Q3	WGISS
DATA-23-01	AI/ML White Paper	2024 Q4	WGISS
DATA-24-01	White Paper on EO Data collections management and governance	2025 Q1	WGISS
DATA-24-02	White paper on Software preservation	2025 Q2	WGISS
DATA-24-03	CEOS Interoperability Handbook 2.0	2025 Q4	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.

2024-2026: 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.

The harmonization of tropospheric ozone datasets (VC-20-01) is progressing well. The achievements of the ongoing community effort Tropospheric Ozone Assessment Report, Phase II (TOAR-II, 2020-2024) were presented at a workshop in Q4 2023 and are being published in the TOAR-II Community Special Issue (ACP/AMT/BG/GMD inter-journal). The validation and harmonization of products from the air quality missions in orbit in particular TEMPO, GEMS and S5P/TROPOMI is progressing well. A joint Announcement of Opportunity Call for the validation of products from the future Sentinel-4 and Sentinel-5 will be released in spring 2024. While the validation efforts will continue, the parent Action VC-20-02 (validation coordination) and its children VC-20-03 (validation plans) and VC-20-04 (announcements of opportunity) can be closed. A review of the recommendations from the

whitepaper on validation needs of the geostationary air quality constellation (Geo-AQ) has been initiated. The PM2.5 whitepaper is being followed up (VC-20-05). A roadmap is in the making with a roadmap pursuing the whitepaper recommendations and a presentation of use cases. 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. The next AC-VC meeting will be held in the second half of 2024. In 2024, AC-VC would also like to initiate a new white paper related to the remaining gaps in the geostationary ring of air quality satellites, in particular the lack of hourly satellite air quality observations over Africa and South America.

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. In 2024, LSI-VC aims to improve the discoverability and accessibility of CEOS-ARD by publishing a new CEOS-ARD STAC extension and to increase community participation and transparency with a new CEOS-ARD GitHub repository.

LSI-VC is also a key contributor to the CEOS-ARD Oversight Group, the CEOS-ARD Strategy (being updated in 2024), and the OGC ARD Standards Working Group, which will use CEOS-ARD as a basis for broader geospatial ARD standards.

In 2024, LSI-VC aims to host its first workshop to engage with the commercial sector on CEOS-ARD and other land surface imaging topics. This is planned to take place in Tokyo, Japan, alongside LSI-VC-15 and will focus on the Japan's commercial EO sector.

LSI-VC also continues its work on land surface imaging gap and requirement analyses, with a focus on agriculture and forests (noted below, led by the LSI-VC subgroups) as well as new activities in collaboration with WGClimate on Land Surface Temperature Climate Data Records and the Space Agency Response to the GCOS Implementation Plan.

Following the endorsement of the CEOS AFOLU Roadmap in 2023, the LSI-VC Forests and Biomass Subgroup now turns its attention to defining specific actions to implement the Roadmap and achieve the 2035 observing system required to address the AFOLU information needs of society.

The LSI-VC GEOGLAM (agriculture) Subgroup will serve as the forum for a CEOS response to the updated GEOGLAM observation requirements that are driven by the Essential Agricultural Variables (EAVs). The subgroup will seek to explore how the operational products required to achieve the agricultural monitoring ambitions of GEOGLAM might be met with the support of CEOS Agencies.

III. P-VC

The CEOS Precipitation Virtual Constellation (P-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, 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 (rainfall and snowfall) 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).

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. 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 will look for areas to collaborate with the newly proposed COAST-VC, ensuring no overlap in work, with the SST-VC focusing on user needs and mission requirements of very and ultra-high resolution SST in coastal and high-latitude regions. The

SST-VC will intend to expand participation to the team from the CEOS members by seeking additional engagements.

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.

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.

OCR-VC activities for 2024 will focus on continuing the development of the Aquatic Carbon roadmap. Carbon-related activities include the Blue Carbon Workshop taking place early in 2024, whose outputs will feed into the roadmap. The OCR-VC will continue to contribute to the Aquatic Reflectance Product Family Specification for CEOS-ARD to extend it to all water types including seas and open oceans. Finally, in 2024, capacity building will continue to provide new resources and training to users.

OCR-VC activities for 2025-2026 will include the continuation of developing a coordinated multi-mission basis for OCR cal/val, including System Vicarious Calibration (SVC) infrastructures and protocols for bio-optical in situ measurements, as well as collect and synthesize feedback from users through the International Ocean Colour Symposium (IOCS) being held in 2025.

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).

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

VC-20-03	Air quality constellation validation coordination: validation plans	2026 Q2	AC-VC WGCV
VC-20-04	Air quality constellation validation coordination: announcements of opportunity	2026 Q4	AC-VC WGCV
VC-20-10	CEOS–Industry ARD Workshop	2025 Q2	CEOS-ARD OG LSI-VC SIT Chair
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-22-04	Mission continuity timelines for land domain CEOS-ARD PFS	2024 Q4	LSI-VC
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-23-05	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-23-08	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	2024 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
VC-24-01	CEOS-ARD Strategy 2024 Implementation	2026 Q4	CEOS-ARD OG LSI-VC
VC-24-02	CEOS-ARD Github Repository	2024 Q4	CEOS-ARD OG LSI-VC
VC-24-03	CEOS-ARD STAC Extension (Optical)	2025 Q4	CEOS-ARD OG LSI-VC
VC-24-04	CEOS-ARD STAC Extension (SAR)	2025 Q1	CEOS-ARD OG LSI-VC
VC-24-05	CEOS AFOLU Roadmap Actions Supplement	2024 Q3	LSI-VC F&B Team
VC-24-06	List of POLINSAR Reference Sites	2024 Q4	LSI-VC
VC-24-07	Establishment of POLINSAR data repository	2024 Q3	LSI-VC
VC-24-08	Coordination with Agency PoCs, incl. tasking of new polarimetric observations and requests for archived data	2025 Q1	LSI-VC

3.11 Observations in support of the United Nations Sustainable Development Goals

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 U.N. Sustainable Development Goals (SDGs). The **CEOS SDG Coordination Group (CEOS SDG CG)**, consists of representatives from the CEOS Strategic Implementation Team (SIT) Chair, the CEOS Systems Engineering Office (SEO), the CEOS Executive Officer (CEO), and other key members from the former SDG *ad hoc* Team. The CEOS SIT Chair provides strategic oversight to the Coordination Group, while the CEOS Systems Engineering Office (SEO) provides coordination and implementation leadership. The SEO coordinates SDG deliverables and work plan activities by liaising with all 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 existing groups (WG, VC, AHT), and SDG-related GEO Work Programme activities.

The SDG Coordination Group continued to focus its activities on four SDG indicators: 6.6.1 on water extent, 11.3.1 on urbanization, 14.1.1 on coastal eutrophication/marine pollution, and 15.3.1 on land degradation. It continues to provide support to UN custodian agencies and other strategic partners, by analyzing satellite data requirements and supply for key indicators upon request, and liaising with other CEOS groups (capacity building, ARD strategy, EO-enabling infrastructure, etc.) to harness CEOS collective expertise and maximize benefits for the CEOS Agencies and for the SDG stakeholder community.

2024-2025:
At the 2023 CEOS Plenary in Chiang Rai, Thailand, the SDG Coordination Group held a face-to-face side meeting to review the status of 2023 deliverables and planned activities for 2024. The SEO subsequently reported on status of SDG activities and planned deliverables for 2024, which include engagement with Pacific Island Countries and Territories (PICTs) through the SPC (Pacific Community).
At three face-to-face meetings held in 2023, the SDG Coordination Group reviewed its progress and presented to CEOS members, confirming the need for a coordinating body to ensure that CEOS provides satellite data expertise to stakeholders including UN custodian Agencies (e.g., UNEP on water extent, UNCCD on land degradation, etc.), and GEO which is focused on transitioning to implementation of the GEO Post-2025 Strategy. Following last year's feedback, the SDG Coordination Group further engaged with other CEOS bodies (WGCapD, Ecosystem Extent, WG Climate) to ensure it promotes SDG efforts and leverages existing expertise across the CEOS organisation. In this context, the the SDG Coordination Group agreed to maintain proposed activities for end-users, while exploring other activities

aligning with CEOS strategic priorities and responding to external requests. In 2024 and beyond, the SDG Coordination Group will:

- Ensure continuity with:
    - **EO Support Sheets Review**: as key CEOS technical resources useful for SDG stakeholders, the first versions of these four documents (4 Indicators) were published on the SDG website in 2022. Three out of four were reviewed late 2023, with the one on 15.3.1 granted an extension until 2024 to align with the UNCCD and GEO LDN reviewing processes. In 2024, the SDG Coordination Group will request another annual review to CEOS experts, so that users can refer to it and meet their needs. These updates will consider new missions, tools and resources relevant to SDGs.
    - **Broad contributions to SDGs/Communications:** the SDG webpages and CEOS social media will be updated and rearranged to reflect the current activities undertaken by the group. The Group will continue its effort to call out for inputs to other CEOS bodies to promote CEOS work on SDG in CEOS communications.
- Improve Outreach and Coordination:
    - Internal:
        - WGCapD: the Group has started to re-engage with new leadership including with WGCapD, and facilitated external connections (UNESCAP) to increase SDG capacity building support
        - Ecosystem Extent Task Team: the Group will continue to explore opportunities to address 2024 CEOS Chair priority (Biodiversity) with the Ecosystem Extent Task Team
        - The Group will assess which CEOS work activities support SDGs and identify them as part of the online tool. Propose identification of SDG indicator-level support of relevant CEOS work activities in the 2025 work plan.
        - The Group will continue to call for inputs and ideas from other CEOS bodies to maximize our impacts
    - Communications: the Group will review and propose new communications material, as needed, to promote upcoming SDG work (e.g., EO support sheets)
    - External:
        - United Nations Global Geospatial Information Management (UN-GGIM) 'Rescuing the SDGs' Paper: the Group has agreed to co-author and contribute to a UN-GGIM-led paper to highlight the value of using EO data and help accelerate the UN SDG delivery process. By doing this, the Group aims to better position CEOS and international satellite data providers to influence future policy frameworks beyond 2030.

- Respond to external requests and refine specific data needs:
    - **GEO LDN Task**: the GEO Land Degradation Neutrality Flagship works closely with UNCCD (UN Convention to Combat Desertification), and requested CEOS help to address specific needs with regards to satellite data and decision tree documentation (see the Good Practice Guidance).
    - Future work associated with other SDG indicators will be considered through normal CEOS governance processes: *CEOS External Requests Process Paper* and *CEOS New Initiatives Process Paper*.
    - Continue CEOS engagement with **Small Island Developing States** (SIDS) including **PICTS**: following an Open Data Cube application for SDG deliverables which demonstrates how CEOS tools and services can directly support the SDGs (not necessarily at the indicator level), as well as with refining their satellite data requirements through the Digital Earth Pacific project and GEO Pacific Islands Advisory Group PIAG, the CEOS SDG Coordination Group (through SEO and CEO) will continue to explore opportunities and support regional and country sustainability efforts to achieve their goals, beyond the indicators level (Global SDG Indicators Framework).

2025- 2026:
Additional ideas and activities are being discussed, but require further strategic and resources refinement. If CEOS aims to support GEO and its members to improve the use of EO satellite data in the SDG Framework, and continue to offer its expertise to UN Agencies (see the two engagement papers shared with GEO, 2022), CEOS Principals need to allocate appropriate resources.

This includes exploring ways to support and deliver a **Wetland inventory;** 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); and opportunities to collaborate with **New Space** (potential future demonstration project targeted on SDGs (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, or Radar data in other regions, etc.).

Finally, the CEOS SDG Coordination Group will maintain awareness of evolving United Nations activities to develop a follow-on global policy framework that will address global sustainable development post-2030. The value and impact of Earth observations must be integrated early in this process as foundational information, rather than the 'non-traditional data' status it holds currently in the existing county-owned, country-led SDG reporting process.

Number	Objective/Deliverable Title	Projected Completion	Responsible CEOS Entity(ies)
SDG-23-04	EO Support sheet for SDG Indicator 15.3.1 (Land degradation) 2024 Review	2024 Q4	CEOS SDG Coordination Group
SDG-23-05	GEO-LDN Land Degradation Neutrality (LDN) Task	2024 Q2	CEOS SDG Coordination Group
SDG-24-01	EO Support sheet for SDG Indicator 6.6.1 (Water) 2024 Review	2024 Q4	CEOS SDG Coordination Group
SDG-24-02	EO Support sheet for SDG Indicator 11.3.1 (Urbanization) 2024 Review	2024 Q4	CEOS SDG Coordination Group
SDG-24-03	EO Support sheet for SDG Indicator 14.1.1 (Marine Pollution) 2024 Review	2024 Q4	CEOS SDG Coordination Group
SDG-24-04	UN-GGIM IAEG-SDGs WGGI Paper: Rescuing the SDGs	2024 Q3	CEOS SDG Coordination Group
SDG-24-05	UNCCD Support: Land Cover Suitability for SIDS	2024 Q4	CEOS SDG Coordination Group

3.12 Support to Other Key Stakeholder Initiatives

I. Continue CEOS contributions to UN Ocean Decade and maintain leadership role in the GEO Blue Planet Initiative.

2024-2025: CEOS Agencies will continue to develop and distribute experimental and operational data, products and services, undertaken within the CEOS COAST Virtual Constellation, including contribution to the UN Ocean Decade (IOC). Both activities include linkages with GEO Blue Planet, and likewise continue 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 use.

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

2024-2025: At the 2022 CEOS Plenary, the Ecosystem Extent Task Team (EETT) was formed for a two-year duration to assess the utility of mapping Ecosystem Extent using current and New Space EO available in the next 10 years. As a forum for national and international organisations focused on space-based EO, CEOS is uniquely positioned to explore how data products from these missions can support user needs for mapping ecosystem extent. CEOS assistance can include coordinating space agency activities on using mission capabilities to support and enhance the measurement, monitoring, and understanding of biodiversity from space.

At the 2023 CEOS Plenary, the EETT delivered a White Paper that provides an integrated international perspective on how space-based EO can be used to support ecosystem mapping and monitoring with a focus on ecosystem extent. In 2024, a science journal version of the white paper will be developed to present and publish some of the white paper concepts in more detail for a biodiversity science audience, Earth scientists, and other audiences that help to inform policy making and the public.

Further development of a demonstrator on the use of EO for ecosystem extent mapping and monitoring will continue in 2024 for delivery at the CEOS Plenary on 22-24 October 2024, in Montreal, Canada. The Hudson's Bay Lowlands demonstrator being developed by Environment and Climate Change Canada will utilize the CEOS Analytics Lab and focus on Wapusk National Park. Work will continue on a recent CNES-funded project on the use of EO for ecosystem monitoring in Costa Rica, and a recently funded CSIRO project focused on Australia's Great Western Woodlands will begin. All three of these projects will be developed around data cubes that, among other advantages, will simplify combining data from different types of sensors and data sources, including in situ data.

In December 2022, the Parties to the Convention on Biological Diversity (CBD) agreed to the Kunming-Montreal Global Biodiversity Framework (KMGBF), which identifies the CBD's Goals and Targets for the next decade and beyond. A key component of the KMGBF is its Monitoring Framework which includes specific indicators, many of which are directly or indirectly dependent on space-based EO data products. Ecosystem extent is one such indicator; others include ecosystem condition, invasive species, and ecosystem services. While the KMGBF does not identify all of the information needed to assess and protect biodiversity, it does provide a policy context that CEOS can use as it evaluates approaches for a sustained and enduring CEOS contribution in the biodiversity area--a priority proposed by the incoming 2024 CEOS Chair that was endorsed by the 2023 CEOS Plenary in Chiang Rai, Thailand. Another key input to CEOS in this regard is the United Nations System of Environmental Economic Accounting (UNSEEA), which has identified Ecosystem Extent, Ecosystem Condition, and Ecosystem Services as three of its ecosystem accounts. The biodiversity area has a variety of ongoing activities in addition to the more specific ones outlined above for 2024. These are discussed next.

Essential Biodiversity Variables (EBVs) are a collection of 21 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 such as those identified in the KMGBF and other international conventions. Although space-based EO can play a primary role in many EBVs and a supportive role in most of them, the value of space-based EO for EBVs and many other important products is not yet fully exploited. Utilizing the full potential of space-based EO will take time and involve advancement in several areas including:

- More complete integration with in situ data
- Increased incorporation of space-based EO by the biodiversity community of practice, much of which has traditionally focused mainly or exclusively on in situ measurements

- More higher-level, value-added data products such as EBVs and indicators
- Easy-to-use tools so that greater numbers of data users in the biodiversity community can access and utilize space-based EO and derived products
- Outreach to and capacity building for the broader biodiversity community

Another relevant and important activity undertaken by GEO BON and partners is the continued enhancement of the "BON-in-a-Box" toolkit. By facilitating access to and utilization of products, as well as enabling a generation of value-added products, this toolkit addresses several of the above areas. Significantly, it also provides a sustainable, open source home for product algorithms that agencies might develop, either in-house or via third parties, such as universities. This approach would help address the very limited availability of EO-based higher-level products from Earth observing missions. International dialogue on an ambitious concept for a global observation system for biodiversity will continue. This concept is perhaps roughly analogous to the WMO Integrated Global Observing System (WIGOS) and space-based EO will play a key role in any such global system.

III. CEOS Coastal Observations, Applications, Services and Tools Virtual Constellation

The COAST (Coastal Observations, Applications, Services and Tools) virtual constellation (VC) 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, and WGISS, and calibration/validation). The COAST VC 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 use 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 Programme and high visibility activities such as the UN Decade of Ocean Science for Sustainable Development (2021-2030).

In 2023 the COAST AHT successfully released a public version of the Application Knowledge Hub (AKH), held a successful 90-minute Product Demonstration Side Event during the SIT Technical Workshop on October 17th 2023, and advanced several new products in pilot regions. The end of the ad hoc team term arrived, and to continue progress permission was granted by CEOS during Plenary 2023 to begin the transition of COAST into a virtual constellation, requiring a final implementation plan and Terms of Reference documents to be approved during SIT-39. In February 2024, CNES agreed to become the third co-lead for COAST, joining ISRO and NOAA who have committed to serve through 2025.

2024-25: 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 finalize a COAST-VC Implementation Plan draft, and recommence activities. New Products in the Blue Carbon thematic area and Arctic Pilot regions are expected (contingent on funding availability). Potential collaborations with other VCs and WGs are planned, as well as external partners like COAST Predict (an endorsed

programme) in support of our UN Ocean Decade activities. Demonstration Side Events during SIT TWs are planned to continue as a way to showcase CEOS COAST progress.

V. 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 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. This one-year effort of the NSTT was open to representatives of all CEOS Members and Associates who were then free to consult within their respective communities to bring forward observations and ideas. Additionally, the leads of the various CEOS entities (Working Groups, Virtual Constellations, and Ad Hoc Teams) were consulted in order to assess the potential for existing CEOS initiatives to better address the potential of the New Space sector and to consider what else might be done in the context of their work.

The following recommendations were put forward to CEOS Principals:

1. In view of augmenting the scientific and operational potential of long-term, institutional programmes, CEOS Members and Associates should act collectively in using the CEOS mechanisms to identify and support potential complementary capabilities enabled by New Space and other commercial actors.
2. CEOS Members and Associates should strive to continue to share information on

relevant events and activities related to New Space, including commercial data evaluation results when possible. CEOS Agencies should also investigate ways to work together on cooperation agreements with New Space actors possibly including common lines to take on end-user license agreements and Intellectual Property Rights (IPR) issues.

3. Cooperation and collaboration opportunities should be sought to facilitate interoperability between private and public sector data and future CEOS SIT Chairs are encouraged to routinely provide the opportunity for CEOS Members and Associates to report on developments in the standards domain, be they from public or private sources, at future SIT Technical Workshops.

The NSTT reached the end of its mandate at the 2023 CEOS Plenary. Whilst there is now no dedicated team responsible for this, it was agreed by CEOS Principals that it would be important to keep the topic on the CEOS agenda and the specific actionable outcomes to be noted within this 2024-2026 CEOS Work Plan. These are referred to in the table below as "OUT-" deliverables.

Number	Objective/Deliverable Title	Projected Completion	Responsible CEOS Entity(ies)
OUT-24-01	Explore engagement opportunities with the commercial sector to discuss topics such as: ARD, data interoperability between mission and between innovation cycles, data policy/data sharing, Cal/Val, continuity of data streams	2024 Q4	CEOS Chair SIT Chair
OUT-24-03	Unify CEOS engagement with the commercial sector at key meetings with respect to ARD and Cal/Val	2026 Q4	CEOS-ARD OG
OUT-24-04	Revise the CEOS-ARD Industry Engagement Strategy	2024 Q4	CEOS-ARD OG
OUT-24-05	Ensure that legacy and new public and commercial datasets can be used more interoperably	2024 Q4	WGISS
OUT-24-06	Integrate New Space data into the CEOS Analytics Lab	2024 Q4	SEO
BON-23-02	Ecosystem Extent Demonstrator	2024 Q4	EETT
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	2024 Q4	COAST

3.13 CEOS Services

This section describes services provided by CEOS to the international Earth observation community. These are ongoing functions, that 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 Agency Datasets

Full representation and accessibility of CEOS Agency 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, all CEOS Agencies must 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, All CEOS Agencies and Entities

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 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

I. 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 climatemonitoring.info.

Completion date is recurrent: Q4 every year from 2019 onward.

Responsible CEOS Entity: WGClimate

II. 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

III. 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

IV. Space Agency Statement to UNFCCC/SBSTA

The WGClimate Chair drafts the annual "Space Agency 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

V. 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 programmes 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

VI. Publish the CEOS Newsletter

CEOS, through contributions of JAXA, will continue the publication of this valuable, longstanding 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

VII. 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

VIII. 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