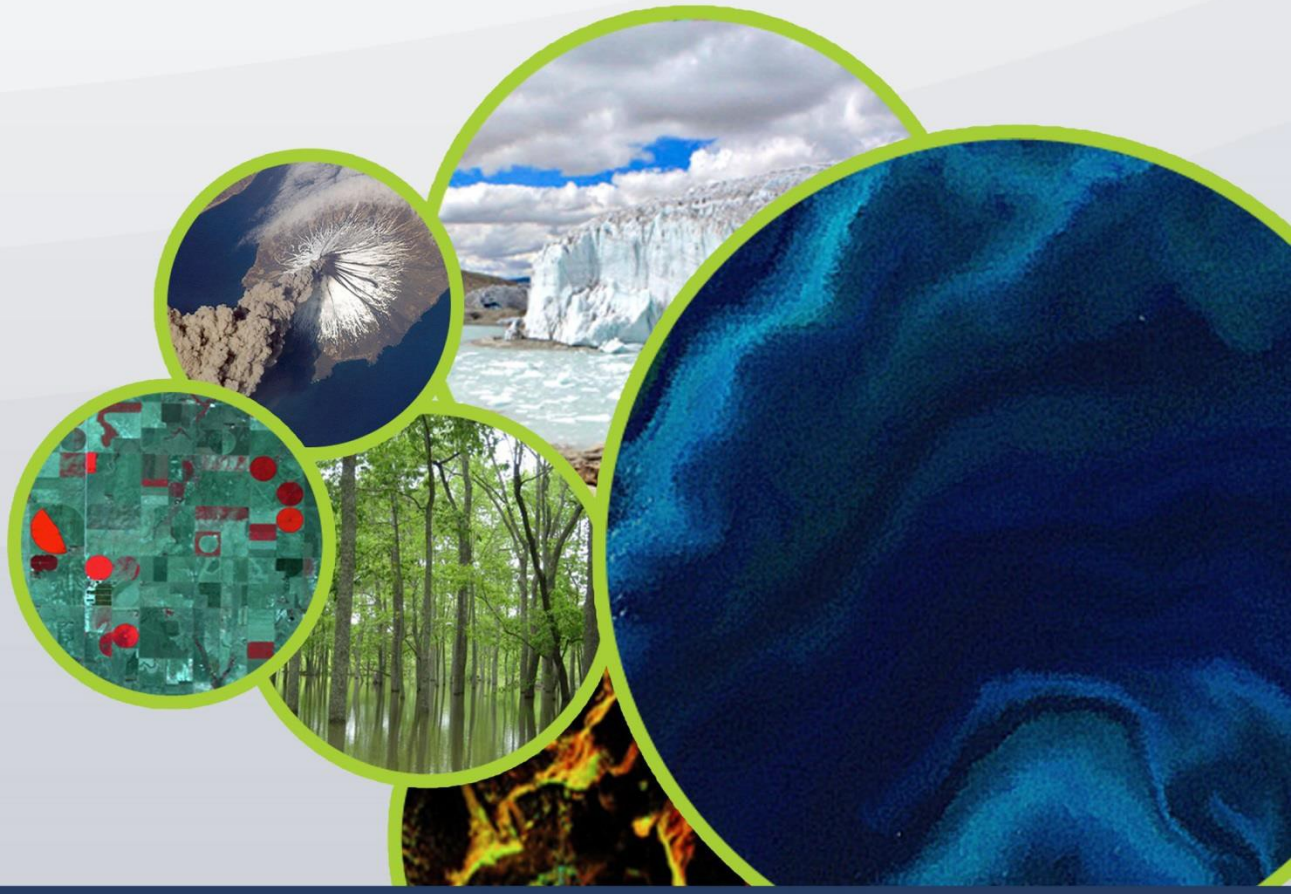
Committee on Earth Observation Satellites



2020-2022 Work Plan

July 2020 v1.1

Contents

1. Introduction and Overview

The *2020-2022 CEOS Work Plan* has been developed by the CEOS Executive Officer (CEO) under direction of the CEOS Chair (Indian Space Research Organisation [ISRO]), 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 (WG), CEOS Virtual Constellations (VC), CEOS *Ad Hoc* Team, the CEOS Systems Engineering Office (SEO), CEOS Agencies at large, and CEOS's external stakeholders. The purpose of this document is to set forth near-term objectives and deliverables designed to achieve the goals outlined in the *CEOS Strategic Guidance* document. It includes a description of CEOS activities to be executed in the current calendar year, and summarizes anticipated activities for the subsequent two years (2021-2022). Additional documents contributing information to this plan are located on the CEOS website (http://ceos.org/) and include: the *2019-2021 CEOS Work Plan*; the *2019-2021 CEOS Work Plan* Progress Report; 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, 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 optimize 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 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 organizations participating in treaties and global programs affiliated with the United Nations (UN)[1].

[1] These treaties, international organizations, and international programs include United Nations Framework Convention on Climate Change (UNFCCC), 2030 Agenda for Sustainable Development (the SDGs), UN Office for Disaster Risk Reduction (UNDRR), UN Convention to Combat Desertification, and Convention on Biodiversity (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 33rd CEOS Plenary meeting held in Hanoi, Viet Nam in 2019 reviewed the progress made on the priority areas of the outgoing CEOS Chair, Vietnam Academy of Science and Technology/Vietnamese National Space Centre (VAST/VNSC). VAST/VNSC's priorities for 2019 focused on two specific applications utilizing Open Data Cube software: Carbon observations, including forested regions, and observations for agriculture, with a focus on the Mekong basin, which is a cross-border region strongly affected by climate change and human activities. Also at the 33rd Plenary, CEOS Principals endorsed the CEOS Analysis Ready Data (ARD) Strategy, the CEOS Response to the GEO Agricultural Monitoring (GEOGLAM) Requirements 2019, and the Geostationary Satellite Constellation for Observing Global Air Quality: Geophysical Validation Needs White Paper. Lastly, CEOS Principals agreed to the establishment of the CEOS Coastal Observations and Applications Study Team (COAST).

The incoming CEOS Chair (ISRO) presented four initiatives as priorities for 2020: Virtual Constellation gap analyses for priority measurements, including global studies of continuity; applications focused on Sustainable Development Goals (SDGs) for the BISTEC (Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation) Region, incorporating Data Cube technology and CEOS ARD; renewable energy assessments (solar and wind) from space; and new tools for disaster management.

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 (2021-2022) this document summarizes 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* Team(s) may prepare separate, more detailed Work Plans that complement this overall guiding Work Plan.

3. Expected Outcomes for 2020-2022

The expected outcomes for 2020-2022 reflect the ongoing and emerging priorities of CEOS, as characterized 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:

The projected outcomes for each thematic area are summarized 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 http://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 Activity (separate field for this link) or UNFCCC/UNCBD/etc. activity.

Changes to Format of 2020-2022 Work Plan

As of July 2020, there are 136 CEOS Deliverables, 53 existing and 83 new. To address the large number of Deliverables and to facilitate tracking and reporting on Deliverables, an updated renaming convention system has been instituted with the 2020-2022 Work Plan, requiring a renumbering of existing Deliverables. Please see Appendix A for a remapping of the 2019 to 2020 Deliverables. The format of the Deliverables is now:

XX(XX)-YY-01 (2 to 4-character identifier-2-digit year-2-digit number, beginning at 01 for each year)

There is also a new "CEOS Services" section, which includes ten routine actions and services of CEOS such as the CEOS Newsletter, the Missions, Instruments, and Measurements Database, the Essential Climate Variables Inventory, and other organizational actions with annual and concrete deadlines.

3.1. Climate Monitoring, Research, and Services

CEOS and the Coordination Group for Meteorological Satellites (CGMS) have committed to work together, through the Joint CEOS/CGMS Working Group on Climate (WGClimate), to monitor climate from space through the coordinated planning, production, improvement, and availability of space-based climate data records on a global scale. This work is focused towards implementation of the *Strategy Towards an Architecture for Climate Monitoring from Space* developed and endorsed by CEOS, CGMS and the World Meteorological Organization (WMO). The following sections summarize activity from the perspective of CEOS contributions to the joint effort, as well as CEOS-specific activities in the climate domain.

During **2020**, WGClimate will address:

- Update and exploitation of the comprehensive Essential Climate Variable (ECV) Inventory of climate data records including the implementation of coordinated actions arising from the analysis. The Inventory is the prime asset of the WGClimate that is used to identify issues in the future availability of measurements for the Global Climate Observing System (GCOS) ECVs leading to actions mitigating such issues by improving coordination on long-term mission planning. In addition, the gap analysis is looking for opportunities for improvement of data records and their usage along the climate information value chain outlined by the *Architecture*. It also supports efforts to communicate progress of the satellite coordination community within the United Nations system and more broadly.
- Coordination of CEOS and CGMS activities towards the definition and implementation of an integrated operational global carbon observing system including a targeted observing system for monitoring the column concentrations of CO_2, CH_4 and other greenhouse gases from space. A more consolidated roadmap will be presented in 2020 with updates of the planning coming in the following years. This involves maintaining the strong relationship with the United Nations Framework Convention on Climate Change 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 demonstrating use cases for climate data records to ensure full usability of the satellite observation in applications. This is to validate the Architecture and to foster usage of satellite-derived Climate Data Records. The use cases may include cases for the use of the global carbon observing system by UNFCCC Parties that would be part of the user engagement process. In addition, also CEOS and CGMS capacity-building activities are targeted for cooperation as use cases developed for training activities certainly foster 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 CO_2 column concentration data for use in the UNFCCC Global Stocktake inclusive further user engagement cooperating with various other activities.
- Enhanced engagement with UNFCCC/SBSTA to better facilitate other CEOS contributions than atmospheric CO_2 monitoring.
- 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).	2020 Q4 2021 Q3 2026 Q3	WGClimate
CMRS-19-05	Update definitions for FCDR, CDR, ICDR (Coordinated Action 1)	2020 Q3	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, Including Forested Regions

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).

2020: 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 Working Group on Calibration and Validation (WGCV's) Land Product Validation (LPV) subgroup.

2021-2022: In subsequent years, 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 space data role in future updates of GFOI Methods and Guidance Document (MGD)

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 in relation to any periodic stocktake role for CEOS in relation to the Paris Climate Agreement and the Intergovernmental Panel on Climate Change (IPCC).

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*. 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 2020-2022 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.

2020: WGClimate will progress the GHG Constellation White Paper to develop a more detailed Roadmap and planning document to help coordinate the implementation of the Constellation. LSI F&B team has also initiated an equivalent document for the land sector, which aims to provide a set of dataset targets for agriculture, forestry and other land uses (AFOLU) that could be coordinated by CEOS Agencies in support of the first global stocktake of the UNFCCC in 2023. CEOS Plenary will be asked to endorse this AFOLU Roadmap and to support the dataset production through 2021 and into 2022.

2021-2022: The GHG Roadmap lays out actions to realize the implementation of the GHG Constellation in subsequent years. The AFOLU Roadmap is anticipated to identify actions required of CEOS agencies around the production of key datasets that could be provided by CEOS and space agencies in support of the 1st global stocktake.

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

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 - seeking to ensure an integrated process that assures policy relevance of CEOS data and links to the space agency planning processes from conventions and parties.

2020: First steps will include a number of events in 2020: a virtual GHG-AFOLU workshop; invitations to UNFCCC SEC and GCOS to a Strategic Implementation Team Technical Workshop (SIT TW) virtual session, in collaboration with WGClimate. Topics will include the opportunity for space agency and CEOS support to the global stocktake process. SIT Chair will revisit the issue of CEOS observer status in UNFCCC.

2021-2022: Subject to 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 important datasets into the stocktake process, including as a result of the work of the GHG and AFOLU Roadmap activities 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 missions	2022 Q4	WGCV
CARB-19-02	Phase II R&D Program for GFOI	2020 Q1	LSI-VC Forests Team
CARB-19-03	Early Warning Module for GFOI	2021 Q1	LSI-VC Forests Team
CARB-19-04	Forest Biomass measurements for GFOI countries	2022 Q1	WGCV LSI-VC Forests Team
CARB-19-05	Forest applications in support of the CEOS ARD Strategy	2021 Q4	LSI-VC Forests Team
CARB-19-06	Updated space data content in the 2019 GFOI Methods and Guidance Documentation (MGD)	2020 Q2	LSI-VC Forests Team
CARB-20-01	Develop a CEOS AFOLU roadmap	2021 Q4	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-20-03	CEOS Biomass Validation Workshop	2020 Q1	CSIRO WGCV LPV
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

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 2020 – 2022 with a focus on the first and second year of this 3-year period.

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 2020. 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 2020 for that relationship to be established.

- **GEOGLAM EO Data Requirements**: very minor adjustments are expected to the GEOGLAM EO Data Requirements only to ensure harmonization 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 action in which CEOS WGCapD will serve as a "reviewer" for GEOGLAM CapDev Team's forthcoming (Q4 2020) "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

2020: 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 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"	2020 Q4	LSI-VC GEOGLAM Team
AGRI-20-01	CEOS Response to GEOGLAM Requirements	2021 Q3	LSI-VC GEOGLAM Team

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 2020 the WG 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 WG expects to complete the development of several ongoing Pilot activities to Demonstrators as well as the formulation of a new Pilot activity. The WG organizes 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 WG stakeholders and partners. By the end of 2020, the Haiti Recovery Observatory will transition to a Generic Recovery Observatory Demonstrator, the Landslide Pilot to a Landslide Demonstrator and a new GEO/LEO/SAR Flood Pilot will obtain CEOS approval. 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 2021-2022 timeframe, the WG 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 out on effective Best Practices and value of data and methodologies shared by Pilot Team members to CEOS member Agencies. The additional WG Demonstrator activities will produce reporting products in accordance with specified WG Deliverables.

Number	Objective/Deliverable Title	Projected Completion	Responsible CEOS Entity(ies)
DIS-15-04	Implementation of data coordination for the GEO GSNL initiative	2020 Q4	WGDisasters
DIS-18-01	Report on follow-on actions to Landslide Pilot	2020 Q4	WGDisasters
DIS-19-01	Volcano demo reports	2021 Q4	WGDisasters
DIS-19-02	Pursue the standardization of geohazards EO-products and produce report	2020 Q1	WGDisasters
DIS-19-03	Seismic Demonstrator and Report	2020 Q3	WGDisasters
DIS-19-04	Final Haiti RO Report	2020 Q3	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 Q1	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 an 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. 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
- 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.

II. Engagement and Support for the GEO Blue Planet and GEO AquaWatch Initiatives

CEOS implemented the CEOS Coastal Observation and Application Study Team (COAST) in 2019. In 2020, CEOS-COAST has been actively engaging with both the GEO Blue Planet and AquaWatch

Initiatives to support the data and information needs of their respective users and stakeholders. As part of the CEOS-COAST "Land to Sea" Component, two pilot projects are being co-designed and co-developed in collaboration with Blue Planet and AquaWatch, focusing on characterization of loadings of nutrients and sediments in the coastal zone and their attendant ecological impacts. CEOS-COAST will:

- Assist AquaWatch and Blue Planet in data needs and requirements and development of metadata standards for CEOS COAST pilot projects.
- Assist Blue Planet and AquaWatch in providing suitable satellite data inputs for development of machine-learning based and transboundary coastal eutrophication and sediment loading indicators.

Number	Objective/Deliverable Title	Projected Completion	Responsible CEOS Entity(ies)
WAT-17-03	Response to satellite-related aspects of GEO AquaWatch Initiative Implementation Plan	2020 Q4	OCR-VC
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	CEOS-COAST

3.6. Data Quality

The CEOS Working Group on Calibration and Validation (WGCV) continue 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 in 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 characterization of satellite-based EO sensors, the on-orbit calibration of EO missions, and the validation of satellite-based Level 1 and Level 2 products.

2020-2022: As is evident throughout this document, the interoperability and utility of 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 the data providers for alignment with CARD4L and, contribute towards terminology definitions.

A similar effort will be undertaken related to GHG data products by developing a set of standards for CO_2 and CH_4 products that are suitable for inter-comparisons across multiple missions. WGCV will also collaborate with WGClimate and AC-VC contributing towards calibration and validation efforts on the 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.

2020-2022: 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 CO_2 and CH_4 sensors.

2020-2022: 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 WGCV will be used to promote these principles and best practices. 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 the Atmosphere, Terrestrial, and Ocean communities.

Number	Objective/Deliverable Title	Projected Completion	Responsible CEOS Entity(ies)
CV-14-03	Workshop on state of the art for pre-flight calibration techniques	2020 Q4	WGCV
CV-16-02	Report on application of approaches for cloud masking	2020 Q2	WGCV
CV-17-01	L1 top-of-atmosphere interoperability	2019 Q4	WGCV
CV-18-02	Greenhouse gas reference standards for interoperability	2020 Q4	WGCV
CV-18-03	Biomass validation protocols	2020 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
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 workshops. WGCapD also supports CEOS initiatives and helps WGs, AHTs, and VCs undertake their own capacity building initiatives, by providing guidance on best practices and communicating to the WGCapD community about training events.

WGCapD has offered a variety of training and capacity building activities, including in-person training workshops, webinars, and efforts to better collect, coordinate, synergize and make available existing capacity-building resources for satellite Earth observation users in developing countries. In 2019, WGCapD convened massive open online courses (MOOCs) on radar backscatter and SAR applications, supported the AmeriGEO and AfriGEO events with trainings, led multiple in-

person training workshops in Asia and the Americas, and helped coordinate webinars on wildfires and agriculture. A webinar was held jointly with WGISS to build awareness about Future Data Architectures. To allow training participants to be able to more easily find, participate, and learn from training activities to use Earth observations for their needs, WGCapD actively supports the implementation of the CEOS training calendar, which aims to gather Earth observation-related training opportunities in one place for easy access. Ways to improve coordination across capacity building networks was presented first as a CEOS white paper, then as a published paper.

2020-2022: WGCapD plans to continue delivering on-line and hands-on training for users in developing countries on data access, awareness, processing, and applications. During the period of the global pandemic, most training activities will be delivered online due to health and safety concerns.

The WGCapD will continue to address a global need for the identification, collection, and coordination of the World's diverse and often disparate capacity building and training resources related to satellite Earth observations. The approach to coordination across capacity building networks via a Space Capacity Development Advisory Board will be implemented to enable sharing of resources and plans.

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

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

1) For **global work**:
   - Focus on on-line learning through e-learning, MOOCs, webinars, blended learning approaches.
2) For **regional work**:
   - Focus on support to the three regional GEOs annual meetings: AfriGEO, AmeriGEO, and AOGEO.
   - Support trainings in conjunction with regional society and other meetings.
   - Leverage single-agency regional activities as possible.
3) For **national work**:
   - Support national trainings as possible.
   - Strengthen our understanding of national needs in other thematic areas.

Number	Objective/Deliverable Title	Projected Completion	Responsible CEOS Entity(ies)
CB-17-02	Explore future options for providing portal-based access to capacity building and training resources	2020 Q4	ISRO
CB-18-05	Provide CB support to regional and thematic AOGEOSS initiative	2021 Q4	ISRO
CB-18-06	Conduct global capacity building courses through a multi-lingual MOOC (Massive Online Open Course) for advanced practitioners/experts on radar backscatter	2020 Q2	DLR
CB-18-07	Conduct global capacity building courses through Webinar on Asia-GEOGLAM, SAR Missions present and future, Disaster Risk Reduction (UNOOSA) (global training-interactive)	2020 Q4	ISRO

Number	Objective/Deliverable Title	Projected Completion	Responsible CEOS Entity(ies)
CB-18-09	Conduct global capacity building courses a MOOC (Massive Online Open Course) on Land Cover and Land Use Changes	2021 Q1	EO College ESA DLR
CB-19-02	Provide webinar on LCLUC theme	2020 Q3	NASA
CB-19-06	Provide CB support to Hyperspectral Remote Sensing.	2020 Q4	DLR
CB-20-01	SDG Training on Land Use Efficiency (11.3.1): EO Data, Indicator Methodology, and Tool Training Webinar	2021 Q4	NASA
CB-20-02	COVE Webinar	2020 Q4	SEO, USGS
CB-20-03	CARD4L Awareness Webinar	2021 Q3	USGS
CB-20-04	Jupyter Notebooks Awareness Webinar	2021 Q1	CSIRO, NASA
CB-20-05	Space Capacity Development Advisory Board	2020 Q4	NASA, ISRO, CRECTEALC
CB-20-06	Metadata Standards Tiger Team	2021 Q4	EO College
CB-20-07	Best Practice Guide to E-Learning	2020 Q4	EO College
CB-20-08	Virtual EO Education Conference	2021 Q4	EO College
CB-20-09	Capacity Development Guidance Document for GEOGLAM	2021 Q1	NASA
CB-20-10	In-Person Air Quality Training (Thailand)	2020 Q4	NASA
CB-20-11	In-Person Air Quality Training (Vietnam)	2021 Q4	VNSC, NASA
CB-20-12	Collaborative Feasibility Study	2021 Q4	NASA, VNSC, CREACTEALC
CB-20-13	Indigenous Peoples-focused In-Person Training (Canada)	2021 Q4	NASA, CSA
CB-20-14	Indigenous Peoples-focused In-Person Training (Australia)	2021 Q4	NASA, GA
CB-20-15	In-Person SAR training	2021 Q1	VNSC, ESA
CB-20-16	In-Person SAR training	2021 Q2	VNSC
CB-20-17	Provide CB support to AGEOS on forest monitoring	2020 Q4	CNES
CB-20-18	Provide CB to Recovery Observatory Project	2020 Q4	CNES
CB-20-19	In-Person Regional Training in South Asia	2020 Q3	ISRO
CB-20-20	SELPER 2020	2021 Q4	ESA
CB-20-21	Copernicus User Uptake in Africa	2021 Q4	DLR
CB-20-22	AOGEO Contribution	2021 Q4	ISRO
CB-20-23	AmeriGEO Contribution	2020 Q3	CREACTEALC, NASA
CB-20-24	Remote Sensing Training in Africa	2021 Q4	SANSA, NASA, DLR

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 organizations can confidently invest their resources and leverage their distribution channels to users in an effort to realize benefits that go far beyond the traditional mono-mission approach. WGISS will continue in the period 2020-22 its FDA activities as agency contributions begin to mature and interoperability and integration of new services becomes increasingly important. The goal to establish a common understanding of the functional blocks of a generic Future Data Architecture and of its internal and external interfaces, and the establishment of interoperability arrangements for CEOS Agencies data and analysis systems federation.

WGISS will also work with the CEOS Systems Engineering Office (SEO) to explore opportunities to integrate systems such as the CEOS Visualization Environment (COVE), the CEOS Data Cube (CDC) and the EO Handbook Database to streamline data management processes and improve consistency. 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.

Downscaling of Mekong Data Cube to provincial level since Vietnam National Space Center (VNSC) has received the comments from users of forest monitoring system by Mekong Data Cube. With the present SAR data (Sentinel-1, ALOS-2), the system can be used for forest monitoring at map scale of 1:50.000, suitable for provincial level. The present gap is lack of *in situ* data for verification. During the years of 2020 and 2021, the verification data will be collected for central highland of Vietnam and the product of provincial level forest monitoring will be available at Mekong Data Cube.

Number	Objective/Deliverable Title	Projected Completion	Responsible CEOS Entity(ies)
DATA-17-04	Technology Exploration webinars and workshops	2020 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.	2020 Q4	WGISS
DATA-18-02	CEOS data holdings reported and accessible in GEO and other international relevant contexts	2019 Q4	WGISS
DATA-19-02	Mekong Data Cube	2020 Q4	VNSC LSI-VC GEOGLAM Team LSI-VC Forests Team SEO
FDA-17-02	Collaborative development of CEOS Data Cube technology	2021 Q4	SEO
FDA-18-01	Establish a common description of Future Data Architecture functional blocks and identify interfaces and interoperability approaches	2020 Q2	WGISS
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.	2020 Q4	WGISS
DATA-20-01	CEOS Glossary of Terms Related to Analysis Ready Data, Future Data Architectures, and Interoperability	2020 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.

2020-2022: 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 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 harmonized 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). The completion of the first CARD4L Product Family Specifications (PFS) is a key milestone in the CEOS effort to lower the barrier to broad utilization of space-based data. Hurdles remain in relation to data production, accessibility, and usability, in particular.

LSI-VC ARD efforts in 2020-2022 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, SAR) and maintaining and assessing products against the specifications, headline activities will include evaluating CARD4L supply, user access, and user experiences via pilot activities and also engaging with industry (both data producers and hosts) via a dedicated CEOS-Industry ARD Workshop, among other opportunities.

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 publish an open-source software library for the generation of CARD4L surface reflectance products.

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	2020 Q4	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
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	2020 Q4	LSI-VC
VC-19-06	Update of CEOS OST-VC User Requirements Document	2021 Q4	OST-VC
VC-19-07	Definition of an improved Precipitation CDR	2020 Q4	P-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	2020 Q4	LSI-VC
VC-20-07	Identify the need for and prioritize development of future target products as the basis for new CEOS ARD specifications	2020 Q4	SIT Chair
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-20-09	Discussion paper on private industry interactions with CEOS ARD	2020 Q4	SIT Chair LSI-VC WGISS
VC-20-10	CEOS–Industry ARD Workshop	2020 Q3	LSI-VC SIT Chair
VC-20-11	CEOS ARD stocktake and outlook	2020 Q3	LSI-VC
VC-20-12	Promote CEOS ARD to data providers	2022 Q4	SIT Chair
VC-20-13	Precipitation Constellation white paper	2020 Q3	P-VC
VC-20-14	IPWG/GEWEX Precipitation Assessment white paper	2020 Q3	P-VC
VC-20-15	Community engagement	2020 Q3	P-VC
VC-20-16	Precipitation product new version: GSMaP	2020 Q4	P-VC
VC-20-17	GPM L2A precipitation products	2021 Q4	P-VC
VC-20-18	New version IMERG	2022 Q2	P-VC
VC-20-19	New capabilities	2022 Q4	P-VC
VC-20-20	New capabilities	2023 Q4	P-VC
VC-20-21	New capabilities	2023 Q4	P-VC
VC-20-22	CEOS VC ARD survey	2021 Q2	SST-VC
VC-20-23	CEOS Search Relevance Recommendations	2021 Q4	SST-VC

Number	Objective/Deliverable Title	Projected Completion	Responsible CEOS Entity(ies)
VC-20-24	Aquatic Carbon From Space Special Issue	2021 Q4	OCR-VC
VC-20-25	Aquatic Carbon From Space Workshop	2021 Q4	OCR-VC
VC-20-26	System Vicarious Calibration (SVC) infrastructures in support of Climate-quality OCR data records	2021 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	2020 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

2020: 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 maximize 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.
- Analyzing, in cooperation with GEO, the "*Satellite data requirements*" for four selected SDG indicators: 6.6.1 on water; 11.3.1 on urbanization, 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 maximize 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 urbanization, 15.3.1 on land degradation, as well as 14.1.1 on coastal eutrophication, which will be addressed by the newly formed CEOS Coastal Observations and Applications Study Team (COAST), in close

collaboration with SDG-AHT and GEO Blue Planet. The four indicators will be individually assessed and managed by three SDG sub-teams and COAST (14.1.1).

2021-2022: 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 2020.

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

2019-2021: 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 utilization.

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

2020-2022: 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) marks the beginning of the next phase in EBV development and application and the CEOS Biodiversity activity will continue to work closely with the GEO Biodiversity Observation Network (GEO BON, a GEO Flagship), other organizations, and a variety of projects to further this work.

While some further refinement of the EBVs is planned for the next year--the Ecosystem Function class, in particular, will be a focus--a key component of this next phase is to begin the process of defining the observation requirements for these EBVs and related derived products. Another important activity for the coming year is to start populating the EBV Data Portal with EBV-relevant products. The EBV Data Portal is a concept, now being implemented, to provide access to a variety of EBV data and derived products; it is hosted by iDiv in Germany. Further development of workflows that provide EBV data products or related derived products such as indicators is also planned. Eight NASA-funded projects, mostly now in their last year, are among the groups that will support these activities.

An additional, and ongoing, task is outreach to the broader biodiversity and ecosystem communities because many in these communities do not utilize remote sensing data despite its value in addressing biodiversity- and ecosystem-relevant issues. As an umbrella organization, GEO BON can help facilitate this outreach, something it has been doing with, for example, the Convention on Biological Diversity, an organization with which GEO BON works closely.

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 a coherent set of data products from the four Ocean VCs and implement a technology platform providing value-added services for improved, more integrated ocean data access in support of marine GEO initiatives, including Marine Biodiversity Observation Network (MBON) and Blue

Planet. COVERAGE project 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 that have closed: 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 detailed COVERAGE project implementation plan and schedule for the Phase B.

2020. COV-4: COVERAGE Phase B (one-year duration, ending Q4-2020) involves technical implementation 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 and select in-situ datasets demonstrated in the context of a pilot demonstration application. COV-4 also includes implementation of COVERAGE's distributed architecture with satellite nodes on NASA-AWS and EUMETSAT-WEkEO and connectivity to select CSIRO, NOAA and IMOS in-situ data repositories. Ongoing stakeholder engagement and the solicitation of feedback remains integral to this and subsequent phases of the project.

2021. COV-5: Phase C of the COVERAGE project will commence thereafter within the first quarter of 2021 and is also expected to be one year in duration. Technical work will address community comment on the prototype, implement refinements and any necessary enhancements to develop the fully featured COVERAGE system. Also under COV-5, COVERAGE capabilities will be demonstrated in support of target GEO applications that have previously been identified.

2022. COV-6: The final phase of COVERAGE (D) is expected to last 6 months through Q3-2022 and will involve testing and evaluation of the COVERAGE system (COV-6). Central to this activity will be the demonstration of capabilities amongst key COVERAGE stakeholders, including agency partners and GEO-BON, GEO-Blue-Planet, with a view to possible future operationalization.

Number	Objective/Deliverable Title	Projected Completion	Responsible CEOS Entity(ies)
BP-17-02	CEOS Action Plan for GEO Blue Planet Initiative Working Group and Pilot Project activities as documented in the 2020-2022 Blue Planet	2020 Q1	CEOS Blue Planet Expert
COV-17-04	COVERAGE Phase B prototype system	2020 Q4	COVERAGE
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	2020 Q4	SEO
SDG-20-01	GEO Federated Approach on SDGs	2020 Q1	SDG AHT
SDG-20-02	SDG EO Toolkit Specification	2020 Q1	SDG AHT
SDG-20-03	Satellite data requirements for SDG Indicator 6.6.1 (Water-related ecosystems)	2020 Q4	SDG AHT (Water Sub-team)
SDG-20-04	Satellite data requirements for SDG Indicator 11.3.1 (Sustainable urbanization)	2020 Q4	SDG AHT (Urban Sub-team)
SDG-20-05	Satellite data requirements for SDG Indicator 14.1.1 (Marine Pollution)	2020 Q4	COAST(with the support of SDG AHT)
SDG-20-06	Satellite data requirements for SDG Indicator 15.3.1 (Land Degradation Neutrality)	2020 Q4	SDG AHT (Land Degradation Sub-team)
SDG-20-07	EO Enabling Infrastructures for SDGs (for SDG EO Toolkits)	2020 Q4	SDG AHT WGISS SEO
SDG-20-08	EO Good Practice Guidance (for SDG EO Toolkits)	2020 Q4	SDG AHT

Number	Objective/Deliverable Title	Projected Completion	Responsible CEOS Entity(ies)
SDG-20-09	EO Demonstration Cases for SDGs (for SDG EO Toolkits)	2020 Q4	SDG AHT SEO
SDG-20-10	Data Supply Analysis and Strategy Document	2020 Q2	SDG AHT SIT Chair

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

Responsible CEOS Entity: WGClimate

IV. Essential Climate Variable (ECV) Inventory Gap Analysis

Perform gap analysis work that always provides incremental updates to the year before in terms of improvements on the compliance to GCOS requirements and a report in focus areas addressing needs of CEOS and CGMS. The gap analysis is coordinated by the WGClimate Chair 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 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 CEOS' external stakeholders. This document shall be consistent with and mutually supporting of other CEOS guiding documents.

Appendix A – Remapping of 2019 to 2020 Deliverables Numbering

As of June 2020, there are 140 CEOS Deliverables, 55 existing and 85 new. To address the large number of Deliverables and to facilitate tracking and reporting on Deliverables, an updated renaming convention system has been instituted with the 2020-2022 Work Plan, requiring a renumbering of existing Deliverables. Please see Appendix A for a remapping of the 2019 to 2020 Deliverables. The format of the Deliverables is now:

XX(XX)-YY-01 (2 to 4-character identifier-2-digit year-2-digit number, beginning at 01 for each year)

2020 Deliverable Numbering (new)	2019 Deliverable Number (former)	2020 Deliverable Numbering (new)	2019 Deliverable Number (former)
CMRS-19-03	CMRS-24	**CB-19-06**	CB-38
CMRS-19-04	CMRS-25	**DATA-17-04**	DATA-11
CMRS-19-05	CMRS-26	**DATA-19-01**	DATA-15
CMRS-19-06	CMRS-27	**DATA-18-02**	DATA-16
CARB-17-05	CARB-16	**DATA-19-02**	DATA-17
CARB-19-02	CARB-21	**FDA-17-02**	FDA-2
CARB-19-03	CARB-22	**FDA-18-01**	FDA-8
CARB-19-04	CARB-23	**FDA-19-01**	FDA-14
CARB-19-05	CARB-24	**VC-14-09**	VC-9
CARB-19-06	CARB-25	**VC-14-14**	VC-14
AGRI-19-04	AGRI-13	**VC-14-15**	VC-15
DIS-15-04	DIS-10	**VC-18-01**	VC-31
DIS-18-01	DIS-16	**VC-18-03**	VC-33
DIS-19-01	DIS-18	**VC-18-07**	VC-37
DIS-19-02	DIS-20	**VC-19-03**	VC-40
DIS-19-03	DIS-21	**VC-19-05**	VC-42
DIS-19-04	DIS-22	**VC-19-06**	VC-43
WAT-17-03	WAT-6	**VC-19-07**	VC-44
CV-14-03	CV-3	**BP-17-02**	BP-4
CV-16-02	CV-14	**COV-17-04**	COV-4
CV-17-01	CV-15	**COV-18-01**	COV-5
CV-18-02	CV-18	**COV-18-02**	COV-6
CV-18-03	CV-19	**SDG-19-02**	SDG-6
FDA-18-05	FDA-12	**CEOS Services**	DATA-2
CB-17-02	CB-21	**CEOS Services**	CV-9
CB-18-05	CV-27	**CEOS Services**	CMRS-17
CB-18-06	CB-28	**CEOS Services**	CMRS-20
CB-18-07	CB-29	**CEOS Services**	CMRS-21
CB-18-09	CB-31	**CEOS Services**	CMRS-22
CB-19-02	CB-34	**CEOS Services**	CB-10