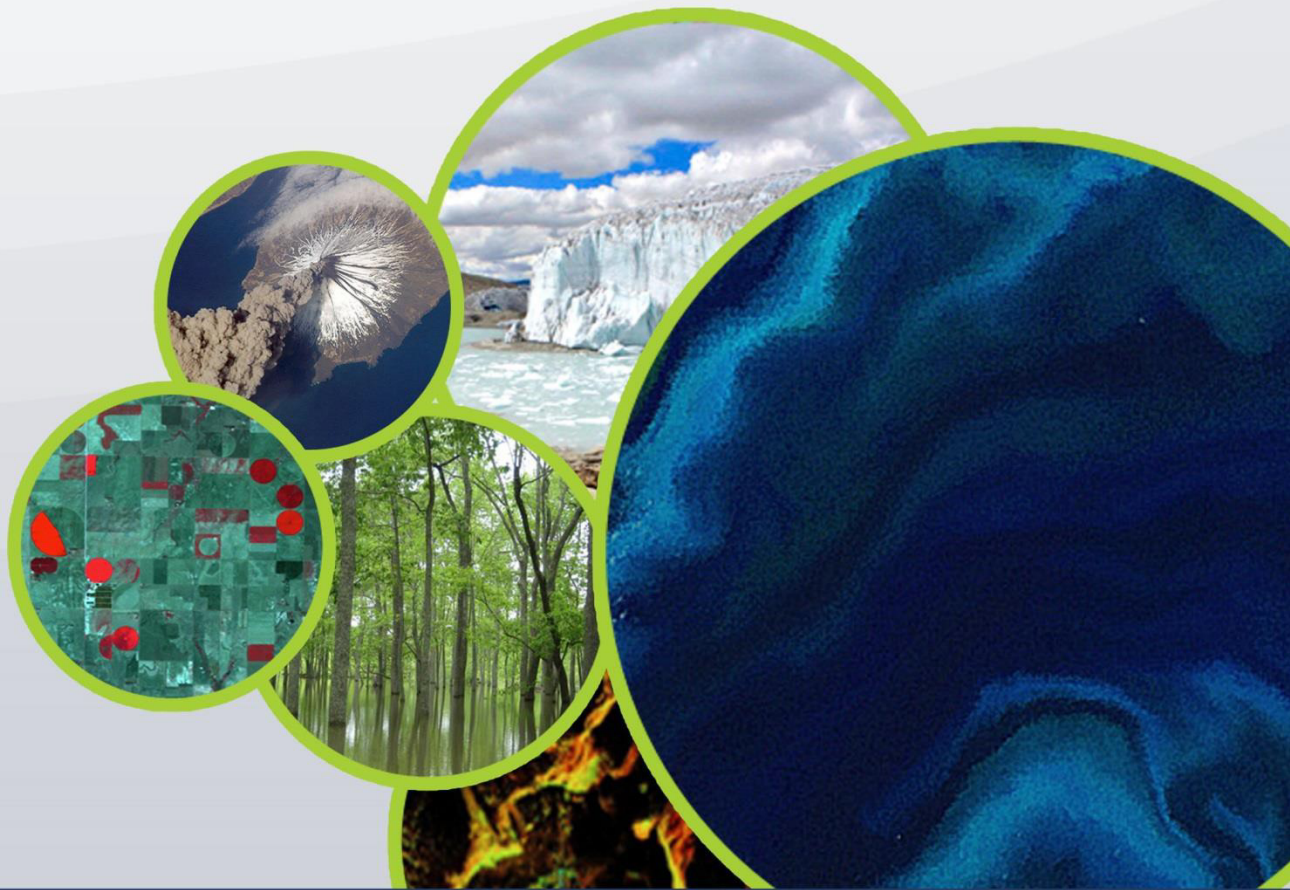




Committee on Earth Observation Satellites



# 2022-2024 Work Plan

March 2022 v1.0

## Contents

Acronyms .....	2
1. Introduction and Overview .....	3
2. CEOS Priorities .....	4
3. Expected Outcomes for 2022-2024 .....	6
3.1. Climate Monitoring, Research, and Services .....	7
3.2. Carbon Observations in support of Climate Science and Policy .....	8
3.3. Observations in Support of the Global Stocktake of the UNFCCC .....	11
3.4. Observations for Agriculture .....	14
3.5. Observations for Disasters .....	16
3.6. Observations for Water .....	18
3.7. Data Quality .....	19
3.8. Capacity Building and Data Democracy .....	20
3.9. Data Discovery, Access, Preservation, Usability and Exploitation: approaches, systems, tools and technologies .....	22
3.10. Advancement of the CEOS Virtual Constellations .....	23
3.11. Support to Other Key Stakeholder Initiatives .....	27
3.12. CEOS Services .....	32

## Acronyms

CEOS	Committee on Earth Observation Satellites
UN	United Nations
GEO	Group on Earth Observations
CGMS	Coordination Group for Meteorological Satellites
CEO	CEOS Executive Officer
SIT	CEOS Strategic Implementation Team
SEC	CEOS Secretariat
SEO	CEOS Systems Engineering Office
WG	CEOS Working Group
VC	CEOS Virtual Constellation
WGCV	CEOS Working Group on Calibration and Validation
WGCapD	CEOS Working Group on Capacity Building and Data Democracy
WGClimate	Joint CEOS – CGMS Working Group on Climate
WGDisasters	CEOS Working Group on Disasters
WGISS	CEOS Working Group on Information Systems and Services
AC-VC	CEOS Atmospheric Composition Virtual Constellation
LSI-VC	CEOS Land Surface Imaging Virtual Constellation
OCR-VC	CEOS Ocean Colour Radiometry Virtual Constellation
OSVW-VC	CEOS Ocean Surface Vector Winds Virtual Constellation
OST-VC	CEOS Ocean Surface Topography Virtual Constellation
P-VC	CEOS Precipitation Virtual Constellation
SST-VC	CEOS Sea-Surface Temperature Virtual Constellation
COAST AHT	CEOS Coastal Observations Applications Services and Tools <i>ad hoc</i> Team
COVERAGE	CEOS Ocean Variables Enabling Research and Applications for GEO

## 1. Introduction and Overview

The *2022-2024 CEOS Work Plan* has been developed by the CEOS Executive Officer (CEO) under direction of the CEOS Chair (Centre National d'Etudes Spatiales [CNES]), in consultation with the CEOS Strategic Implementation Team (SIT) Chair (European Space Agency [ESA]), CEOS Secretariat (SEC), CEOS Working Groups (WGs), CEOS Virtual Constellations (VCs), CEOS *ad hoc* Teams, the CEOS Systems Engineering Office (SEO), CEOS Agencies at large, and external stakeholders.

The purpose of this document is to present near-term objectives and deliverables identified by CEOS in support of the mission and goals outlined in the *CEOS Strategic Guidance* document. It includes a description of CEOS activities to be executed in the current calendar year (2022) and summarises anticipated activities for the subsequent two years (2023-2024). Additional documents contributing information to this plan are located on the CEOS website (<https://ceos.org/>) and include: the *2021-2023 CEOS Work Plan*; the terms of reference for the CEOS Virtual Constellations and Working Groups; and several thematic observation strategies adopted by the CEOS Plenary. This Work Plan is revised annually as current activities are completed, planned activities are executed, and new initiatives are projected. However, many of the priorities and activities outlined herein are expected to remain consistent from year to year.

### CEOS Mission Statement:

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

To this end, the primary objectives of CEOS are:

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

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

---

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

## 2. CEOS Priorities

This Work Plan has been developed in the context of long-term CEOS priorities as described in the CEOS Governing Documents, and specific priorities identified in the *Kyoto Statement* issued at the 29<sup>th</sup> 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 35th CEOS Plenary meeting was held virtually in 2021 due to travel restrictions imposed because of the COVID-19 global pandemic. The meeting reviewed the progress made in the priority areas of the outgoing CEOS Chair, the National Aeronautics and Space Administration [NASA]. In 2021 NASA's priority theme was "Space-based Earth Observation Data for Open Science and Decision Support" with a focus on three topical areas: accessibility, transparency, and reproducibility. The intent was to consolidate existing activities and to seek to broadly disseminate the relevance of CEOS contributions in support of open science and decision making. Measures of success for the 2021 CEOS chair theme encompassed both existing and new aspects of the work of CEOS and its entities. At the 35th CEOS Plenary there was consensus that, largely because of the success of the 2021 CEOS chair, open science had been established as an underpinning principal for CEOS. The incoming CEOS Chair, CNES, agreed that open science for decision support would continue to be a central focus during their tenure in 2022.

At the 35th CEOS Plenary, CEOS Principals endorsed the *CEOS Strategy to Support the Global Stocktake of the UNFCCC Paris Agreement (v3.1)*, the *CEOS Analysis Ready Data (ARD) Strategy 2021*, the *CEOS Analysis Ready Data (ARD) Governance Framework*, the *EOTEC DevNet Phase 1 Report*, the *Joint CEOS-CGMS Statement for SBSTA at COP26*, the *CEOS Statement for GEO Week 2021*, an updated *CEOS Governance and Processes document (v1.2)*, and new *CEOS Branding Guidelines* and a *CEOS Communications Strategy*. CEOS Principals also endorsed a new "Federated Approach" for CEOS support to the Sustainable Development Goals (SDGs), as described in the CEOS SDG Strategy Implementation document, and to disband the CEOS SDG *ad hoc* Team, which had been set up as a short-term and temporary entity in 2016. Support to the SDGs have been established as an important and continuing aspect of the work of CEOS, thus it was agreed by CEOS Principals to establish a permanent mechanism to support a small core SDG Coordination Group, the implementation of which will be led by the Systems Engineering Office (SEO).

The incoming CEOS Chair (CNES) presented the priorities for 2022 under the banner "*Paths to Sustainability: from Strategy to Practical Measures*". Firstly, the aim for 2022 is to put an emphasis on the evolution of R&D and demonstration activities to applications and services by identifying key suitable activities across the CEOS structure. This evolution has the target to engage with key stakeholder agencies through the GEO mechanisms, and with the ultimate goal of establishing

operational services. The WGDIs Recovery Observatory and the Space Climate Observatory initiatives and projects are prime candidates. Secondly, the support to the UNFCCC Global Stocktake, including the development of the AFOLU (Agriculture, Forestry and Other Land Use) roadmap and the CEOS Biomass Protocol uptake and engagement with GEO-TREES (Forest Biomass Reference System from Tree-by-Tree Inventory Data; a GEO community activity), is a key target. Finally, increased support to calibration and validation (cal/val) initiatives will also be encouraged with specific emphasis on cross-calibration of thermal infrared measurements from future CEOS Agencies' missions - in particular those missions identified as key for Surface Biology and Geology (SBG) - and the development of multi-thematic cal/val sites based on capacity pooling as much as possible, in order to develop international synergies between CEOS Agencies. The focus is for the 2022 effort to ensure attention to the Paris Agreement, to establish policy drivers and frameworks as appropriate, to continue to work on relevant SDGs, and to respond to the *Sendai Framework for Disaster Risk Reduction 2015-2030*.

The focus areas of the 2020-2021 CEOS SIT Co-Chairs, CSIRO and Geoscience Australia, were Analysis Ready Data; Carbon and Biomass; and support for UN Sustainable Development Goals (SDGs). These remain important aspects of the work of CEOS entities as the SIT chair role moves to ESA for the period 2022-2023, supported by JAXA as SIT vice-chair. During their tenure, ESA plan to specifically focus on global challenges with strong UN mandates, providing support through GEO as appropriate and where there is high relevance for satellite Earth observation (EO). An important emerging activity of potential interest to CEOS is the new and fourth GEO priority on *Resilient Cities and Human Settlements*, which is a response to the UN's New Urban Agenda. Improving CEOS support to global challenges through consideration of new geometries for space agencies, and how CEOS engages with commercial entities in both the space observation and the downstream space sectors, including the necessity to address new mission and new user requirements as they emerge, should hopefully translate into opportunities for CEOS to engage a wider user audience. It is important for CEOS to keep a watching brief on new activities in EO in both Government and commercial sectors, which may have implications for the current thematic observation strategies, taking advantage of the complementarities between public and commercial assets and services.

CEOS will continue to support more effective societal decision-making in the areas of climate monitoring and research; carbon observations, including observations to support the effective monitoring and management of the world's forested regions; food security; disaster risk management; oceans; biodiversity; capacity building; and data availability and access. Satellite mission coordination will be strengthened, particularly through the CEOS Virtual Constellation activities. CEOS Working Groups and Virtual Constellations will expand their technical and scientific coordination to support these priorities and improve the overall level of complementarity and compatibility of CEOS Agency Earth observation and data management systems for societal benefit.

For subsequent years (2023-2024), this document summarises planned CEOS activities more broadly; details regarding these future activities will be established in forthcoming updates of this document. Virtual Constellations, Working Groups, and *ad hoc* Teams may prepare separate, more detailed, Work Plans that complement this overall guiding Work Plan.



### 3. Expected Outcomes for 2022-2024

The expected outcomes for 2022-2024 reflect the ongoing and emerging priorities of CEOS, as characterised by its internal decision-making and external commitments. They are intended to focus on improved Earth observation (EO) systems coordination and enhanced data access for key global programs 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 potential activities related to the fourth GEO priority on *Resilient Cities and Human Settlements*, will be defined later when the GEO community, working with the relevant actors (e.g., UN Habitat, UNEP, International Financial Institutions, etc), will be able to establish priorities and projects that would need the support from CEOS Agencies.

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

This Work Plan is expected to be a companion document to the CEOS Deliverables Online Tracking Tool (see next section), 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.

#### CEOS Deliverables Online Tracking Tool

The CEOS Deliverables Online Tracking Tool (accessible via <https://ceos.org/tracking/>), captures significantly more information than presented in this Work Plan. It is particularly important for CEOS Deliverables to have an identified external link, i.e., to a particular GEO 2020-2022 Work Programme Flagship / Initiative / Community Activity<sup>1</sup> or UNFCCC / UNCBD / etc. activity. As of March 2022, there are 130 active CEOS Deliverables, which includes 52 newly created in 2022.

---

<sup>1</sup> [https://www.earthobservations.org/documents/gwp20\\_22/gwp2020\\_summary\\_document.pdf](https://www.earthobservations.org/documents/gwp20_22/gwp2020_summary_document.pdf)

### 3.1. Climate Monitoring, Research, and Services

CEOS and the Coordination Group for Meteorological Satellites (CGMS) work together, through the Joint CEOS – CGMS Working Group on Climate (WGClimate), to monitor climate from space through the coordinated planning, tracking, production, improvement, and availability of space-based climate data records on a global scale. 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). WGClimate works closely with WMO's SCOPE-CM (Sustained and COordinated Processing of Environmental satellite data for Climate Monitoring) and CEOS and CGMS members on Climate Data Record (CDR) sustainment matters. Further, in 2018 WGClimate chartered a Greenhouse Gas (GHG) Task Team focused on supporting the Global Stocktakes required by the *UNFCCC Paris Agreement*, signed in 2015 under the United Nations Framework Convention on Climate Change (UNFCCC).

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

During **2022**, WGClimate will:

- Update and exploit the comprehensive Essential Climate Variable (ECV) Inventory (Version 4) of Climate Data Records (CDRs) and implement coordinated actions arising from an Inventory gap analysis. The gap analysis identifies opportunities for improvement of data records and their usage along the climate information value chain outlined by the *Architecture*. In 2022, WGClimate will carry out the Version 4 analysis, which is dedicated to the Carbon Cycle.
- Link the gap analysis outcome related to the Carbon Cycle ECVs to the CEOS Global Stocktake Strategy. Findings and recommendations are to be discussed and included in the GHG and AFOLU roadmap, accordingly.
- Examine the Inventory to identify issues in the future availability of measurements for the Global Climate Observing System (GCOS) ECVs. As issues are found, WGClimate will initiate mitigation actions by improving coordination on long-term mission planning. Additionally, WGClimate will leverage the 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 targeted system for monitoring the column concentrations of CO<sub>2</sub>, CH<sub>4</sub> and other greenhouse gases from space. In 2020, CEOS and CGMS endorsed the Greenhouse Gas Roadmap (v2.4), which included a set of tasks and milestones in an annex. Together with the GHG Task Team, WGClimate will coordinate progress on these tasks and continue to update and refine the annex as appropriate. This will involve sustaining a strong relationship with the UNFCCC Subsidiary Body of Scientific and Technological Advice (UNFCCC/SBSTA) and GCOS processes to support the implementation of the Paris Agreement.
- Continue the activity on demonstration of use cases for climate data records to encourage wider application of the use of satellite observation. This activity effectively validates the *Architecture* and fosters usage of satellite-derived Climate Data Records. Some use cases may leverage the global carbon observing system contributed by UNFCCC Parties and therefore support the Parties' user engagement process. Other use cases may demonstrate CEOS and CGMS capacity-building and training activities and likely foster further usage.



- Publish a selection of use cases in a dedicated report.
- Support the drafting of the GCOS implementation plan, which shall be published at COP-27.

For **2023-2024**, significant outputs will be:

- Updated versions of the ECV Inventory, Gap Analysis Report and Coordinated Action Plan.
- The coordination of delivery of CO<sub>2</sub> column concentration data for use in the UNFCCC Global Stocktake, including further user engagement and in cooperation with other activities.
- Enhanced engagement with UNFCCC/SBSTA to better facilitate CEOS contributions beyond atmospheric CO<sub>2</sub> monitoring, including from Agriculture Forestry and Other Land Use (AFOLU).
- The publication of use cases on the ECV inventory web portal (<https://climatemonitoring.info>).

Number	Objective/Deliverable Title	Projected Completion	Responsible CEOS Entity(ies)
CMRS-19-04	Provide oversight to the implementation of the greenhouse gas monitoring activities (Coordinated Actions 11, 13, and 14).	2026 Q3	WGClimate
CMRS-19-05	Update definitions for FCDR, CDR, ICDR (Coordinated Action 1)	2023 Q2	WGClimate
CMRS-19-06	Implement Coordinated Actions 5 on FCDR Inventory, 6 on nomenclature document for CDRs, 10 on meta data standards	2023 Q2	WGClimate
CMRS-22-01	Gap Analysis Workshop on Carbon Cycle ECVs including gap analysis report and feedback to GCOS	2022 Q3	WGClimate
CMRS-22-02	Provide condensed feedback from the Gap Analysis to the GHG task team and AFOLU allowing refinement of their work plan	2022 Q3	WGClimate
CMRS-22-03	Provide condensed feedback from the Gap Analysis in support of the Ocean community within CEOS in support of the CEOS GST Strategy	2022 Q2	WGClimate
CMRS-22-04	Comment and support the draft of the GCOS implementation plan	2022 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 Space Data Component of the GEO Global Forest Observations Initiative (GFOI).

**2022:** Through the LSI-VC Forests and Biomass (LSI F&B) Team, CEOS is coordinating the implementation of the CEOS Strategy for Space Data for GFOI (endorsed by CEOS Plenary in 2011) for the provision of satellite observations in support of the development of national forest monitoring and measurement, reporting and verification (MRV) systems. This strategy will evolve to reflect changes in relevant CEOS agency mission plans, and to include coordination of the missions contributing to estimation of above-ground biomass (AGB). This new generation of missions, amounting to an investment of more than \$US4bn by CEOS Agencies, are of significant

interest to countries and institutions seeking to estimate avoided carbon emissions through incentive schemes such as REDD+. The LSI F&B Team proposes to support the accelerated policy relevance of the data from these missions by facilitating interaction between the GFOI community and technical CEOS communities, such as those pioneering the CEOS Biomass Protocol in the Working Group on Calibration and Validation (WGCV)'s Land Product Validation (LPV) subgroup, as well as the outreach and engagement defined and implemented through the anticipated CEOS AFOLU Roadmap.

Further work is expected in relation to the promotion and implementation of the GEO-TREES initiative, which seeks to develop a Forest Biomass Reference Network (FBRN) proposed by the WGCV LPV Biomass team as promoted through the SIT Chair Team and others via CEOS partners in GFOI and GEO. Priorities of 2022 are to establish the governance structure of GEO-TREES, establish a trust fund, intensify the outreach activities, and get first funding partners on board.

**2023-2024:** In subsequent years, the LSI F&B Team will continue to steward the updated GFOI Space Data Strategy and to progress the priority initiatives identified in relation to the policy relevance of AGB estimation missions. Further activities are anticipated in relation to:

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

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

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

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

At the 30<sup>th</sup> 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 first set of initiatives cover a broad range of CEOS WGs and VCs and are addressed by the CARB objectives/deliverables proposed over the 2022-2024 period.

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.

**2022:** Based on the GHG Constellation White Paper, WGClimate provided a Roadmap and planning document, as approved by the CEOS and CGMS plenaries in 2020, to help coordinate the implementation of the GHG Constellation, including delivery of prototype GHG inventory products in late 2021 in support of the first Global Stocktake (GST). In parallel, the LSI F&B team delivered a number of Agriculture, Forestry and Other Land Use (AFOLU) products, in support of the GST, in time for promotion at COP-26 in November 2021. Both the GHG and AFOLU products were provided through the CEOS GST Portal (<https://ceos.org/gst>) along with technical explanations and user guidance.

In 2022, the LSI F&B team will build on the AFOLU datasets contributed for COP-26 and develop a roadmap document that complements the GHG Roadmap for the land sector. The SIT Chair team will coordinate with the LSI F&B team and update the CEOS GST Portal and to include a user case studies section to help inspire prospective EO data users.

**2023-2024:** The GHG and AFOLU roadmaps foresee a long-term commitment to the further refinement of CEOS Agency data products in support of the GST process. Further implementation actions can be expected, including efforts to promote, educate and build capacity as we approach the first GST in 2023. Calibrated and validated harmonised products from multiple sensors and multiple agencies can provide seamless long-term, frequent, and intense global data for GHG monitoring. The WGCV hopes to work in the coming years with the GHG community to perform intercomparison of both radiance and retrieved GHG density levels, undertake calibration and validation (cal/val) campaigns, and provide common standard cal/val datasets.

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

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

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

**2021-2022:** First steps will include several activities already undertaken in 2021, including a virtual GHG-AFOLU workshop, and a strategy paper proposing a comprehensive approach for CEOS and its Agencies in support of the GST process. CEOS is engaged with the *ad hoc* group working on the Synthesis Report on Systematic Observation in support of the Global Stocktake, which may result in requirements for additional products to support the synthesis and technical assessment phases of the process. The SIT Chair will also revisit the issue of CEOS observer status to the UNFCCC.

**2022-2023:** Subject to an anticipated SIT-37 discussion, and Plenary endorsement for a UNFCCC Global Stocktake schedule, a number of measures can be expected in subsequent years in relation to the planning and provision of space-based datasets for use in the GST process, including results

from the work of the GHG and AFOLU Roadmap activities, related measures recommended by the GST Strategy paper, and GFOI support from the LSI F&B team. Specific GST recommendations and deliverables are set out in Section 3.3.

Number	Objective/Deliverable Title	Projected Completion	Responsible CEOS Entity(ies)
CARB-17-05	Cal/Val and production of biomass products from CEOS Agency missions	2023 Q4	WGCV
CARB-19-02	Phase II R&D Program for GFOI	2022 Q1	LSI-VC F&B Team CEOS GFOI Lead
CARB-19-03	Early Warning Module for GFOI	2022 Q4	LSI-VC F&B Team CEOS GFOI Lead
CARB-19-04	Forest Biomass measurements for GFOI countries	2023 Q4	WGCV LSI-VC F&B Team CEOS GFOI Lead
CARB-20-01	Develop a CEOS AFOLU roadmap	2023 Q2	LSI-VC F&B Team SIT Chair LSI-VC GEOGLAM Team WGClimate GHG Task Team
CARB-20-02	Integrated Carbon Cycle interface between CEOS and the UNFCCC	2022 Q4	WGClimate WGClimate GHG Task Team SIT Chair CEOS GFOI Lead LSI-VC GEOGLAM Team
CARB-20-04	Space Data support to GFOI Capacity Building component	2023 Q4	LSI-VC F&B Team
CARB-20-05	Support and encourage space data uptake in GFOI countries	2023 Q4	LSI-VC F&B Team
CARB-21-01	GST1 Prototype Products and Guidance	2023 Q4	LSI-VC F&B Team WGClimate GHG Task Team SIT Chair
CARB-21-03	Forest Biomass Reference Network (GEO-TREES)	2023 Q4	WGCV LPV LSI-VC F&B Team CEOS GFOI Lead SIT Chair
CARB-22-01	Production of harmonised biomass products from CEOS Agency missions	2023 Q4	WGCV LPV

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

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

The GST strategy paper covers the specific modalities of the GST and proposes where and how CEOS member Agencies can support its implementation.

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

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

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

1. WGClimate and WGClimate GHG Task Team should consult with the relevant elements of CEOS, including Associates such as ISC, WCRP and GCOS, together with modelers, to check the GHG Implementation roadmap on completeness concerning requirements for terrestrial observation (SIF; NPP, land cover, biomass, etc.) for supporting mitigation actions through the development of Monitoring and Verification System (MVS). The actions in Annex C of the roadmap shall be complemented as needed.
2. The need for parallel inputs to ocean models deemed necessary for the support of MVS and for a wider validation of carbon flux estimates globally should be considered and appropriately combined into the actions in Annex C of the GHG roadmap.
3. The results of the actions from the above recommendations should inform (a) the report of CEOS to UNFCCC, e.g. SBSTA/RSO (Research and Systematic Observation) discussion on observation to support the implementation of the Paris Agreement and should pro-actively flow (b) into the consultation process of the *ad hoc* group for the Synthesis Report on Observations for the GST.
4. CEOS should consider, in conjunction with modelers, setting up one or more focused observational campaigns in the areas suggested above, or others, as a major contribution to the understanding of the trends of GHG emissions from natural sources in key areas.
5. The AFOLU roadmap team should continue the work it has started for CEOS, reflecting the decisions taken at CEOS Plenary 2020. The AFOLU roadmap team and WGClimate GHG Task Team should work together to ensure consistency between data for emissions reported via AFOLU and for prior biogenic terrestrial emissions, and those due to changing land use, in implementing monitoring and verification systems. These need to be consistent on both temporal and spatial scales. The WGClimate GHG Task Team should ensure that their Roadmap is consistent with the outcomes of this discussion.
6. It is recommended that, to help in ensuring the take-up of satellite-based methods for AFOLU (and indeed in the context of MVS), CEOS should work with a few selected demonstrator countries to assist them in their national reporting under AFOLU (the model of GFOI can be compared). USGS through its SilvaCarbon programme would be well placed to lead this.
7. CEOS should work with the various partners set out above to identify data requirements and actions for CEOS in relation to adaptation, including participation of relevant CEOS groups such

as WGClimate and WGDisasters. Case studies might be of value to demonstrate competence and relevance. Partnership with specific countries in implementing their National Adaptation Plans (NAPs) could be of value, as in the case of AFOLU above, both to demonstrate worked examples and to strengthen support for this approach at UNFCCC, including at COPs.

8. CEOS should maintain a watch over the implementation of projects funded through climate fund mechanisms to ensure that all appropriate assistance is given by agencies in their implementation and governance.
9. CEOS must continue all efforts to provide the necessary climate data records that support the assessment of the actual status of the climate and the prediction and projection of future climate change, its response to changing GHG emissions and other drivers, and the impacts of climate change.

Number	Objective/Deliverable Title	Projected Completion	Responsible CEOS Entity(ies)
GST-22-01	Provide ongoing coordination, oversight and external communications for the GST Strategy deliverables	2023 Q4	SIT Chair SIT Vice-Chair
GST-22-02	Ensure that all 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.	2022 Q3	WGClimate GHG Task Team LSI-VC
GST-22-03	Ensure that all 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.	2022 Q2	COAST AHT OCR-VC SST-VC WGClimate
GST-22-04	Deliver results of GST Strategy actions to key meetings in the UNFCCC Calendar, including SBSTA and COP, and meetings of the GST Ad hoc group for the Synthesis Report on Observations for the GST.	2023 Q4	WGClimate WGClimate GHG Task Team
GST-22-05	Prepare short document on potential focused observational campaigns for discussion at SIT Technical Workshop	2022 Q2	SIT Chair SIT Vice-chair
GST-22-06	GHG TT and AFOLU Roadmap Team to ensure their plans are consistent with each other in treatment of relevant areas.	2022 Q3	LSI-VC F&B Team WGClimate GHG Task team
GST-22-07	Establish National Inventory Test User Group and channels for country feedback on CEOS products and their application.	2022 Q2	LSI-VC F&B Team
GST-22-08	Identify a specific process to explore requirements and actions for CEOS in relation to adaptation aspects of the GST.	2022 Q2	SIT Chair WGDisasters WGClimate LSI-VC
GST-22-09	As part of a GST Strategy update, provide periodic updates at Plenary and SIT meetings on CEOS actions relevant to Finance and Equity aspects of the GST	2023 Q4	SIT Chair
GST-22-10	Ongoing use of the ECV Inventory and the related analyses to address the climate data record requirements.	2023 Q4	WGClimate



### 3.4. Observations for Agriculture

GEO Global Agricultural Monitoring Initiative (GEOGLAM) aims to enhance agricultural production estimates using Earth observations to address concerns raised by the G20 Agricultural Ministers about market volatility for the world’s major crops, as well as to provide early warnings of crop shortages and failures in countries most at risk of food insecurity. The work described in the following paragraphs will be carried out over the period 2022 – 2023.

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

In 2018-2019, GEOGLAM completed its Requirements Refresh, which provided a more holistic view of needs beyond acquisition and into accessibility and utilization. An important component of this is GEOGLAM’s Essential Agricultural Variables (EAV), which are articulations of user-oriented key agricultural products for assessing state and change in agricultural land use and productivity; CEOS deliverable AGRI-19-04 reflects this. GEOGLAM is internally undertaking this definition and specification process of required products as well as their co-dependencies, with an expected completion of Q2 2022. From this EAV definition, several public-facing GEOGLAM documents will be updated to reflect these needs, including:

- GEOGLAM Community Research and Operationalization Agenda. First published in 2018, this sets out key priorities for GEOGLAM with respect to its operational R&D activity – JECAM – as well as identifying barriers in implementing EO in operational systems. Part of the EAV articulation is a gap analysis, i.e., a data-to-information lifecycle analysis, which seeks to identify the drivers of gaps in operationalisation utilising EO (e.g., EO data coverage, EO access, EO utilisation, training data and validation, computing infrastructure, training). With respect to “Training Data and Validation,” as has already been mentioned in AGRI-19-04, conversations with the CEOS WGCV Land Product Validation subgroup are expected, and it remains in 2022 for that relationship to be deepened through an upcoming planned joint workshop (AGRI-22-01) related to developing validation protocols for agricultural assessment.
- A joint workshop to develop community best practices and product accuracy protocols for cropland and crop type products. The proposed workshop builds on existing cooperation between the CEOS WGCV Land Product Validation (LPV) subgroup’s Land Cover focus area (CEOS WGCV LPV Land Cover) and GEOGLAM’s Essential Agricultural Variables working group (GEOGLAM EAV). The workshop will involve substantial participation by interagency partners and practitioners. Participants will be invited from the remote sensing research community who are producing such products, interested private sector entities that are starting to generate products, and users of the information.
- GEOGLAM EO Data Requirements. Very minor adjustments are expected to the GEOGLAM EO Data Requirements to ensure harmonisation between the EAVs and the EO data. Most changes will be in “Target Product” names, with some small adjustments in target resolutions anticipated. A new CEOS Response to GEOGLAM Requirements should then be completed (AGRI-22-02).

Out of the GEOGLAM Requirements Refresh, there were additional opportunities identified for GEOGLAM to interface with CEOS as CEOS seeks to advance adoption of EO data. None of these have been approved by CEOS but are proposed to the sub-working group as items of value to the agricultural community and should be discussed in calendar year 2022. These include:

- A White Paper Produced by CEOS LSI-VC GEOGLAM on Data Quality Control & Assessment. In light of the recent proliferation of data streams and associated products from CEOS agency missions, many users expressed uncertainty about which products were appropriate for their applications as well as how to gain access to them. Interoperability between sensors was consistently referenced as of utmost importance. A white paper explainer on which data sources and space agency funded products are suitable for which applications would be valuable.
- Analysis Ready Data (ARD) and Application Ready Data (ARD+). The CEOS Analysis Ready Data for Land (CARD4L) is useful to highly trained remote sensing technicians with adequate computational infrastructure or access to cloud-based data processing modalities (e.g., CEOS Data Cube). There was agreement that, with the rapidly expanding volumes of data from new missions, increased attention to data access, continuity, and quality is needed. The GEOGLAM community should be continually apprised of the CEOS LSI-VC work on ARD to maintain open lines of communication.
- Coordination on Capacity Development Activities. GEOGLAM launched a CapDev Team in 2019 and is already coordinating with the CEOS Working Group on Capacity Building and Data Democracy (WGCapD), including one shared now completed action (CB-20-09) in which CEOS WGCapD served as a “reviewer” for GEOGLAM CapDev Team’s “Guidance Document on Theory and Practice in Capacity Development for Earth Observations for Agriculture.” The GEOGLAM CapDev Team will develop a new action in 2022 on how to move forward related to this document and any cross-effort relationships.

## **II. Continue support to the Joint Experiments on Crop Assessment and Monitoring (JECAM) Initiative**

**2022:** CEOS Agencies will continue data acquisitions for support to GEOGLAM’s operational R&D network JECAM at selected sites for both Northern Hemisphere and Southern Hemisphere growing seasons. It is expected that these acquisitions will continue at least through to the end of 2022 and be described in an annual report. CEOS Agencies will continue to liaise with the GEOGLAM R&D Co-Leads and the GEOGLAM EO Data Coordination Lead on data requirements related to this matter.

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

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

To better inform stakeholders and priority applications, the CEOS SEO is supporting a project in the context of GEOGLAM to utilise Earth observation (EO) data, best-in-class machine learning

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

Number	Objective/Deliverable Title	Projected Completion	Responsible CEOS Entity(ies)
AGRI-19-04	Iteratively respond to GEOGLAM EO Data Coordination team’s definitions of “Applications Ready Data” (ARD+) and “Essential Agricultural Variables for GEOGLAM”	2022 Q2	LSI-VC GEOGLAM Team
AGRI-22-01	Joint CEOS LPV & GEOGLAM EAV Crop Mapping Validation Protocol Workshop	2022 Q4	CEOS LPV
AGRI-22-02	CEOS Response to GEOGLAM Requirements	2022 Q3	LSI-VC
AGRI-22-03	Soil Organic Carbon Stock and Flux estimates for Agricultural Land Uses: Input to GST AFOLU, Nationally Determined Contributions, and National Adaptation Planning	2023 Q2	CEOS SEO

### 3.5. Observations for Disasters

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

Increased impacts of global climate change bring more frequent and extreme hydro-meteorological events, often leading to consequences such as landslides, which present enhanced opportunities for the EO community to demonstrate the unique scope and reach of satellites in support to the full cycle of risk management.

The primary objectives of the WGDisasters are:

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

In **2022** and **2023** the WGDisasters will support the ongoing work of international initiatives, including GEO, to strive to increase the awareness of decision-makers of the critical role of satellite EO (including a new joint activity with CEOS WGCapD directly related to this), and reinforce the need for enhanced satellite EO Programs to better address Disaster Risk Management (DRM) needs. The WGDisasters has highlighted the importance of moving from technical demonstrations to sustained application of EO for improved risk management. A new cross-cutting reflection has been initiated in this regard, with a view to bringing forward the best practices in past WGDisasters successes. Such reflection will include an analysis of possible links and synergies with the SCO (Space for Climate Observatory), to take the increasing impact of climate change on disasters into account, and the usefulness of EO data to reduce risks and vulnerability of territories.

With this objective in mind, the WGDisasters expects to initiate plans for sustainable activities with partners outside of CEOS for mature “Demonstrators” over the next two years. 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 *Seismic Demonstrator*, the *Volcano Demonstrator*, and the *Recovery Observatory Demonstrator*. The Recovery Observatory was recently recognised by the UN General Assembly, in the framework of the Space 2030 Agenda, as “a means to increase the contribution of satellite data to recovery from natural disasters” and to contribute to Sendai framework priority 4: *Build Back Better*. The WGDisasters intends to build on this recognition by engaging new partners to support this critical phase of risk management.

The WGDisasters will also support the overlapping CEOS / GEO Work Plans, and their programme deliverables / activities, to include a Geohazards Supersites and Natural Laboratory (GSNL) Evolution Feasibility Study. The aim is to select GEO-DARMA (Data Access for Risk Management) regional projects that facilitate uptake of satellite EO by regional institutions and leading regional DRM initiatives. The recently launched GEO/LEO/SAR Flood Pilot will report on effective best practices and value of data and methodologies shared by pilot team members to CEOS member Agencies. It will also explore how to effectively improve flood risk management with the use of Earth observation from satellites. The Wildfire Pilot will complete its study of user needs and the definition of the final pilot deliverables geared towards integrating satellite based EO observations in support of global fire monitoring. All Demonstrator activities produce reports in accordance with specified WGDisasters Deliverables (see below).

Number	Objective/Deliverable Title	Projected Completion	Responsible CEOS Entity(ies)
DIS-15-04	Implementation of data coordination for the GEO GSNL initiative	2030 Q4	WGDisasters
DIS-18-01	Report on follow-on actions to Landslide Pilot	2022 Q1	WGDisasters
DIS-19-03	Seismic Demonstrator and Report	2022 Q2	WGDisasters
DIS-20-01	CEOS Contribution to GEO GSNL Initiative for DRR	2024 Q4	WGDisasters WGCapD WGISS
DIS-20-02	GNSL evolution feasibility study	2022 Q4	WGDisasters
DIS-20-03	CEOS Support for GEODARMA (Data Access for Risk Management) Regional Implementation	2022 Q4	WGDisasters

Number	Objective/Deliverable Title	Projected Completion	Responsible CEOS Entity(ies)
DIS-20-04	Landslide demonstrator showing value of combining optical and radar data for multi and cascading hazard disaster risk prediction and assessment products (maps and models in areas of high known risk due to activity, exposure and vulnerability), with report on effective practices, key data and practices	2024 Q4	WGDisasters
DIS-20-05	RO Demonstrator Proposal (3 to 5 PDNA over two years)	2023 Q4	WGDisasters
DIS-20-06	Flood Pilot with GEO-LEO-SAR for areas of intensive flood risk	2022 Q1	WGDisasters
DIS-22-01	Flood Pilot with GEO-LEO-SAR “Understanding Flood Risk from Space”	2024 Q4	WGDisasters
DIS-22-02	Volcano Demonstrator Sustainability Report	2023 Q4	WGDisasters
DIS-22-03	Use cases for the Operationalization of EO at the local level	2023 Q3	WGDisasters
DIS-22-04	Wildfire Pilot Final Report	2023 Q4	WGDisasters

### 3.6. Observations for Water

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

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

### 3.7. Data Quality

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

#### 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.**

**2022-2024:** Interoperability and utility of Analysis Ready Data (ARD) products are an emphasis of CEOS. WGCV efforts to provide the guidance needed to allow users to assess ARD quality will begin with defining and quantifying uncertainties for surface reflectance product validation at continental scales. In addition, the WGCV developed, and will be working with LSI-VC on, the peer review process for the evaluation of documentation of data providers for alignment with CARD4L and will contribute to terminology definitions.

A similar effort will be undertaken related to greenhouse gases (GHG) data products by developing a set of standards for CO<sub>2</sub> and CH<sub>4</sub> products such as radiance spectra, densities, and flux that are suitable for inter-comparisons across multiple missions. The WGCV will also collaborate with the WGClimate and the AC-VC, contributing to calibration and validation efforts of CEOS GHG initiatives. WGCV activities will build upon the recent progress towards understanding global biomass by developing an initial set of guidance for biomass product validation using near-term missions such as NISAR, GEDI, and BIOMASS. Ensuring that the results of this work are readily available will take place through a significant update to the CEOS Cal/Val portal, the Vicarious Calibration portal, and the WGCV website within the CEOS interface. From these websites, calibration and validation data are available.

The calibration of missions in the thermal infra-red domain is a topic of growing importance, including several CEOS agencies working on future missions covering this spectral domain, in particular SBG (NASA), LSTM (ESA, Copernicus) and Trishna (CNES/ISRO). 2022 will see specific efforts - including the definition of a common network of *in situ* calibration sites - to harmonise calibration methods for thermal infra-red instruments taking advantage of the previous work done for the “Land Surface Temperature Product Validation Best Practice Protocol”, written by the CEOS WGCV Land Product Validation (LPV) subgroup, to maximise the benefit of these missions for users.

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

**2022-2024:** The WGCV will continue to strengthen its cooperation with GSICS on the topic of sensor calibration following the joint effort on a recommendation for a GSICS/CEOS solar spectrum with various spectral resolutions and solar cycles that ensures interoperability. This includes a cross-



working group effort with WGISS on quality indicators, with sea surface temperature (SST) as a test case, and efforts in the standards for calibration of space-based CO<sub>2</sub> and CH<sub>4</sub> sensors.

The WGCV will continue working with the GEO Secretariat, including work to support relevant GEO activities mainly by encouraging widespread adoption of quality assurance principles. The development of calibration and validation infrastructure and comparison campaigns within the frame of the WGCV will be used to promote these principles and best practices. The WGCV will continue to foster cooperation with WMO, ground-based networks, and CEOS WGs and VCs through dedicated presence during WGCV meetings and by reaching out to the science users and data product providers in 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	2022 Q1	WGCV
CV-17-01	L1 top-of-atmosphere interoperability	2022 Q1	WGCV
CV-20-01	Surface Reflectance measurements Intercomparison exercise for vegetation (SRIX 4Veg)	2022 Q4	WGCV
CV-20-02	Biomass Retrieval Intercomparison eXercise (BRIX-2)	2022 Q1	WGCV
CV-20-03	DEMIX	2022 Q1	EC ESA
CV-20-05	Standards and metrics for scatterometers and wind retrievals	2022 Q2	WGCV
CV-22-01	Validation protocols for atmospheric aerosol and cloud profiles	2023 Q1	WGCV
CV-22-02	CEOS Terms and Definitions Wiki	2024 Q4	WGCV

### 3.8. Capacity Building and Data Democracy

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

**2022:** WGCapD will continue to increase its efforts at the global, regional and national level by building upon activities carried out in 2021, delivering trainings in different formats (e.g., in-person, virtual), collaborating with other CEOS working groups, and developing new activities in support of GEO and the global agendas. New resources will be made available on the WGCapD webpages. 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 pursue greater engagement of its regional communities of practice and will continue developing the network of networks.

**2023-2024:** WGCapD will continue to address a global need for the identification and coordination of the world’s diverse and often disparate capacity building and training resources related to satellite Earth observations. EOTEC DevNet will continue developing through Pilot Phase 2 to enable a greater sharing of resources and plans and will focus on the sustainable development frameworks’ nexus of disaster risk reduction, climate adaptation and climate mitigation. It is expected that EOTEC DevNet

will transition from pilot phase to a routine phase following the completion of Pilot Phase 2. WGCapD also plans to continue collaborating with GEO to strengthen AmeriGEO, AfriGEO, and through training contributions at their respective meetings/workshops.

WGCapD plans to continue with the approach of dividing the work the group supports into global, regional, national, and infrastructure activities:

- 1) For **global work**:
  - Focus on on-line learning through e-learning, MOOCs, webinars, and blended learning approaches.
  - EOTEC DevNet will continue connecting CEOS WGCapD with other global networks through Pilot Phase 2, which concludes in March 2023.
  - Development of a curriculum using WGCapD produced resources will begin.
  - Deliverables: CB-20-01, CB-21-04, CB-21-06, CB-22-01, CB-22-02, CB-22-03, CB-22-04, CB-22-05, CB-22-06, CB-22-07.
- 2) For **regional work**:
  - Focus on support to regional GEOs: AfriGEO and AmeriGEO.
  - Support trainings in conjunction with regional societies and other meetings.
  - Leverage single-agency regional activities as possible.
  - Deliverables: CB-20-21, CB-20-23, CB-20-24, CB-22-08
- 3) For **national work**:
  - Support national trainings where fitting.
  - Strengthen our understanding of national needs in other thematic areas.
  - Deliverables: CB-20-12, CB-20-14, CB-20-15, CB-22-09
- 4) For **infrastructure**:
  - Enablers, with a focus on sharing of best practices and resources, convening key stakeholders, and addressing users’ needs.
  - Deliverables: CB-20-06, CB-20-07, CB-20-08, CB-21-01, CB-21-02, CB-21-03, CB-22-X1, CB-22-10, CB-22-11, CB-22-12, CB-22-13, CB-22-14.

Number	Objective/Deliverable Title	Projected Completion	Responsible CEOS Entity(ies)
<b>Global Deliverables</b>			
CB-20-01	Earth Observations Toolkit for Sustainable Cities and Human Settlements Training Webinar	2022 Q1	WGCapD
CB-21-04	Zero Hunger MOOC	2022 Q2	WGCapD
CB-21-06	Space Based Observations for Meteorological Hazards	2022 Q2	WGCapD
CB-22-01	Webinar on Agricultural Crop Monitoring with SAR and Optical Remote Sensing	2022 Q2	WGCapD
CB-22-02	Webinar on Air Quality Data Access and Analysis from Geostationary Satellites	2022 Q3	WGCapD
CB-22-03	Webinar on Satellite Remote Sensing for Urban Heat Islands	2022 Q3	WGCapD
CB-22-04	Earth Observation and Recovery Observatories – Capacity-Building for Decision Makers	2022 Q4	WGCapD WGDisasters
CB-22-05	Indigenous Mapping Workshop 2022	2022 Q4	WGCapD
CB-22-06	Webinar on joint applications for land and climate	2023 Q3	WGCapD
CB-22-07	Open-Source Science Outreach Plan and Training	2023 Q4	WGCapD

Number	Objective/Deliverable Title	Projected Completion	Responsible CEOS Entity(ies)
<b>Regional Deliverables</b>			
CB-20-21	Copernicus User Uptake in Africa	2023 Q4	WGCapD
CB-20-23	AmeriGEO Contribution	2022 Q2	WGCapD
CB-20-24	Remote Sensing Training in Africa	2022 Q4	WGCapD
CB-22-08	Copernicus training of trainers in Africa	2024 Q4	WGCapD
<b>National Deliverables</b>			
CB-20-12	Collaborative Feasibility Study (Mexico)	2022 Q3	WGCapD SEO
CB-20-14	Indigenous Peoples-focused In-Person Training (Australia)	2023 Q1	WGCapD SEO
CB-20-15	SAR Training for Forest and Rice Monitoring (Vietnam)	2022 Q2	WGCapD
CB-22-09	Chesapeake Bay Feasibility Study	2022 Q4	WGCapD
<b>Infrastructure Deliverables</b>			
CB-20-06	Metadata Standards Tiger Team	2022 Q2	WGCapD WGISS
CB-20-07	Best Practice Guide to E-Learning	2022 Q3	WGCapD
CB-20-08	Virtual EO Education Conference	2022 Q2	WGCapD
CB-21-03	EOTEC DevNet Tools and Information Collection	2022 Q4	WGCapD
CB-22-10	Sentinel Selected Applications: practical training with Jupyter Notebooks on the ESA EO Platform	2022 Q4	WGCapD
CB-22-11	EOTEC DevNet Pilot Phase 2 Report	2023 Q1	WGCapD
CB-22-12	EOTEC DevNet Multi-Stakeholder Network Analysis	2023 Q1	WGCapD
CB-22-13	Jupyter Notebooks Foundations Webinar	2023 Q3	WGCapD WGISS
CB-22-14	EO Capacity Building Curriculum	2023 Q4	WGCapD

### 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 the CEOS Virtual Constellations, the CEOS Working Groups, and GEO, providing discovery and access capabilities to mature data services and analytics tools provided by CEOS Agencies. WGISS will support adoption of supported WGISS standards (e.g., Open Geospatial Consortium [OGC] Catalogue Service for the Web [CSW] 2.0.2 and CEOS OpenSearch Best Practices) with the aim of connecting as many CEOS Agencies as possible into the federated system. WGISS will also continue to accomplish its Data Preservation and Curation efforts through the Data Stewardship Interest Group (DSIG), addressing space data and associated technical content archiving, preservation, consolidation, and valorisation aspects.

WGISS will continue development of the five core areas of Data Architectures best practices as these alter the way that agencies provide access and exploitation of their EO data:

- I. CEOS Analysis Ready Data (ARD)
- II. Interoperable Free and Open Tools
- III. Data, Processing, and Architecture Interface Standards
- IV. Analytical Processing Capabilities
- V. User Metrics

The outcome of these initiatives should be a more coordinated and coherent EO data offering, against which organisations can confidently invest their resources and leverage their distribution channels to users to realise benefits that go far beyond the traditional mono-mission approach. WGISS will continue, in the period 2022-24, its Data Architectures activities as agency contributions begin to mature, and interoperability and integration of new services becomes increasingly important. The goal is to establish interoperability arrangements for CEOS Agencies’ data and analysis systems federation, which is now expanding to include both Cloud and Agency systems.

The WGISS System Level Team (SLT) for data access will continue exploring and evolving interoperable discovery platforms (e.g., FedEO, CWIC and IDN) for metadata manipulation, data collections, services, tools, and associated metrics. The SLT is also very active in maintaining best practises for OpenSearch (with recent inclusion of services) and analysing the applicability of STAC principle to metadata, interfaces, and data discovery.

WGISS will also work with the CEOS Systems Engineering Office (SEO) to jointly operate the CEOS Earth Analytics Interoperability Lab (EAIL), providing an area for multi-organisation collaboration by CEOS WGs and VCs, and to explore the interoperability needs and services required. WGISS will also continue to explore edge of the horizon technologies and evaluate their applicability and use in the Earth observation domain, supporting the development of a knowledge oriented GEOSS and GEO Knowledge Hub.

Number	Objective/Deliverable Title	Projected Completion	Responsible CEOS Entity(ies)
DATA-18-02	CEOS data holdings reported and accessible in GEO and other international relevant contexts	2022 Q4	WGISS
DATA-22-01	Jupyter Notebook Best Practice	2022 Q4	WGISS
DATA-22-02	Discovery and Access for Data Analytics and Processing Tools and Services	2022 Q4	WGISS
DATA-22-03	OpenSearch Best Practices to include Service Discovery	2022 Q4	WGISS
DATA-22-04	Data Management and Stewardship Maturity Matrix	2023 Q1	WGISS WGCV
DATA-22-05	Feasibility Study for Common Guidelines for the STAC Implementations	2023 Q2	WGISS
DATA-22-06	Archive Technologies White Paper	2023 Q2	WGISS

### 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.

**2022-2024:** 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.

## **AC-VC**

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

Activities for **2022** focus on first-ever intercomparisons of tropospheric ozone datasets and on harmonised validation plans for the three geostationary air quality missions now in development. AC-VC climate activities focus on the development and delivery of atmospheric greenhouse gas inventories and Observing System Simulation Experiments (OSSEs) to support the Greenhouse Gas (GHG) task team within the Working Group on Climate.

## **LSI-VC**

The CEOS Land Surface Imaging Virtual Constellation (LSI-VC) continues to serve as the forum for developing CEOS Analysis Ready Data (ARD) for Land (CARD4L). At the 35th CEOS Plenary, CEOS agreed to build upon the concept and has established a broader effort on CEOS ARD. LSI-VC will continue its activities on ARD for land products under the umbrella of the new CEOS ARD governance framework and efforts will be in line with the ambitions of the 2021 CEOS ARD Strategy.

As well as continuing to add to the collection of land-focused Product Family Specifications (PFSs), and maintaining and assessing products against these specifications, LSI-VC members will serve on the CEOS ARD Oversight Group, undertake further outreach with the community (see tasks in the CEOS ARD Strategy, 2021), and address technical topics related to the development and provision of analysis-ready land products.

Outside of ARD, LSI-VC will also be working to identify potential modifications to existing CEOS information tools that can be made to help improve their value for gap analyses/. LSI-VC will also contribute to the CEOS effort on the UNFCCC Global Stocktake. The LSI-VC Forests and Biomass Team is the lead for the CEOS AFOLU Roadmap activity.

## **P-VC**

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

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

1. Provide a coordination mechanism to harmonise precipitation-capable satellite systems,

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

### **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 (GHRSSST) Project. For the **2022-2023** horizon, the SST-VC will remain as members and contributors to the 1) CEOS ARD Oversight Group and 2) the CEOS Ocean Coordination Group. For Task 1), this will include working with the SIT chair and other CEOS ARD interests to continue to evolve and improve the CEOS ARD Framework, and to address emerging user needs and collaborations (e.g., the proposed 2022 Q4 CEOS ARD Workshop). For Task 2), the SST-VC will participate in the Ocean Coordination group to bring expertise from the GHRSSST project in data formats and metadata for marine products, remote sensing requirements in high latitude regions, and other related activities. The SST-VC also intends to support Level 4 (merged) ocean data product validation in a South Africa regional pilot project in collaboration with the COVERAGE initiative.

### **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.

Upcoming efforts for **2022-2023** will focus on updating the CEOS OST-VC Constellation User Requirements Document. The previous version is dated 2009 and considered the future of the constellation for a period of 15 years: 2019-2025.

### **OCR-VC**

The goal of the CEOS Ocean Colour Radiometry Virtual Constellation (OCR-VC) is 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 **2022** will focus on *Aquatic Carbon from Space*, with an international community workshop planned for 2022, and a journal special issue - *Aquatic Carbon Stocks and Fluxes: The Big Picture from Remote Sensing* – to be published at the end of 2022 in Earth Science Reviews (<https://www.journals.elsevier.com/earth-science-reviews/>). Both the Workshop and



the Journal special issue are intended to contribute to defining the foundations for a CEOS Aquatic Carbon Strategy.

OCR-VC activities for **2022-24** will include the continuation of developing a coordinated multi-mission basis for OCR cal/val, including system vicarious calibration infrastructures and protocols for bio-optical *in situ* measurements. Synergistic activities with the COVERAGE project are planned with the goal of supporting the integration of OCR missions and methodologies. Support is now transitioning from COVERAGE Phase-B prototype development to Phase-C full implementation. OCR capacity building is continuing and providing new resources to users, including an IOCCG Summer Lecture Series in July 2022 in Villefranche-sur-Mer, France.

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).

### OSVW-VC

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

Number	Objective/Deliverable Title	Projected Completion	Responsible CEOS Entity(ies)
VC-14-09	Implementation of the International Network for Sensor InTercomparison and Uncertainty Assessment for Ocean Colour Radiometry (INSITU-OCR)	2023 Q4	OCR-VC
VC-14-15	OSVW Standards and Metrics	2022 Q1	WGCV MWSG OSVW-VC
VC-18-01	Evaluate CARD4L supply, user access, and user experiences via pilot activities (e.g., with Digital Earth Africa, LSI-Forests & Biomass, LSI-GEOGLAM, Mekong Data Cube)	2022 Q4	LSI-VC LSI-VC GEOGLAM Team CEOS GFOI lead
VC-18-07	Gap Analysis Tools	2022 Q4	SEO MIM Database Team LSI-VC
VC-19-05	Open-source library for surface reflectance product generation	2022 Q2	LSI-VC
VC-19-06	Update of CEOS OST-VC User Requirements Document	2023 Q1	OST-VC

Number	Objective/Deliverable Title	Projected Completion	Responsible CEOS Entity(ies)
VC-20-01	Tropospheric ozone dataset validation and harmonization	2022 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	2022 Q4	AC-VC WGCV
VC-20-04	Air quality constellation validation coordination: announcements of opportunity	2023 Q4	AC-VC WGCV
VC-20-05	Aerosol air quality coordination	2022 Q4	AC-VC
VC-20-06	Water Leaving / Aquatic Reflectance CARD4L PFS	2022 Q1	LSI-VC
VC-20-07	Identify the need for and prioritize development of future target products as the basis for new CEOS ARD specifications	2022 Q1	SIT Chair
VC-20-10	CEOS–Industry ARD Workshop	2022 Q4	LSI-VC SST-VC SIT Chair
VC-20-12	Promote CEOS ARD to data providers	2022 Q4	SIT Chair
VC-20-17	GPM L2A precipitation products	2022 Q2	P-VC
VC-20-18	New version IMERG	2022 Q2	P-VC
VC-20-24	Aquatic Carbon From Space Special Issue	2022 Q4	OCR-VC
VC-20-25	Aquatic Carbon From Space Workshop	2022 Q1	OCR-VC
VC-20-26	System Vicarious Calibration (SVC) infrastructures in support of Climate-quality OCR data records	2024 Q4	OCR-VC
VC-20-27	Development of protocols for bio-optical in situ measurements	2022 Q4	OCR-VC
VC-20-28	Capacity building summer schools and online resources	2022 Q4	OCR-VC
VC-20-29	Synergistic activities with CEOS COVERAGE	2022 Q4	OCR-VC SST-VC
VC-22-01	CEOS ARD Product Family Specifications (PFSs) for land products	2024 Q4	LSI-VC
VC-22-02	CEOS ARD product assessments for land products	2024 Q4	LSI-VC
VC-22-03	Implementation of CEOS ARD Strategy 2021 tasks relevant to LSI-VC	2024 Q4	LSI-VC WGCV
VC-22-04	Mission continuity timelines for land domain CEOS ARD PFS	2022 Q4	LSI-VC
VC-22-05	CEOS ARD Strategy 2021 Implementation	2023 Q4	SIT Chair
VC-22-06	CEOS ARD Strategy 2023	2023 Q4	SIT Chair

### 3.11. Support to Other Key Stakeholder Initiatives

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

At the 35th CEOS Plenary in 2021, the CEOS SDG *ad hoc* Team transitioned to a new "federated" approach for the management of all CEOS activities related to the U.N. Sustainable Development Goals (SDGs). Future efforts will be coordinated by a new **CEOS SDG Coordination Group**, which includes representatives from the CEOS Strategic Implementation Team (SIT), the CEOS Systems Engineering Office (SEO), the CEOS Executive Officer (CEO), a CEOS-GEO liaison on SDG matters, and a representative from the past SIT Chair Team (initiator of the former SDG *ad hoc* Team). The CEOS SIT Chair will lead the overall strategic oversight and delegates the technical implementation

to the CEOS Systems Engineering Office (SEO). The SEO will coordinate SDG deliverables and work plan activities by liaising with a few lead experts responsible for each SDG deliverable. The lead experts will organise their technical capacity and support using a pool of experts 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.

**2022:** CEOS will focus its activities concerning the Sustainable Development Goals (SDGs) by:

- Supporting GEO efforts to advance the uptake of Earth observation in the implementation of the *2030 Agenda on Sustainable Development*, acting as a “Space Enabler” to facilitate access and use of satellite data in the SDGs, focusing on the unique role that CEOS should play as a coordination body of the space community efforts.
- Participating to the GEO federated approach on SDGs that aims to harness all expertise inside and outside of GEO (including CEOS) to maximise impact. This is done by interfacing primarily with GEO EO4SDG (Earth Observation for Sustainable Development Goals) but also with the relevant GEO Work Programme activities related to SDGs through the GEO Secretariat.
- Contributing to the development of additional GEO Toolkits on SDGs led by GEO EO4SDG, which will package all available EO assets (datasets, software tools, IT platforms, best practices examples, capacity building material) with practical guidelines and tools for easy appropriation by countries.
- Analysing, in cooperation with GEO, the satellite data requirements for four selected SDG indicators: 6.6.1 on water; 11.3.1 on urbanisation, 15.3.1 on land degradation and 14.1.1 on coastal pollution (with the COAST *ad hoc* Team). This analysis will help satellite data users have a precise understanding of the data details (e.g., coverage, frequency, resolution, etc.), which are provided by CEOS Agencies to support countries to achieve their SDG targets and report on SDG indicators.
- Assisting GEO to respond to specific requests from the UN Statistical Division, UN custodian agencies and countries, about satellite data requirements and acquisition for the implementation of EO-relevant SDG indicators.
- Liaising with CEOS permanent structures (VCs, WGs and SEO) on capacity building (with WGCapD), on ARD strategy and definitions (with the CEOS ARD Oversight Group and LSI-VC), on EO-enabling infrastructures (with SEO and WGISS) and on EO product validation (with WGCV) to harness CEOS collective expertise and maximise benefits for the CEOS Agencies and for the SDG stakeholders.

**2023-2024:** The previous CEOS SDG *ad hoc* team (now the CEOS SDG Coordination Group) focused its activities on four SDG indicators: 6.6.1 on water extent, 11.3.1 on urbanisation, 15.3.1 on land degradation, and 14.1.1 on coastal eutrophication. Some work may continue on these indicators beyond 2022, but the details of those future tasks will be developed in late 2022. 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*.

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

**2022-2024:** CEOS Agencies will continue to develop and distribute experimental and operational data, products, and services, along with the further evolution of the COVERAGE model and initiatives undertaken within the CEOS COAST *ad hoc* Team, and likewise operational satellite oceanography activities (EUMETSAT, NOAA) to facilitate distributed access to collocated, synergistic datasets with fit-for-purpose latency, quality, coverage, and content for applied, commercial, and research utilisation.

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

**2022-2023:** Essential Biodiversity Variables (EBVs) are a collection of (currently) 20 biological variables that capture key dimensions of biodiversity and how they are changing. They are of particular importance for monitoring biodiversity change and are intended to be the feedstock for a variety of important derived products, especially for indicators used by international conventions such as the Convention on Biological Diversity and the UN Sustainable Development Goals. Remotely-sensed data play a primary role in many EBVs, and a supportive role in most of them.

While some further refinement of the EBVs is planned, one component of this next phase will be to advance the observation and production requirements for selected EBVs and derived products. The EBV Data Portal, still under development and hosted by iDiv in Leipzig, is starting to provide access to data relevant to the EBVs. Further development of workflows that provide important data products such as indicators and tying these into GEO BON's Biodiversity Observation Networks (BONs) is also planned. One aspect to this could be to identify related or common variables relevant to other areas or policy conventions, particularly climate.

Discussion on an ambitious concept for a global observation system for biodiversity will continue. Key areas needing exploration include but are not limited to: overall scope; users and their priority needs; connection to existing systems; integration of remotely sensed and *in situ* data; scalability; and growth plan.

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

## **IV. CEOS Ocean Variables Enabling Research and Applications for GEO**

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

initiatives, including the Marine Biodiversity Observation Network (MBON) and Blue Planet. COVERAGE development is comprised of four phases (A-D).

The COVERAGE phase A (technical scoping) activity officially kicked off with NASA support in November 2017 and has been successfully completed (deliverables COV-1 through COV-3). COVERAGE Phase B (COV-17-04 deliverable) successfully concluded in Q4 2020. This 1-year activity involved technical development of a prototype COVERAGE system demonstrating core functionality for a limited range of data types, with an emphasis on collocated, multi-parameter satellite products from the 4 Ocean VCs that are integrated with select *in situ* datasets in support of a pilot ecosystem thematic application. Phase B included implementation of COVERAGE's distributed architecture with satellite nodes on NASA-AWS and EUMETSAT-WEKEO cloud platforms and connectivity to select CSIRO, NOAA and IMOS *in situ* data repositories accessible via prototype Web portal capabilities accessible at <https://coverage.ceos.org>.

**2022:** COV-18-01: Phase C of the COVERAGE project commenced in June 2021 as a planned 18-month activity with an expected completion date of December 2022. Technical work will address community comment on the prototype, implement refinements and any necessary enhancements to develop a more mature and fully featured COVERAGE system. Phase C will also undertake further development and expansion of thematic application use cases as proof-of-concept demonstrations. Continued stakeholder engagement remains integral to the approach including in the context of the advancement of the COVERAGE concept to the UN Decade of the Oceans for Sustainable Development in coordination with CEOS. COVERAGE will also support CEOS ocean coordination efforts and contribute to any related group activities.

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

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

The COAST (Coastal Observations, Applications, Services and Tools) *ad hoc* team (AHT) is a dedicated coastal-focused *ad hoc* team helping bridge land and ocean observations within CEOS and, given its cross-cutting nature, helping to integrate across multiple CEOS entities and domains, both thematic (e.g., Disasters, Sustainable Development Goals [SDGs], and Capacity Development) and technical (e.g., Ocean, Land and Atmosphere, Biodiversity, WGISS, cal/val, and COVERAGE). The COAST AHT is advancing 2 pilot projects that leverage the CEOS Analysis Ready Data (ARD) framework already demonstrated for terrestrial applications. The COAST AHT is well-positioned to highlight the broader utilisation of Earth observations for greater societal benefits within coastal zones (e.g., Blue Economy; SDG-14), and demonstrates a specific mechanism for CEOS to engage with external stakeholders such as GEO, IOC/GOOS, UN Environment and high visibility activities such as the *UN Decade of Ocean Science for Sustainable Development (2021-2030)*.

In 2021 progress was made on coastal products, tools, and services in both pilot projects and in utilising the ARD infrastructure available through the EAIL, Digital Earth Africa, and hosted DataCubes. Close collaboration with WGDisasters, WGISS, and WGCapD occurred throughout 2021 and will continue in 2022. In June 2021 COAST was endorsed as a UN Ocean Decade

contribution to coordinate with other global entities to support *A Predicted Ocean*, among other UN Decade Outcomes. A notable accomplishment in 2021 was the successful GEO-hosted public event to engage users, which resulted in production of 7 outreach videos for the COAST AHT website.

The COAST AHT’s 2022-24 deliverables will be defined in **2022** and will likely incorporate 1) Demonstration use cases for select regional products (up to 4 are expected) and 2) a Communications Management Plan, which will include pilot-specific stakeholder lists and communication preferences. The demonstration use cases will be the basis for discussion with regional stakeholders at half-day workshops in early 2022.

In **2022-23**, the COAST AHT expects to engage in product demonstration, training, validation of the products, and capacity development of pilot products in initial geographical regions. Expansion of demonstrated products into new geographical regions is also expected including into Blue Carbon, likely in partnership with the GEO Blue Planet and the GEO MBON initiatives.

Number	Objective/Deliverable Title	Projected Completion	Responsible CEOS Entity(ies)
COV-18-01	COVERAGE Phase C system	2022 Q4	COVERAGE
COV-18-02	COVERAGE system evaluation (Phase D)	2023 Q1	COVERAGE
SDG-19-02	Open Data Cube algorithms for the SDGs	2022 Q4	SEO
SDG-20-03	Satellite data requirements for SDG Indicator 6.6.1 (Water-related ecosystems)	2022 Q2	SDG Coordination Group
SDG-20-04	Satellite data requirements for SDG Indicator 11.3.1 (Sustainable urbanization)	2022 Q2	SDG Coordination Group
SDG-20-05	Satellite data requirements for SDG Indicator 14.1.1 (Marine Pollution)	2022 Q2	COAST AHT
SDG-20-06	Satellite data requirements for SDG Indicator 15.3.1 (Land Degradation Neutrality)	2022 Q2	SDG Coordination Group
SDG-20-07	EO Enabling Infrastructures for SDGs (for SDG EO Toolkits)	2022 Q4	SDG Coordination Group WGISS SEO
SDG-20-08	EO Good Practice Guidance (for SDG EO Toolkits)	2022 Q4	SDG Coordination Group
SDG-20-09	EO Demonstration Cases for SDGs (for SDG EO Toolkits)	2022 Q4	SDG Coordination Group SEO
BON-21-01	Explore the relationship between biodiversity and ecosystem function at different scales by combining satellite data with <i>in situ</i> data and models	2022 Q4	CEOS Biodiversity Expert
BON-21-02	Explore concepts to improve the operational connection between BONs and broader information systems	2022 Q3	CEOS Biodiversity Expert
SDG-22-01	CEOS SDG web portal	2022 Q4	SEO
WAT-22-01	Provide inputs for coastal sediment, coastal eutrophication and Blue Carbon pilot projects being co-designed and co-developed on a regional basis in concert with GEO Blue Planet, GEO AquaWatch, MBON and associated downstream stakeholders	2022 Q4	COAST AHT

### 3.12. CEOS Services

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

#### I. Accessibility of CEOS Agencies Datasets

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

**Responsible CEOS Entity:** WGISS

#### II. Radiometric Calibration Network (RadCalNet)

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

Following an initial developmental period with four sites, and an opening to the community in 2018, a fifth site was added (July 2020) following a peer review of the site against the membership criteria. Over the next few years, we anticipate small evolutions in documentation and procedures both at individual sites and at network level to account for improvements in technology, methodology and feedback from users. Whilst continuing to expand the range and number of users, we also anticipate and encourage membership of new sites. Increased number will not only increase access and temporal availability of data but also the variety of spectral radiometric properties of the target surfaces facilitating further improvements in the range of sensor characteristics that can be evaluated.

**Responsible CEOS Entity:** WGCV



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

Update and verify the content of the ECV Inventory based on contributions by data providers and publish the annual version on [cimatemonioring.info](http://cimatemonioring.info). Completion date is recurrent: Q4 every year from 2019 onward.

**Responsible CEOS Entity:** WGClimate

### **IV. Essential Climate Variable (ECV) Inventory Gap Analysis**

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

**Responsible CEOS Entity:** WGClimate

### **V. Coordinated Action Plan – Climate**

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

**Responsible CEOS Entity:** WGClimate

### **VI. Space Agencies Statement to UNFCCC/SBSTA**

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

**Responsible CEOS Entity:** WGClimate

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

The CEOS Database (a.k.a., the Missions, Instruments and Measurements Database, or MIM) is the only official consolidated statement of CEOS Agency programs and plans. Each year, the database will be updated based on survey inputs provided by all CEOS Agencies to reflect the current status of CEOS Agency missions and instruments. The European Space Agency (ESA) and the SEO have developed a number of analysis and visualization 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' capability 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, 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>).

In 2020, the ESA CEOS MIM Database team will continue work on the development and promotion of new tools for, and in collaboration and coordination with, the community to discover and browse the information contained in the MIM, including content on GCOS, carbon, water, and other CEOS thematic activities.

**Responsible CEOS Entity:** ESA

### **VIII. Publish the CEOS Newsletter**

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

**Responsible CEOS Entity:** JAXA

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

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

**Responsible CEOS Entity:** SEO

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

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

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

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