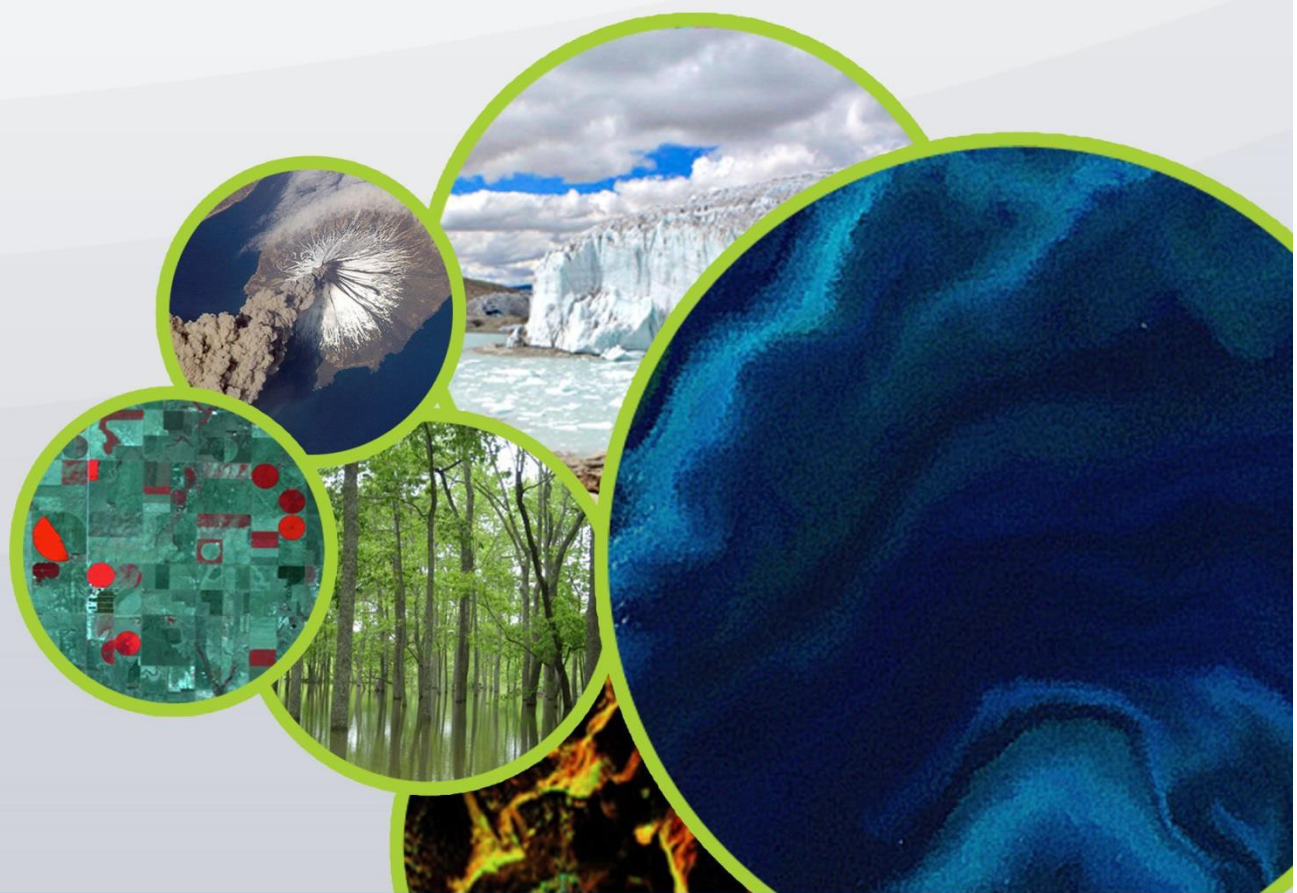




Committee on Earth Observation Satellites



2021-2023 Work Plan

March 2021 v1.0

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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 |
| SDG AHT | CEOS Sustainable Development Goals <i>Ad Hoc</i> Team |
| COVERAGE | CEOS Ocean Variables Enabling Research and Applications for GEO |

1. Introduction and Overview

The *2021-2023 CEOS Work Plan* has been developed by the CEOS Executive Officer (CEO) under direction of the CEOS Chair (National Aeronautics and Space Administration [NASA]), in consultation with the CEOS Strategic Implementation Team (SIT) Co-Chairs (Commonwealth Scientific and Industrial Research Organisation [CSIRO] / Geoscience Australia [GA]), 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 (2021) and summarises anticipated activities for the subsequent two years (2022-2023). Additional documents contributing information to this plan are located on the CEOS website (<https://ceos.org/>) and include: the *2020-2022 CEOS Work Plan*; the terms of reference for the CEOS Virtual Constellations and Working Groups; and a number of 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)¹.

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

2. CEOS Priorities

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

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

The 34th CEOS Plenary meeting was held virtually in 2020 due to travel restrictions imposed as a consequence of the COVID-19 global pandemic. The meeting reviewed the progress made in the priority areas of the outgoing CEOS Chair, the Indian Space Research Organisation [ISRO]. In 2020 ISRO's four priority initiatives had provided a specific focus for efforts in the following areas: Virtual Constellation gap analyses for priority measurements, including global studies of continuity; applications focused on Sustainable Development Goals (SDGs) for the BIMSTEC (Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation) Region, incorporating CEOS Data Cube architecture and CEOS Analysis Ready Data (ARD); renewable energy assessments (solar and wind) from space; and new tools for disaster management.

At the 34th Plenary, CEOS Principals endorsed the *CEOS Working Group on Disasters (WGDisasters) Strategy* paper; the *CEOS WGDisasters Recovery Observatory Demonstrator Implementation Plan*; the *CEOS WGDisasters Geostationary / Low Earth Orbit / Synthetic Aperture Radar Flood Risk Pilot Implementation Plan*; the *CEOS External Request Process* paper; the *Roadmap for Implementation of a Constellation Architecture for Monitoring Carbon Dioxide and Methane from Space (v2.4)*; the *CEOS Interoperability Terminology v1.0* document, the *CEOS Analysis Ready Data – Involving the Private Sector* paper and its recommendations; the updated *CEOS New Initiatives Process* paper and the *CEOS Statement to GEO Week 2020*. The CEOS Plenary also endorsed the creation of the CEOS Coastal Observations, Applications, Services, and Tools (COAST) *Ad Hoc* team to continue the activities started under the CEOS Coastal Observations and Applications Study Team in 2020. COAST and the CEOS Ocean Variables Enabling Research and Applications for GEO (COVERAGE) initiative have been submitted to the United Nations Decade of Ocean Science for Sustainable Development (2021-2030) to address international coastal stakeholder needs.

The incoming CEOS Chair (NASA) presented the priorities for 2021 as the continued advancement of activities in the CEOS 2020-2022 Work Plan, including the major focus areas of the current CEOS SIT Co-Chairs, CSIRO and Geoscience Australia: Analysis Ready Data; Carbon and Biomass; and support for UN Sustainable Development Goals (SDGs). The 2021 implementation year will leverage results from the 2020 CEOS Chair, ISRO, and the 2019 CEOS Chair, VAST-VNSC, with the aim to dedicate 2021 as a benchmark year to elevate and more widely communicate how CEOS actively realises its vision through

the theme: “*Space-based Earth Observation Data for Open Science and Decision Support*”. The intent is to consolidate existing activities in 2021 and to seek to broadly disseminate the relevance of CEOS contributions in support of Open Science and decision making.

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 (2022-2023), 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 2021-2023

The expected outcomes for 2021-2023 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 for Agriculture
- 3.4. Observations for Disasters
- 3.5. Observations for Water
- 3.6. Data Quality
- 3.7. Capacity Building and Data Democracy
- 3.8. Data Discovery, Access, Preservation, Usability and Exploitation: approaches, systems, tools and technologies
- 3.9. Advancement of the CEOS Virtual Constellations
- 3.10. Support to Other Key Stakeholder Initiatives
- 3.11. CEOS Services

The projected outcomes for each thematic area are summarised in short introductory paragraphs that list the objectives / deliverables to be pursued in 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 description of the Objective / Deliverable, background information, current status, and 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 our CEOS Deliverables to have an identified external link, i.e., to a particular GEO 2020-2022 Work Programme Flagship / Initiative / Community Activity¹ or UNFCCC / UNCBD / etc. activity. As of March 2021, there are 123 CEOS Deliverables, 106 existing and 17 newly created in 2021.

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

¹ https://www.earthobservations.org/documents/gwp20_22/gwp2020_summary_document.pdf

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, it recently chartered a Greenhouse Gas 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 **2021**, WGClimate will:

- Update and exploit the comprehensive Essential Climate Variable (ECV) Inventory (Version 3) of climate data records 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 2021, WGClimate will refine and finalise the Version 3 analysis.
- 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 CO₂, CH₄ 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.
- Develop a strong continuous activity on demonstration of use cases for climate data records to encourage wider application of the 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.

In the following years, significant outputs will be:

- Updated versions of the ECV Inventory, Gap Analysis Report and Coordinated Action Plan.
- The coordination of delivery of CO₂ 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 CO₂ monitoring, including from Agriculture Forestry and Other Land Use (AFOLU).
- The publication of a use case report (transferred to the use case action in *CEOS Services* section).

| Number | Objective/Deliverable Title | Projected Completion | Responsible CEOS Entity(ies) |
|------------|---|----------------------|------------------------------|
| CMRS-19-03 | Support to the GCOS Status report on observing systems for climate monitoring | 2021 Q3 | WGClimate |
| 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) | 2021 Q2 | WGClimate |
| CMRS-19-06 | Implement Coordinated Actions 5 on FCDR Inventory, 6 on nomenclature document for CDRs, 10 on meta data standards | 2021 Q3 | WGClimate |
| CMRS-20-01 | Implement plan for case studies on CDRs | 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).

2021: 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 in particular 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.

2022-2023: 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 program
- Analysis Ready Data (ARD) trials and pilots in the GFOI community, 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 GFOI Methods and Guidance Document (MGD)

The LSI F&B Team will seek to ensure that the CEOS work in support of GFOI is consistent with, and supportive of, the broader CEOS Carbon Strategy activities, including any periodic stocktake role for CEOS in relation to the Paris Climate Agreement and the Intergovernmental Panel on Climate Change (IPCC).

Further work is expected in relation to the promotion and implementation of the Forest Biomass

Reference Network (FBRN) proposed by the WGCV LPV Biomass team, and promoted through the SIT Chair Team and others via CEOS partners in GFOI and GEO.

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 the three domains— atmospheric, oceanic and terrestrial — and their interfaces, and identifies a number of recommended actions to be completed by space agencies.

At the 30th CEOS Plenary Meeting, CEOS determined a number of targeted initiatives to advance to implementation of the *CEOS Strategy for Carbon Observations from Space*. These initiatives are cross-cutting 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 2021-2023 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.

2021: 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 1st Global Stocktake (GST1). In parallel, the LSI F&B team is planning to deliver Agriculture, Forestry and Other Land Use (AFOLU) products, in support of GST1, in time for promotion at COP-26 in November 2021. They will subsequently build on this and develop a Roadmap document that complements the GHG Roadmap for the land sector. CEOS Agencies will be asked to support the dataset production through 2021 and into 2022.

2022-2023: 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 GST1 in 2023.

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

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

The SIT Chair has asked that CEOS give full consideration to the opportunities provided by the UNFCCC global stocktake 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 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: First steps will include a number of activities in 2021, including: a virtual GHG-AFOLU workshop; and a strategy paper proposing a comprehensive approach of CEOS and its agencies in support of the GST process. CEOS will also engage in the UNFCCC *ad hoc* group on Systematic

Observation support to 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 revisit the issue of CEOS observer status in UNFCCC.

2022-2023: Subject to the anticipated SIT-36 discussion, and Plenary endorsement and direction and to clarity on the 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 stocktake process, including as a result of the work of the GHG and AFOLU Roadmap activities, related measures recommended by the GST Strategy paper, and the GFOI support from LSI F&B team.

| Number | Objective/Deliverable Title | Projected Completion | Responsible CEOS Entity(ies) |
|------------|--|----------------------|--|
| CARB-17-05 | Cal/Val and production of biomass products from CEOS Agency missions | 2022 Q4 | WGCV |
| CARB-19-02 | Phase II R&D Program for GFOI | 2022 Q1 | LSI-VC Forests Team CEOS GFOI Lead |
| CARB-19-03 | Early Warning Module for GFOI | 2021 Q1 | LSI-VC Forests Team CEOS GFOI Lead |
| CARB-19-04 | Forest Biomass measurements for GFOI countries | 2022 Q1 | WGCV LSI-VC Forests Team CEOS GFOI Lead |
| CARB-19-05 | Forest applications in support of the CEOS ARD Strategy | 2021 Q4 | LSI-VC Forests Team CEOS GFOI Lead |
| CARB-20-01 | Develop a CEOS AFOLU roadmap | 2022 Q2 | LSI-VC Forests Team SIT Chair CEOS GFOI Lead LSI-VC GEOGLAM Team WGClimate (GHG Task Team) |
| CARB-20-02 | Integrated Carbon Cycle interface between CEOS and the UNFCCC | 2021 Q4 | WGClimate (Chair and GHG Task Team) SIT Chair CEOS GFOI Lead LSI-VC GEOGLAM Team |
| CARB-20-04 | Space Data support to GFOI Capacity Building component | 2021 Q4 | LSI-VC Forests Team |
| CARB-20-05 | Support and encourage space data uptake in GFOI countries | 2021 Q4 | LSI-VC Forests Team |
| CARB-21-01 | GST1 Prototype Products and Guidance | 2021 Q4 | LSI-VC Forests Team WGClimate GHG Task team SIT Chair |
| CARB-21-02 | National Inventory Users Test Group | 2021 Q2 | LSI-VC Forests Team CEOS GFOI Lead WGClimate/GHG Task Team |
| CARB-21-03 | Forest Biomass Reference Network (GEO-TREES) | 2022 Q4 | WGCV LPV LSI-VC Forests Team CEOS GFOI Lead SIT Chair |
| CARB-21-04 | CEOS UNFCCC GST Strategy | 2021 Q2 | SIT Vice-Chair |

3.3. Observations for Agriculture

GEO Global Agricultural Monitoring Initiative (GEOGLAM) aims to enhance agricultural production estimates through the use of Earth observations in order 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 2021 – 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. Action AGRI-19-04 is a reflection of this. GEOGLAM is internally undertaking this definition and specification process of required products as well as their co-dependencies, with an expected completion of Q4 2021. 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 set 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 operationalization utilizing EO (e.g., EO data coverage, EO access, EO utilization, training data + validation, computing infrastructure, training). With respect to “Training Data + Validation,” as has already been mentioned in AGRI-19-04, conversations with CEOS WGCV Land Product Validation subgroup are expected, and it remains in 2021 for that relationship to be established.
- **GEOGLAM EO Data Requirements:** very minor adjustments are expected to the GEOGLAM EO Data Requirements only 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.

With respect to both of these activities, CEOS and its constituent agencies will be apprised of relevant updates, including in the next round of CEOS Response to GEOGLAM’s EO Data Requirements.

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

- **A White Paper Produced by CEOS LSI-VC GEOGLAM on Data Quality Control & Assessment:** In light of the recent proliferation of data streams and associated products from CEOS agency missions, many users expressed uncertainty about which products were appropriate for their applications as well as how to gain access to them. Interoperability between sensors was consistently referenced as of utmost importance. A white paper explainer on which data sources and space-agency funded products are suitable for which applications would be valuable.

- **Analysis Ready Data (ARD) and Application Ready Data (ARD+):** the CEOS Analysis Ready Data for Land (CARD4L) is useful to highly trained remote sensing technicians with adequate computational infrastructure or access to cloud-based data processing modalities (e.g., CEOS Data Cube). There was agreement 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 has launched a CapDev Team as of 2019 and is already coordinating with 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.”

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

2021: 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 2021 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.

| 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” | 2021 Q4 | LSI-VC GEOGLAM Team |
| AGRI-20-01 | CEOS Response to GEOGLAM Requirements | 2021 Q3 | LSI-VC |

3.4. 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. 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 pursuit of these primary objectives, in 2021 the WGDisasters will contribute to the monitoring of the implementation of this Framework, support the ongoing work of international initiatives to include

GEO, strive to increase the awareness of decision-makers of the critical role of satellite EO, and reinforce the need for enhanced satellite EO Programs to better address Disaster Risk Management needs.

Specifically, the WGDisasters expects to complete the development of several ongoing Pilot activities to Demonstrators as well as the formulation of a new Pilot activity. The WGDisasters organises new activities as Pilots that demonstrate feasibility of a stated objective and, if successful, these activities will evolve into Demonstrators that address integration and sustainability by WGDisasters stakeholders and partners. Endorsed during the 34th CEOS Plenary, the Haiti Recovery Observatory transitioned to a Generic Recovery Observatory Demonstrator and a new GEO/LEO/SAR Flood Pilot was launched. A Landslide Pilot to a Landslide Demonstrator transitional Implementation Plan, as well as a new Wildfire Pilot Implementation Plan, will be submitted for endorsement at CEOS SIT-36. Existing Demonstrator activities (Seismic and Volcano Demonstrators) as well as Joint WGDisasters/GEO Work Programme 2020-2022 Elements (GEO-DARMA, GSNL) will produce annual Reports.

Regarding the 2021-2023 timeframe, the WGDisasters will support the overlapping CEOS/GEO Work Plan/Programme Deliverables/Activities to include a Geohazards Supersites and Natural Laboratory (GSNL) Evolution Feasibility Study and support a select number of new GEO-DARMA (Data Access for Risk Management) regional projects from a satellite EO perspective. The GEO/LEO/SAR Flood Pilot will report on effective Best Practices and value of data and methodologies shared by Pilot Team members to CEOS member Agencies. The additional Demonstrator activities will produce reporting products in accordance with specified WGDisasters Deliverables.

| Number | Objective/Deliverable Title | Projected Completion | Responsible CEOS Entity(ies) |
|-----------|--|----------------------|--------------------------------|
| DIS-15-04 | Implementation of data coordination for the GEO GSNL initiative | 2021 Q2 | WGDisasters |
| DIS-19-01 | Volcano demo reports | 2021 Q4 | WGDisasters |
| DIS-19-02 | Pursue the standardization of geohazards EO-products and produce report | 2021 Q4 | WGDisasters |
| DIS-19-03 | Seismic Demonstrator and Report | 2021 Q4 | WGDisasters |
| DIS-19-04 | Final Haiti RO Report | 2021 Q1 | 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 |
| 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 | 2021 Q4 | WGDisasters |

3.5. Observations for Water

I. Development of Aquatic Analysis Ready Data for GEO AquaWatch

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 normalized water leaving radiance or reflectance. Through participation in CEOS COAST, GEO AquaWatch will leverage and benefit from the CEOS Earth Analytics Interoperability Lab under development in order to compare the ARD implementation approaches. This comparison will be about developing an aquatic ARD similar to 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
- Insure the interoperability of multi-sensor ARD data and data cubes through communication of best practices to the global water quality community
- 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.

3.6. Data Quality

The CEOS Working Group on Calibration and Validation (WGCV) continues to evaluate and recommend best practices for the characterization/calibration of satellite-based sensors, and the validation of satellite-based Earth Observation data products. The results of this work are the calibration and validation building blocks for data and tools that underpin the work of VCs and other WGs. For these underpinning activities, different tasks are focused within sub-groups and task teams focused on specific areas of interest. Three sub-groups serve, in particular, the calibration of sensors and their link to international acknowledged standards. Another two sub-groups 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.

2021-2023: 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 CO₂ and CH₄ 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 and the WGCV website within the CEOS interface.

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.

2021-2023: The WGCV will continue to strengthen its cooperation with GSICS in the topic of sensor calibration following the joint effort on a recommendation for a GSICS/CEOS solar spectrum that ensures interoperability. This includes a cross WG 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 CO₂ and CH₄ sensors.

2021-2023: 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 | 2021 Q4 | WGCV |
| CV-16-02 | Report on application of approaches for cloud masking | 2021 Q4 | WGCV |
| CV-17-01 | L1 top-of-atmosphere interoperability | 2021 Q4 | WGCV |
| CV-18-02 | Greenhouse gas reference standards for interoperability | 2021 Q3 | WGCV |
| CV-18-03 | Biomass validation protocols | 2021 Q2 | WGCV |
| FDA-18-05 | Inventory of space data product formats used by CEOS Agencies | 2021 Q4 | WGCV WGISS SEO |
| CV-20-01 | Surface Reflectance measurements Intercomparison exercise for vegetation (SRIX 4Veg) | 2022 Q4 | WGCV |
| CV-20-02 | Biomass Retrieval Intercomparison eXercise (BRIX-2) | 2021 Q4 | WGCV |
| CV-20-03 | DEMIX | 2021 Q4 | EC ESA |
| CV-20-04 | SAR Calibration inventory and joint use assessment | 2021 Q4 | WGCV SAR subgroup |
| CV-20-05 | Standards and metrics for scatterometers and wind retrievals | 2021 Q4 | WGCV |

3.7. Capacity Building and Data Democracy

I. Advance CEOS Data Democracy activities.

Through the CEOS Working Group for Capacity Building and Data Democracy (WGCapD), CEOS Agencies raise awareness of the value of EO data products and services to user communities, including support to locate and access data, products, and tools, and targeted training opportunities. WGCapD advocates for the coordinated sharing of EO resources for open science and decision-making support. WGCapD supports CEOS initiatives and helps WGs, AHTs, and VCs undertake their own capacity building initiatives, by providing guidance on best practices and transmitting to the WGCapD community information about training events.

Despite the COVID-19 pandemic impacts in 2020, WGCapD has offered a variety of training and capacity building activities, including in-person training workshops, webinars, massive open on-line courses (MOOCs), and makes efforts to better collect, coordinate, synergise and make available existing capacity-building resources for satellite Earth observation users in developing countries. WGCapD coordinated multiple webinars and virtual trainings on topics such as remote sensing in crop monitoring and assessment, analysis ready data, and air quality monitoring and forecasting. WGCapD also focused efforts on strengthening its infrastructure with updates to the CEOS Training Calendar, resources and templates available on the WGCapD webpages, and a knowledge portal that hosts information about trainings and their content. WGCapD also began convening regional capacity building coordination meetings in the Americas, Europe, Asia & Oceania, and Africa quarterly in March, June, September/October, and December. Another focus was on the design and formulation of the Earth Observation Training, Education, and Capacity Development Network, or EOTEC DevNet, which aims to improve coordination and enhancement of EO space-based asset providers and training providers in support of key global sustainable development outcomes.

2021-2023: WGCapD plans to continue delivering virtual trainings as we are able while pandemic limitations exist (and when appropriate will also offer in-person trainings) for users in developing countries on data access, awareness, processing, and on various applications.

The 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. Coordination across capacity building networks via EOTEC DevNet will be implemented 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 mitigation, and vulnerability.

The WGCapD also plans to continue collaborating with GEO to strengthen AmeriGEO, AfriGEO, and Asia-Oceania GEO (AOGEO) through training contributions at their respective meetings/workshops.

The 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.
 - Deliverables: CB-18-06, CB-18-09, CB-19-06, CB-20-01, CB-20-04, CB-20-05, CB-20-06, CB-20-07

- 2) For **regional work**:
 - Focus on support to three regional GEOs: AfriGEO, AmeriGEO, and AOGEO.
 - Support trainings in conjunction with regional societies and other meetings.
 - Leverage single-agency regional activities as possible.
 - Deliverables: CB-20-19, CB-20-20, CB-20-21, CB-20-22, CB-20-23, CB-20-24, CB-21-08
- 3) For **national work**:
 - Support national trainings where fitting.
 - Strengthen our understanding of national needs in other thematic areas.
 - Deliverables: CB-20-12, CB-20-13, CB-20-14, CB-20-15, CB-20-17, CB-21-09
- 4) For **infrastructure**:
 - Focus on sharing of best practices and resources, convening key stakeholders, and addressing users’ needs.
 - Deliverables: CB-20-05, CB-20-06, CB-20-07, CB-20-08, CB-21-01, CB-21-02, CB-21-03

| Number | Objective/Deliverable Title | Projected Completion | Responsible CEOS Entity(ies) |
|------------------------------------|--|----------------------|------------------------------|
| Global Deliverables | | | |
| CB-18-06 | Advanced Multi-lingual MOOC on Radar Backscatter | 2021 Q2 | WGCapD |
| CB-18-09 | Land Cover and Land Use Change MOOC | 2021 Q3 | WGCapD |
| CB-19-06 | Provide CB support to Hyperspectral Remote Sensing. | 2022 Q1 | WGCapD |
| CB-20-01 | Earth Observations Toolkit for Sustainable Cities and Human Settlements Training Webinar | 2021 Q4 | WGCapD |
| CB-20-04 | Jupyter Notebooks Awareness Webinar | 2021 Q4 | WGISS, WGCapD, SEO |
| CB-21-04 | Zero Hunger MOOC | 2022 Q2 | WGCapD |
| CB-21-05 | Capacity Development for Flooding Plan | 2021 Q4 | WGCapD |
| CB-21-06 | Space Based Observations for Meteorological Hazards | 2021 Q3 | WGCapD |
| CB-21-07 | MOOC on Disaster Risk Management | 2021 Q2 | WGCapD |
| Regional Deliverables | | | |
| CB-20-19 | Regional Training in South Asia on Forest Biomass | 2021 Q2 | WGCapD |
| CB-20-20 | SELPER Conference Engagement | 2022 Q4 | WGCapD |
| CB-20-21 | Copernicus User Uptake in Africa | 2023 Q4 | WGCapD |
| CB-20-22 | AOGEO Contribution | 2021 Q4 | WGCapD |
| CB-20-23 | AmeriGEO Contribution | 2021 Q3 | WGCapD |
| CB-20-24 | Remote Sensing Training in Africa | 2021 Q4 | WGCapD |
| CB-21-08 | Webinar Series: Image Restoration & Processing of SAR Data | 2021 Q2 | WGCapD |
| National Deliverables | | | |
| CB-20-12 | Collaborative Feasibility Study (Mexico) | 2021 Q4 | WGCapD, SEO |
| CB-20-13 | Indigenous Peoples-focused In-Person Training (Canada) | 2021 Q4 | WGCapD, SEO |
| CB-20-14 | Indigenous Peoples-focused In-Person Training (Australia) | 2021 Q4 | WGCapD, SEO |
| CB-20-15 | SAR Training for Forest and Rice Monitoring (Vietnam) | 2021 Q1 | WGCapD |
| CB-20-17 | Provide CB support to AGEOS on Forest Monitoring (Gabon) | 2022 Q4 | WGCapD |
| CB-21-09 | SAR Mini-MOOC: Winter, Water and Warming (Canada) | 2021 Q3 | WGCapD |
| CB-21-10 | EO-focused Webinar Series (Vietnam) | 2021 Q4 | WGCapD |
| Infrastructure Deliverables | | | |
| CB-20-05 | Establish the Earth Observation Training, Education, and Capacity Development Network (EOTEC DevNet) | 2021 Q2 | WGCapD |
| CB-20-06 | Metadata Standards Tiger Team | 2021 Q4 | WGCapD, WGISS |
| CB-20-07 | Best Practice Guide to E-Learning | 2021 Q3 | WGCapD |
| CB-20-08 | Virtual EO Education Conference | 2021 Q4 | WGCapD |
| CB-21-01 | CEOS Webinar Toolkit | 2021 Q2 | WGCapD |

| Number | Objective/Deliverable Title | Projected Completion | Responsible CEOS Entity(ies) |
|----------|--|----------------------|------------------------------|
| CB-21-02 | EOTEC DevNet Regional Community of Practice and Leadership Coordination Meetings | 2021 Q4 | WGCapD |
| CB-21-03 | EOTEC DevNet Tools and Information Collection | 2022 Q4 | WGCapD |

3.8. 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 and 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] Catalog 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 continue development of the five core areas of Future Data Architectures (FDA) 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 in an effort to realise benefits that go far beyond the traditional mono-mission approach. WGISS will continue, in the period 2021-23, its FDA 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.

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 and will support the development of a knowledge oriented GEOSS and GEOSS Knowledge-hub.

| Number | Objective/Deliverable Title | Projected Completion | Responsible CEOS Entity(ies) |
|------------|---|----------------------|------------------------------|
| DATA-17-04 | Technology Exploration webinars and workshops | 2021 Q4 | WGISS |
| DATA-18-02 | CEOS data holdings reported and accessible in GEO and other international relevant contexts | 2021 Q4 | WGISS |
| DATA-19-01 | Explore emerging trends and disrupting technologies (e.g. Artificial Intelligence), evaluate advantages / drawbacks for adoption in Earth observation and identify most relevant use cases. Summarize analysis in the form of white papers. | 2021 Q4 | WGISS |

| Number | Objective/Deliverable Title | Projected Completion | Responsible CEOS Entity(ies) |
|------------|---|----------------------|---|
| DATA-19-02 | Mekong Data Cube | 2021 Q4 | CEOS Chair VNSC LSI-VC GEOGLAM Team LSI-VC Forests Team CEOS GFOI lead SEO |
| FDA-17-02 | Collaborative development of CEOS Data Cube technology | 2021 Q4 | SEO |
| FDA-19-01 | Facilitate discovery and access for end users to data analytics and processing tools and services through the WGISS Connected Data Assets Infrastructure. | 2021 Q4 | WGISS |

3.9. Advancement of the CEOS Virtual Constellations

- I. **Characterize 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.**

2021-2023: 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 2021 focus on a novel initiative for fusion of aerosol information from multiple sources (including satellites, ground observations, and models) to improve global estimation of surface air quality associated with aerosol.

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 task team within the Working Group on Climate.

LSI-VC

The CEOS Land Surface Imaging Virtual Constellation (LSI-VC) served as the forum for developing CEOS Analysis Ready Data (ARD) for Land (CARD4L). The completion of the first CARD4L Product Family Specifications (PFS) was a key milestone in the CEOS effort to lower the barrier to broad utilisation of space-based data. Hurdles remain in relation to data production, accessibility and usability, in particular.

LSI-VC ARD efforts in 2021-2023 are in line with the ambitions of the CEOS ARD Strategy, covering

four key areas:

1. CEOS ARD User Needs & Specifications
2. Assured Production and Access
3. Pilots and Feedback
4. Communication & Promotion

As well as adding to the collection of Product Family Specifications (LIDAR, Aquatic Reflectance, InSAR, Geocoded SLC, Nightlight Radiance) and maintaining and assessing products against the Specifications, a key task will be contributing to the SIT Chair-led effort to establish the governance and framework for an expanded CEOS ARD – one which goes beyond the land domain.

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 and contributing to the CEOS effort on the UNFCCC Global Stocktakes.

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 understanding 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,
4. Supporting and engaging 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. Key recent activities include the publication on the CEOS website of the SST Constellation Whitepaper “Current and sea surface temperature missions: Towards 2050” in collaboration with the Group for High Resolution SST (GHRSS) project and an initial survey of the GHRSS MODIS Aqua/Terra L2P SST datasets for ARD readiness via the CARD4L Product Family Specification.

The SST-VC coordinated and moderated the “CEOS Analysis Ready Data: Beyond Land” session at the 2020 CEOS SIT Technical Workshop and presented a summary for findings, recommendations and proposals at the CEOS-34 Plenary. From this a decision was adopted (CEOS 34-13):

“SIT Chair and Ed Armstrong (SST-VC Co-Lead) to form a team of experts to review the CEOS ARD Framework (Definition, Specifications and processes around CEOS ARD) for completeness and suitability (including looking at changes that make it amenable to non-land domains).”

Upcoming efforts for 2021-2022 are to primarily address this need for reviewing and revising the CARD4L specifications with the goal of delivering recommendations to make it more applicable to non-land domains. The expert team has been assembled and an initial teleconference was held in January 2021.

OST-VC

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

Upcoming efforts for 2021-2022 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 2021-23 will focus on Aquatic Carbon from Space, a journal special issue and a community workshop, to define the foundations for a CEOS Aquatic Carbon Strategy. The OCR-VC is also 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 covered with the goal of supporting the integration of OCR missions and methodologies and are now transitioning from support to COVERAGE Phase-B prototype development to Phase-C full implementation. OCR capacity building is continuing and providing new resources to users.

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 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 the 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 here is to coordinate the sampling of the wind measurements at the time scales which are required for a large variety of applications.

A related discussion on how to involve the perspective and needs of the user community recently took place at CGMS plenary. In this context it was proposed to develop a task team comprising CEOS and CGMS representatives, to optimise the requirements and propose a plan for an optimum constellation to meet the objectives. During the year 2021-22, the team will have discussions involving IOVWST and CGMS International Winds Working Group (IWWG) members. The OSVW-VC plans to have detailed discussions during IOVWST 2021, and during a Special Session on the status and progresses of the OSVW-VC at IGARSS-2021.

As part of a cross-cutting activity with the CEOS WGCV, scatterometer datasets for the OSVW standards are being shared between agencies and interested users, as a step toward a consolidation of standards and metrics for the calibration of the wind measurements. A related Special Session in IGARSS-2021 on the consolidation of standards and metrics for optimised scientific and operational applications to discuss the various related aspects has also been organised.

| 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) | 2021 Q4 | OCR-VC |
| VC-14-14 | Vision for an OSVW Constellation | 2021 Q4 | OSVW-VC |
| VC-14-15 | OSVW Standards and Metrics | 2022 Q1 | WGCV 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-18-03 | CARD4L Product Family Specifications (PFS) | 2022 Q4 | LSI-VC |
| VC-18-07 | Gap Analysis Tools | 2021 Q4 | SEO MIM Database Team LSI-VC |
| VC-19-03 | CARD4L Product Assessments | 2022 Q4 | LSI-VC WGCV |
| VC-19-05 | Open-source library for surface reflectance product generation | 2021 Q1 | LSI-VC |
| VC-19-06 | Update of CEOS OST-VC User Requirements Document | 2022 Q1 | OST-VC |
| 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 | 2021 Q4 | AC-VC |
| VC-20-06 | Water Leaving / Aquatic Reflectance CARD4L PFS | 2021 Q2 | LSI-VC |
| VC-20-07 | Identify the need for and prioritize development of future target products as the basis for new CEOS ARD specifications | 2021 Q4 | SIT Chair |

| Number | Objective/Deliverable Title | Projected Completion | Responsible CEOS Entity(ies) |
|----------|---|----------------------|------------------------------|
| VC-20-08 | Engage Big Data hosts and aggregators and establish formal pipelines and procedures to promote CEOS ARD hosting and uptake on their platforms | 2021 Q4 | SIT Chair LSI-VC SEO |
| VC-20-10 | CEOS–Industry ARD Workshop | 2022 Q4 | LSI-VC SIT Chair |
| VC-20-12 | Promote CEOS ARD to data providers | 2022 Q4 | SIT Chair |
| VC-20-13 | Precipitation Constellation white paper | 2021 Q1 | P-VC |
| VC-20-14 | IPWG/GEWEX Precipitation Assessment white paper | 2021 Q2 | P-VC |
| VC-20-15 | Community engagement | 2022 Q1 | P-VC |
| VC-20-16 | Precipitation product new version: GSMaP | 2021 Q2 | P-VC |
| VC-20-17 | GPM L2A precipitation products | 2021 Q4 | 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 | 2023 Q4 | OCR-VC |
| VC-20-27 | Development of protocols for bio-optical in situ measurements | 2021 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 |

3.10. Support to Other Key Stakeholder Initiatives

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

2021: 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 at harnessing all expertise inside and outside GEO (including CEOS) in order 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.
- Contributing to the development of the GEO Toolkits on SDGs led by GEO EO4SDG, and which will package all available EO assets (datasets, software tools, IT platforms, best practices examples, capacity building material) in 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 CEOS-COAST). This analysis will help CEOS Agencies to have a precise understanding of the satellite data, coverage, frequency, resolution, etc., which are needed by 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 LSI-VC), on EO-enabling infrastructures (with SEO and WGISS) and on EO products validation (with WGCV) to harness CEOS collective expertise and maximise benefits for the CEOS Agencies and for the SDG stakeholders.

CEOS Agencies will continue to contribute to the CEOS SDG *Ad Hoc* Team (SDG-AHT) work plan by providing relevant and updated information about satellite data (in an accessible format), tools and existing methods to facilitate the use of EO data in SDG monitoring and reporting.

The CEOS SDG-AHT has streamlined its work plan, clarifying CEOS and GEO's remits, and focusing its activities on three plus one primary indicators: 6.6.1 on water extent, 11.3.1 on urbanisation, 15.3.1 on land degradation, as well as 14.1.1 on coastal eutrophication, which will be addressed by the newly formed Coastal Observations Applications Services and Tools (COAST) *Ad Hoc* Team, in close collaboration with SDG-AHT and the GEO Blue Planet initiative. The four indicators will be individually assessed and managed by three SDG sub-teams and COAST (14.1.1).

2022-2023: Should the SDG-AHT be renewed after the 2020 CEOS Plenary or, should CEOS Principals decide to pursue CEOS activities on SDGs with another internal mechanism, the above activities will be continued after 2021.

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

2021-2023: CEOS Agencies will continue to develop and distribute experimental and operational data, products, and services, along with the further evolution of the proposed COVERAGE model 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.

2021-2023: Essential Biodiversity Variables (EBVs) are a collection of (currently) 23 biological variables that capture key dimensions of biodiversity and how it is 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 UN Sustainable Development Goals and the Convention on Biological Diversity. Remotely-sensed data can play a central role in many EBVs, and a supportive role in most of them.

The recent update to the list of EBVs (Deliverable BON-19-02, now closed) marks the beginning of the next phase in EBV development and application, and for GEO BON as well. In fact, this new phase coincides with a change in GEO BON leadership following the expiration of the second term of its two co-chairs. Consequently, two new co-chairs, as well as a new Montreal-based Secretariat, were selected and began work at the start of 2021. GEO BON, along with other organisations, will continue to engage with CEOS through the Biodiversity activity.

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 nascent EBV Data Portal, which provides access to data relevant to the EBVs, will continue to be developed and iDiv in Leipzig will continue to host it. Further development of workflows that provide important data products such as indicators, and tying these into GEO BON's Biodiversity Observation Networks, is also planned.

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 explore concepts for developing a Biodiversity Information System that could provide products that are not yet available but needed to support CBD and SDG Goals and Targets.

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 as a three-year 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. This included CEOS work plan deliverables COV-1 through COV-3: 1) assembly of the execution team and advisory board; 2) Compilation of use cases, data inventory, functional requirements and system architecture for the COVERAGE system; and 3) development of the detailed COVERAGE project implementation plan and schedule for the Phase B.

COVERAGE Phase B (COV-17-04 deliverable) successfully concluded in Q4 2020. It 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>.

2021. COV-18-01: Phase C of the COVERAGE project is projected to commence in the first quarter of 2021 as a planned 18-month activity. 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 our 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 Agencies.

2022. 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 (COV-6). 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.

V. CEOS Coastal Observations, Applications, Services and Tools *AD HOC* TEAM

COAST (Coastal Observations, Applications, Services and Tools) is a dedicated coastal-focused *ad hoc* team helping bridge land and aquatic observations within CEOS and, given its cross-cutting nature, help integrate across multiple CEOS entities and domains, both thematic (e.g., Disasters, Sustainable Development Goals [SDGs], and Capacity Development) and technical (e.g., VCs: Ocean, Land and Atmosphere, calibration and validation, and COVERAGE). The *Ad hoc* Team is advancing 2 pilot projects that leverage the CEOS Analysis Ready Data (ARD) framework already demonstrated for terrestrial applications. COAST 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 is expected 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 DataCube(s). Close collaboration with WGDisasters, WGISS, and WGCapD are expected to continue under COAST’s NOAA and ISRO co-leadership team. COAST hopes to be selected as a UN Ocean Decade Programme and to coordinate with other global entities to support A Predicted Ocean, among other UN Decade Outcomes.

COAST’s 2021-22 deliverables will be defined in 2021 and will 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 a joint GEO-CEOS COAST stakeholder engagement workshop series, slated for September 2021. There will be a workshop report as an outcome from the workshop series. The two pilots expect to take the workshop outcomes and further inform product development as part of the team’s co-design/co-development strategy.

In 2022-23 COAST expects to engage in product demonstration, training, and capacity development of pilot products in initial geographical regions. Expansion of demonstrated products into new geographical regions is also expected.

| Number | Objective/Deliverable Title | Projected Completion | Responsible CEOS Entity(ies) |
|-----------|--|----------------------|-------------------------------------|
| COV-18-01 | COVERAGE Phase C system | 2021 Q1 | COVERAGE |
| COV-18-02 | COVERAGE system evaluation (Phase D) | 2022 Q3 | COVERAGE |
| SDG-19-02 | Open Data Cube algorithms for the SDGs | 2021 Q4 | SEO |
| SDG-20-03 | Satellite data requirements for SDG Indicator 6.6.1 (Water-related ecosystems) | 2021 Q4 | SDG AHT (Water Sub-team) |
| SDG-20-04 | Satellite data requirements for SDG Indicator 11.3.1 (Sustainable urbanization) | 2021 Q4 | SDG AHT (Urban Sub-team) |
| SDG-20-05 | Satellite data requirements for SDG Indicator 14.1.1 (Marine Pollution) | 2021 Q4 | COAST SDG AHT |
| SDG-20-06 | Satellite data requirements for SDG Indicator 15.3.1 (Land Degradation Neutrality) | 2021 Q4 | SDG AHT (Land Degradation Sub-team) |
| SDG-20-07 | EO Enabling Infrastructures for SDGs (for SDG EO Toolkits) | 2021 Q4 | SDG AHT WGISS SEO |

| Number | Objective/Deliverable Title | Projected Completion | Responsible CEOS Entity(ies) |
|-----------|--|----------------------|------------------------------|
| SDG-20-08 | EO Good Practice Guidance (for SDG EO Toolkits) | 2021 Q4 | SDG AHT |
| SDG-20-09 | EO Demonstration Cases for SDGs (for SDG EO Toolkits) | 2021 Q4 | SDG AHT 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 Q2 | CEOS Biodiversity Expert |
| WAT-20-01 | Provide inputs for coastal sediment and coastal eutrophication pilot projects being co-designed and co-developed in concert with GEO Blue Planet, GEO AquaWatch and associated downstream stakeholders | 2021 Q4 | COAST AHT |

3.11. CEOS Services

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

I. Accessibility of CEOS Agencies Datasets

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

Responsible CEOS Entity: WGISS

II. Radiometric Calibration Network (RadCalNet)

The CEOS WGCV RadCalNet service provides all satellite operators (agencies and commercial) with access to ‘free and open’ SI-traceable Top-of-Atmosphere (TOA) spectrally-resolved reflectances to aid in the post-launch radiometric calibration and validation of optical imaging sensor data (www.radcalnet.org). This is an essential pre-requisite to achieving sensor-to-sensor 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. 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 is issued twice per 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.