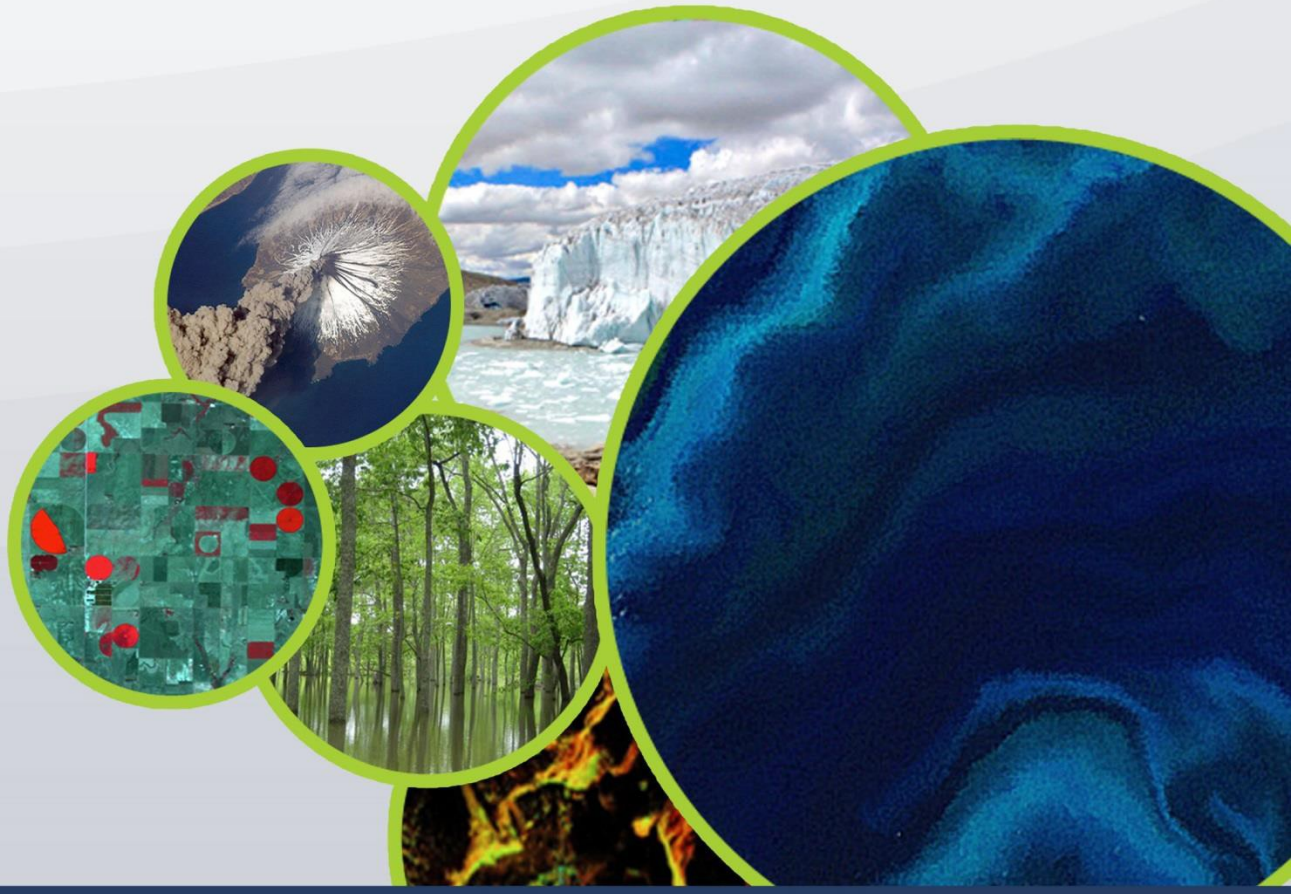
Committee on Earth Observation Satellites



2019-2021 Work Plan

March 2019

Contents

1. Introduction and Overview

The *2019-2021 CEOS Work Plan* has been developed by the CEOS Executive Officer (CEO) under direction of the CEOS Chair (Vietnam Academy of Science/Vietnam National Space Centre [VAST/VNSC]), in consultation with the CEOS Strategic Implementation Team (SIT) Chair (National Oceanic and Atmospheric Administration [NOAA]), CEOS Secretariat (SEC), CEOS Working Groups (WG), CEOS Virtual Constellations (VC), CEOS Ad Hoc Teams, 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 (2020-2021). Additional documents contributing information to this plan are located on the CEOS website (http://ceos.org/) and include: *The Kyoto Statement*, issued at the 29th CEOS Plenary Meeting held in 2015; the *2018-2020 CEOS Work Plan*; the *2018-2020 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 will be 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 fairly 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 Eight (G8) 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 the UN Framework Convention on Climate Change (UNFCCC), the 2030 Agenda for Sustainable Development (the SDGs), the UN Office for Disaster Risk Reduction (UNISDR), the United Nations Convention to Combat Desertification, and the 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 32nd CEOS Plenary meeting held in Brussels in 2018 reviewed the progress made on the priority areas of the outgoing CEOS Chair, the European Commission. These included the ongoing focus on progress toward an international coordinated Greenhouse Gases monitoring system and on facilitating the access to and use of Earth Observation data through Future Data Architectures. In Brussels a change in approach was agreed for this focus area, which until now has been served by an Ad-Hoc Team. In this and subsequent Work Plans, the deliverables relating to Future Data Architectures denoted by the "FDA-" prefix, will now be the responsibility of several standing CEOS entities ranging from the WG on Information Systems and Services, to the Land Surface Imaging Virtual Constellation. The responsibility of retaining a high-level integrated perspective on the FDA theme lies with the CEOS Chair and SIT Chair.

The incoming CEOS Chair (VAST/VNSC) presented the priority focus areas for 2019, which take some of the important user-focused work that has been conducted within CEOS over the past few years and looks to apply it to a specific geographical area: the Mekong Delta. Among the work conducted in 2019, the CEOS Chair will develop and populate a regional scale demonstrator to show-case an example of a Future Data Architecture: a data cube for the Mekong Delta hosting data and algorithms developed within the CEOS community.

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; water, including observations to support the effective monitoring and management of the world's water resources; 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 (2020-2021) 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 Teams may prepare separate, more detailed Work Plans that complement this overall guiding Work Plan.

3. Expected Outcomes for 2019-2021

The expected outcomes for 2019-2021 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 for the period 2019-2021:

3.1. Climate Monitoring, Research, and Services
3.2. Carbon Observations, Including Forested Regions
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. CEOS Services
3.11. Support to Other Key Stakeholder Initiatives
3.12. Organizational Issues and Outreach

The outcomes for each thematic area are summarized in tables that list the objectives/deliverables to be pursued in that area, projected completion dates (typically indicated by quarter of the calendar year), background information, and responsible CEOS Entities. CEOS operates on a best-efforts basis. Responsible CEOS entities are expected to accomplish the objectives and deliverables identified in this document to the best of their abilities.

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 2019-2021 WGClimate will address three major objectives:

- Update and exploitation of the comprehensive 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 data gaps and opportunities for improvement 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 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;
- Maintain the strong relationship with the UNFCCC/SBSTA and GCOS processes to support the implementation of the Paris Agreement.

I. Continue cooperation with GEO, GCOS, WMO, and CGMS in the development of a space-based system to support climate change information and adaptation.

2019-2021: CEOS Agencies will continue to cooperate with CGMS, GEO, GCOS, and WMO, by implementing Agency actions to achieve the socio-economic benefits described in the CEOS-CGMS-WMO *Strategy Towards an Architecture for Climate Monitoring from Space*, with emphasis on the strategy's Applications and Decision-Making pillars. In particular, the WGClimate has been invited by WMO to organize a side event at the 19th Congress of WMO in June 2019. This side event will demonstrate the Architecture for Climate Monitoring from Space at work. Connections to the World Climate Research Programme (WCRP) have been established and will be maintained. During this period, WGClimate will interact with WCRP on their implementation plan for the WCRP strategic priorities published in 2018.

This coordination will be supported by the development and promotion of further case studies. For this further engagement of WMO, WCRP and GEO is sought. Joint CEOS/CGMS WGClimate will maintain its web presence at http://climatemonitoring.info that provides the single authoritative location for information from the WGClimate on the Architecture and its implementation.

II. Continued implementation of the Architecture for Climate Monitoring from Space (now included under CEOS Services, see page 30)

III. Continued strong engagement with UNFCCC/SBSTA and GCOS processes

2019-2021: The Joint CEOS/CGMS WGClimate ensures to be the focal point for a coordinated space agency response to climate observation needs of UNFCCC facilitated by GCOS. WGClimate will keep strong links to the Subsidiary Body for Scientific and Technological Advice (SBSTA) and GCOS during 2019-2021, providing:

- An annual statement of the space agencies on the progress in implementation of the Architecture for Climate Monitoring from Space to SBSTA;

- An annual report that provides more details on items mentioned in the statement and features dedicated topics. In 2018 also a verbal presentation in the meeting of the systematic observation subgroup. If possible this will be repeated;
- Provide inputs to the SBSTA Chair report on systematic observations based on the statement;
- Supporting GCOS at Steering Group, Panel, and Secretariat level, in the preparation of the next version of the GCOS-IP, in particular in the formulation of requirements.

If affordable, it is also planned to participate in the SBSTA Earth Information Day at SBSTA-50.

Climate Monitoring, Research, and Services Objectives/Deliverables: 2019-2021			
Objective/Deliverable	**Projected Completion Date**	**Background Information**	**Responsible CEOS Entity**
Information dissemination and communication			
CMRS-13: Development and Promotion of Case Studies	Q3 2019	Previous work, supervised by the EC JRC and WMO, has already produced WMO 1192 *Case Studies for Establishing an Architecture for Climate Monitoring from Space*. WGClimate #10 will discuss how additional case studies may be realized. The results and potentially an updated plan for case studies is targeted for 2019.	WGClimate
Engagement with GCOS			
CMRS-22: CEOS Statement and report to SBSTA	Q4 every year	WG Chair drafts the "Space Agencies Statement" and presents this for endorsement to CEOS Plenary.	WGClimate
CMRS-23: Intermediate report on the status of the Space Agency Response to the 2016 GCOS Implementation Plan	Q3 2020	This report assesses the status of activities from the "Space Agencies response to the 2016 GCOS IP" and provides an updated of the report to GCOS. Report is assumed to need endorsement by CEOS and CGMS Plenaries. This should consider the Coordinated Action 12 on monitoring progress on GOCS Action T71 (results for this should come from action CMRS-30-2018-1).	WGClimate
CMRS-24: Support to the GCOS Status report on observing systems for climate monitoring	Q3 2021	WGClimate shall support to the assessment of the fulfilment of the 2016 GCOS IP. Outputs from Actions CMRS-23, 24, and 28 shall provide a solid picture of space agencies contributions.	WGClimate
Implementation of the international greenhouse gas monitoring system			
CMRS-25: Provide oversight to the implementation of the international greenhouse gas monitoring system (Coordinated Actions 11, 13, and 14).	Q3 2019 Q3 2021 Q3 2026	Three sub deliverables are defined: • Establish a roadmap for the development of a GHG monitoring system • Develop of a prototype GHG monitoring system • Develop the initial operational GHG monitoring system	WGClimate

Climate Monitoring, Research, and Services Objectives/Deliverables: 2019-2021			
Objective/Deliverable	**Projected Completion Date**	**Background Information**	**Responsible CEOS Entity**
Climate Data Records			
CMRS-26: Update definitions for FCDR, CDR, ICDR (Coordinated Action 1)	Q3 2019	Update definitions for Fundamental Climate Data Records, Climate Data Records for GCOS ECVs and Interim Climate Data Records for both typs of data records. It is planned to agree on definitions at 10th and 11th WGClimate meetings during 2019.	WGClimate
CMRS-27: Implement Coordinated Actions 5 on FCDR Inventory, 6 on nomenclature document for CDRs, 10 on meta data standards	Q3 2020	Upgrade the ECV Inventory technically that it can provide information on Level 1 base data records (FCDRs) used for CDRs of GCOS ECVs. Provide to CEOS agencies documentation on CDR related nomenclature and meta data standards.	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).

2019: Through its Ad Hoc Space Data Coordination Group (SDCG) for GFOI, 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 be updated in 2019 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+. SDCG 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 WGCV's. Land Product Validation subgroup.

2020-2021: In subsequent years, SDCG will continue to steward the updated GFOI Space Data Strategy and to progress the priority initiatives identified in relation to the policy relevance of AGB estimation missions. Further activities are anticipated in relation to:

- A new phase for the GFOI R&D programme;
- ARD trials and pilots in the GFOI community in collaboration with LSI-VC;
- Emergence of a GFOI Early Warning Module;
- Prototyping as requested, eg in support of the Mekong Cube, or with GFOI countries working with Digital Earth Africa;
- Advocacy for space data role in future updates of GFOI MGD.

SDCG 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 stock-take role for CEOS in relation to the Paris Climate agreement and the 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 2019-2021 period.

In 2018 an important accomplishment was in the completion of several Actions from the CEOS Strategy for Carbon Observations from Space, in particular through the report documenting an optimal GHG Constellation. This report provides a blueprint of what CEOS and CGMS agencies need to, collectively, do to address the needs for GHG observations – driven by the Paris Agreement - over the next decade. The GHG Constellation report also make proposals on a way forward and these will be addressed in 2019 though CMRS-25, above. As a part of defining a longer-term roadmap for carbon and GHG monitoring in 2019 we will also address whether the coordination layer for the CEOS Strategy for Carbon Observations from Space should also be integrated under these activities in WGClimate – with the understanding that the specific Action in response to the Strategy will continue within the relevant CEOS Entities (i.e. WG and VCs).

Carbon Observations, Including Forested Regions Objectives/Deliverables: 2018-2020			
Objective/Deliverable	**Projected Completion Date**	**Background Information**	**Responsible CEOS Entity**
CARB-15: Carbon data Portal prototype	Q2 2019	Implement a carbon data portal to facilitate the discoverability and accessibility of ECV products and space-borne CDRs. The portal is designed with a service-oriented architecture and follows the principles outlined by the GEOSS Community Portal white paper. The portal will seamlessly access data both in CWIC and FedEO to provide necessary data, tools and services to the carbon science community of both CEOS and GEOSS. The reference implementation can be shared with the broader CEOS carbon community.	WGISS
CARB-16: Cal/Val and production of biomass products from CEOS missions	Q4 2019	Development of a coordinated cal/val strategy across NASA and ESA biomass missions that rationalizes protocols, data sharing, and the establishment of ground-based carbon super-sites.	WGCV

Carbon Observations, Including Forested Regions Objectives/Deliverables: 2019-2021			
Objective/Deliverable	**Projected Completion Date**	**Background Information**	**Responsible CEOS Entity**
CARB-17: Engaging with IPCC inventories and promoting satellite EO	Q4 2019	The *2006 IPCC Guidelines for National GHG Inventories* currently indicates that satellite data has limitations in spatial, vertical and temporal resolution. However, the IPCC Guidelines will be updated and released in 2019, and update of verification guidance with respect to atmospheric measurement and new datasets is expected. This creates the possibility that the update will include use of GHG observation data from satellites. CEOS has accumulated GHG scientific data by satellites such as GOSAT and OCO-2, and more satellites will follow. Thus, CEOS engagement with IPCC and efforts to support this update are important for EO data uptake in Climate actions.	WGClimate
CARB-20: Updated CEOS Space Data Strategy for GFOI	Q4 2019	The CEOS Space Data Strategy was first developed in 2011 in support of GEO-FCT and GFOI. It will be brought up to date to reflect: the new outlook for forest area observations and the corresponding global baseline acquisition strategy; special needs of individual countries for space data services; the new phase for the GFOI R&D programme; and in particular the inclusion of the new generation of CEOS missions providing Above Ground Biomass measurements. The Strategy should support the broader CEOS Carbon Strategy and links maintained between the relevant actions.	SDCG for GFOI
CARB-21: Phase II R&D Programme for GFOI	Q4 2019	The existing GFOI R&D programme and corresponding data supply activity will be concluded in H1 2019 and a summary achievements report will be produced. ESA as GFOI lead for R&D, with SDCG and other GFOI Leads will lead design of a Phase II programme and respective data supply that is focused on issues identified as a priority by the major donor governments – with the hope of securing stronger funding prospects for GFOI R&D activities going forward. This will likely be an iterative process through 2019.	SDCG for GFOI
CARB-22: Early Warning Module for GFOI	Q3 2020	Scoping discussions continue amongst the GFOI Leads for the definition of a GFOI Early Warning Module. Given the essential role of satellite data in early warning of deforestation, SDCG will follow closely and contribute to the Module, ensuring necessary representation for space data providers.	SDCG for GFOI

Carbon Observations, Including Forested Regions Objectives/Deliverables: 2019-2021			
Objective/Deliverable	**Projected Completion Date**	**Background Information**	**Responsible CEOS Entity**
CARB-23: Forest Biomass measurements for GFOI countries	Q4 2019	The new generation of Above Ground Biomass measurement missions offers great promise to forest monitoring capabilities. SDCG and WGCV Land Product Validation group will work with GFOI Capacity Building partners, including World Bank, to accelerate the policy relevance and application of these missions through strong communications, education, and interchange between GFOI countries and space data providers. SDCG will promote to GFOI countries the CEOS Biomass Protocol currently under development by WGCV LPV (due Q1 2019), and will develop education materials to help inform countries as to the opportunities ahead. Measures to address the policy relevance of the data from the relevant missions will be identified, making best use of the user and policy interface provided by GFOI.	WGCV, SDCG for GFOI
CARB-24: Forest applications in the 2019 CEOS Chair Initiative and CEOS ARD Pilots.	Q4 2019	The 2019 CEOS Chair Initiative aims to establish prototype forest monitoring applications within an Open Data Cube environment for the Mekong Basin region. SDCG and its agencies will assist the selection of analytics and supporting data for realization of the Chair outcomes. Similar support will be provided for the anticipated ARD pilots being proposed within the CEOS ARD strategy (which may also include Mekong Cube).	SDCG for GFOI
CARB-25: Updated space data content in the 2019 GFOI Methods and Guidance Documentation (MGD)	Q2 2020	GFOI will start the process of updating the MGD in 2019 taking into account the "2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories". SDCG will engage to ensure proper representation and promotion of the full range of capabilities from space data.	SDCG for GFOI

3.3. Observations for Agriculture

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

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 2019 – 2021 with a focus on the first and second year of this 3 year period.

Developing a relationship around access and utilization are new frontiers in the evolution of the CEOS-GEOGLAM relationship. Specifically, there were five recommendations for interaction between CEOS and GEOGLAM:

- **GEOGLAM-CEOS Coordination on Data Quality Control & Assessment (AGRI-11):** 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.
- **Analysis Ready Data (ARD) and Application Ready Data (ARD+) (AGRI-13)**: 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 breakout group discussing CARD4L emphasized the following priorities of high value to the agriculture community:
  - Consistent atmospheric adjustment; excellent cloud, snow, and shadow masking
  - Documentation on bandwidth impacts on interoperability, and how to adjust
  - Making 10-30m time series coherent with historical 100+m resolution
  - A thermal infrared product family specification

  Beyond this technical discussion, many users expressed a need for Application Ready derived (ARD+) products, such as NDVI anomaly or long-term vegetation index time series, in order for facilitate application and sustained use.

- **Standard Agricultural Products in Support of International Policy Drivers (AGRI-15):** Due to the proliferation of EO-based data products, the demand for policy-relevant, actionable information is only increasing. This evolving demand is coming from the perspective of market information; early warning and forecasting; climate change; Sustainable Development Goals (SDGs); and disasters. All require a more quantified approach to agricultural monitoring, as well as the ability to go beyond in-season metrics and look at state and change between season and longer term. As such, the group identified a need for consistently validated, standard agricultural products that can be leveraged alongside other data sources. The GEOGLAM focus is currently on a set of critical EO-based products that initially include cropland extent, crop type and area, yield forecast and estimation. Together these form the essential set of information required to meet the evolving needs of GEOGLAM clients. Development of requirements for a set of GEOGLAM "Essential Agriculture Variables (EAVs) for GEOGLAM" would augment the previous GCOS ECVs. Due to the fundamental nature of these variables they would support not only Paris Climate Accord metrics (adaptation, loss & damage, stocktaking) but also SDGs and the Sendai Framework for Disaster Risk Reduction.

- **Data Continuity and Observation Priorities (AGRI-14):** The following data sets, products, or data characteristics were articulated as of high priority. Roughly ranked by most important to least (with operational priorities occupying slots 1-4, and research 5-6):
  1. For all agricultural systems, 10-30m time series product, coherent with historical 100m+ observations

2. For smallholder systems, <10m data with high temporal resolution (cloud-free weekly to biweekly)
3. Passive microwave continuity
4. ~50m thermal observations every 2-3 days
5. In addition to Sentinel 1, access to multi-frequency SAR systems (including X and L), as well as access to upcoming C-band SAR systems (e.g. Radarsat Constellation mission)
6. Missions with bandwidths at 1.9, 2.0, 2.1 microns to target soil quality and organic content monitoring, for implications in tillage monitoring or other emerging policy frameworks.

Further, an updated table of observation requirements was created, and presented at CEOS SIT in September 2019. This table represents community consensus based on inputs from five sources:

1. Original Requirements Document (2012-2014)
2. Requirements Template Sent to JECAM & Asia-RiCE sites (2016)
3. GEOGLAM Requirements Survey (April 2018)
4. Ispra Requirements Meeting (April 2018):
    a. Presentation Templates
    b. Collective Discussion + breakout groups
5. Pierre Defourny (UCL)'s original "Defourny diagram" and his input throughout the process.

- **Coordination on Capacity Development Activities:** GEOGLAM recognizes the evolution and improvement of its monitoring activities will be guided by strengthening capacities at the national and regional level. GEOGLAM sees value in ensuring our Thematic Coordination Team on Capacity Development and Operational Transition is calibrated and coordinated with the CEOS Working Group on Capacity Development.

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

2019: JECAM was initiated in 2009 by the GEO Agriculture Monitoring Community of Practice (CoP) to enhance collaborative international research on agriculture through use of remotely-sensed EO. In 2011, CEOS initiated efforts to supply JECAM users with relevant remote sensing data through a coordinated Earth observations from space data acquisition program involving CEOS Agencies and commercial data providers. In recent years, other activities have received significant funding to carry out operational research and development in support of GEOGLAM, for example the European Commission's FP7 supported Stimulating Innovation for the Global Monitoring of Agriculture (SIGMA) project and the European Space Agency funded Sentinel-2 for Agriculture and GEORICE activities. These activities contribute to GEOGLAM's broader operational R&D efforts, collaborating with and often having complementary test site locations with JECAM sites.

CEOS Agencies will continue data acquisitions for support to JECAM and GEOGLAM R&D activities 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

2019, 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.

Observations for Agriculture Objectives/Deliverables: 2019-2021			
Objective/Deliverable	**Projected Completion Date**	**Background Information**	**Responsible CEOS Entity**
AGRI-4: CEOS Strategic Response to GEOGLAM Requirements	Next update Q2 2019	The *CEOS Strategic Response to GEOGLAM Requirements* identifies how CEOS Agencies will coordinate their relevant Earth observing satellite systems to acquire data to support information requirements arising from GEOGLAM. Updates to this document may include the addition of new mission datasets, updates to primary and contributing datasets, updates to sampling approaches, adjustments to the strategy that improve GEOGLAM coverage, and updates to country coverage. In addition, this task will include updates to the Scope Document, which reflects the high-level plans for the Ad Hoc GEOGLAM team and addresses new requirements evolving from regional networks and RAPP.	CEOS Ad Hoc Working Group on GEOGLAM
AGRI-10: Open Data Cube tools for GEOGLAM	Q4 2019	Develop and demonstrate several data cube analysis tools to support GEOGLAM, including crop mask overlays and NDVI phenology plots that will use moderate resolution data. GEOGLAM will explore utility in the context of its GEOGLAM Crop Monitor activities.	SEO
AGRI-11: **C**reate a document on measurement suitability for agricultural products and associated decisions	Q4 2019	Work with CEOS to document and make available to users information on CEOS data quality, data suitability for a given usage and data access – a proposed activity to leverage the MIM database for the agricultural community. Extract information on measurement suitability from the MIM database to generate target products as identified in the GEOGLAM requirements table to create a "fact sheet" about mission/measurement suitability for agricultural monitoring. The final product should emphasize decisions that can be technically supported by EO data.	CEOS Ad Hoc Working Group on GEOGLAM and SEO
AGRI-13: Iteratively respond to GEOGLAM EO Data Coordination team's definitions of "Applications Ready Data" (ARD+) and "Essential Agricultural Variables for GEOGLAM".	Q4 2019	GEOGLAM will internally lead the development of EAVs and ARD+ based on both biophysical and political requirements. This activity is already underway with a version already under review. Production of these EAVs for GEOGLAM will require a long-term coordinated effort between GEOGLAM and the CEOS Working Group Calibration/Validation's Land Product Validation (LPV) sub-group. It is proposed that in 2019, the mechanisms for such a collaboration are characterized.	GEOGLAM (primary) CEOS Ad Hoc Working Group on GEOGLAM, and WGCV LPV (iterative response)

3.4. Observations for Disasters

CEOS is committed to supporting disaster risk management in the context of the *2030 Agenda for Sustainable Development* and the *Sendai Framework for Disaster Risk Reduction 2015-2030*, and enhancing the contribution of space-based Earth observations in support of disaster risk reduction. CEOS Agencies will work closely with key 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) to foster the use of satellite EO data. The overarching goal of the WG Disasters is to increase and strengthen the contributions of satellite EO to the various DRM phases, and to inform politicians, decision-makers, and major stakeholders of the benefits of using satellite EO in each of those phases. The WG Disasters in late 2018 kicked off a review activity, which will begin in earnest at its 11th meeting in Athens in March 2019, with a view to taking stock of what has been achieved in the recent pilots and demonstrators and reviewing the long-term strategy of the WG towards achieving the goal described above. At the present time, the activities in place to achieve that goal are as described below:

I. Strengthen support to the disaster management community through the sustained coordination of disaster-related activities undertaken by CEOS Agencies.

- **DRM Pilots**: Of the initial 3 pilot DRM activities focused on floods, seismic risk and volcanoes, the seismic risk and volcano themes have transitioned to demonstrator activities that build on pilot success. These are detailed below. A landslide pilot was started in 2016 and will present a final report, including follow-on actions, at 33rd CEOS Plenary.

  The Landslide Pilot aims to: 1) demonstrate the effective exploitation of Earth observation (EO) data and technologies to detect, map, and monitor landslides in different physiographic and climatic regions; and 2) apply satellite EO across the cycle of landslide disaster risk management, including preparedness, situational awareness, response, and recovery with a distinct multi-hazard focus on cascading impacts and risks.

  2019: WG Disasters will continue to implement the Landslide Pilot, as endorsed at the 29th CEOS Plenary Meeting. Final report from the Landslide pilot and follow-on actions will be presented at 33rd CEOS Plenary.

  2020-2021: Pilot activity will cease at the 33rd Plenary.

- **Recovery Observatory**: The main objective of the Haiti Recovery Observatory (RO) is to work with national and local government in Haiti to develop the use of Earth Observation in the reconstruction phase after a major disaster.

  The CEOS Recovery Observatory was triggered on 22 December 2016, covering the area devastated by Hurricane Matthew in Southwest Haiti. CEOS Agencies engaged in the project team and their partners have implemented the Recovery Observatory as a full-scale demonstration over a four-year period, aiming at defining a generic and replicable RO concept.

Following triggering, the project team was constituted, composed of local and international stakeholders and space agencies, led by Global Facility for Disaster Reduction and Recovery (GFDRR) and CNES. CEOS agencies actively engaged in either the Steering Committee or the technical activities include: CNES, ASL, CSA, DLR, NOAA, NASA. In addition several International Charter Agencies provided such as Roscosmos, Kari, CNES made crisis images. Significant progress has been made including user engagement through two User Workshops in Haiti involving many

actors including the Haitian Minister for Planning and the Head of the Haiti UNDP office.

2019: WG Disasters will continue implementing the "Hurricane Matthew Recovery Observatory Operations Plan" approved at the 31st CEOS Plenary. This activity will include the first "early evaluation", with a report to the Steering Committee on issues and recommendations going forward. A feedback mission to UNDP and WB headquarters is planned for 2019, with a view to exploiting the lessons learned in the RO to develop a generic RO concept for more systematic use of satellite observations by these agencies during the early recovery process.

2020-2021: WG Disaster will continue the post Matthew RO operations ensuring product and Dotcloud updates, engage in capacity building activities, generate annual reports to stakeholders and partners, as well as developing a legacy strategy to ensure capacity developed in the project is not lost but applied to other risk management activities in Haiti.

Demonstrators: The further development of the use of EO in Disaster risk management is foreseen through two demonstrators (seismic and volcano) building on the successful elements of the DRM pilots described previously.The seismic hazard demonstrator Implementation Plan was accepted by SIT-33, and the volcano demonstrator will prepare an Implementation Plan in early 2019; when beneficial, demonstrators are linked to existing activities such as GEO-GSNL and GEO-DARMA.

2019: Begin implementation of two new demonstrators (seismic hazards and volcano)

2020-2021: Deliver demonstrator results and build on these to propose to CEOS a long-term vision for sustained use of satellite observations in Disaster Risk Management.

Geohazards Lab:

The Geohazards Lab is a new initiative in the CEOS WG Disasters approved at the 31st CEOS Plenary which will provide users from WG Disasters pilots and demonstrators, the RO, the GSNL and GEO-DARMA access to data and processing on a group of interoperable platforms with federated resources. Resources will include: data collections provided through CEOS WG Disaster activities alongside with open and free EO data sources such as Landsat and the Sentinels; and shared processing chains from these activities and other EO experts/geoscience centers already contributing. The Geohazards Lab has a permanent office based at BRGM.

2019: Develop e-collaboration with EO practitioners to promote further utilisation of CEOS data. A benchmarking activity will start focusing on the standards of geohazards related EO-products, the complementarity and differences of these products.

2020-2021: Identify a framework for standardization of geohazards related EO-products to achieve acceptance by the EO community and decision makers. The Geohazards Lab gathered a Working group that will work on standardization and promotion of EO products. In order to raise awareness, the group intends to work closely with EO practitioners and identify a new or existing framework (e.g. EPOS) that could accommodate and promote their activity.

II. Support implementation of a coordinated approach, convened through the Group on Earth Observations, to implementation of priority recommendations in the Sendai Framework for Disaster Risk Reduction 2015-2030 (GEO-DARMA)

GEO-DARMA, a CEOS-led and supported initiative in the frame of the intergovernmental Group on Earth Observations (GEO), aims to address priorities of the *Sendai Framework for Disaster Risk*

Reduction 2015-2030 using Earth observations (EO). GEO-DARMA (Data Access for Risk Management) will facilitate the sustained provision of accurate EO-based risk information products and services to national and local decision-makers in political and socio-economic sector. A GEO-DARMA Kick-off workshop was held in March 2017 and a Concept Workshop was held in May 2017 during the Global Platform Meeting. Four Steering Committee meetings were held between March 2017 and May 2018. The Concept Phase identified regional priorities through reports by regional institutions in Asia and Africa. This process is on-going for Latin America/Caribbean. In April 2018, the first GEO-DARMA project was approved in Asia (SERVIR Mekong).

2019: The Concept Phase will continue for Latin America/Caribbean. The Prototyping ('pilot') Phase will be implemented beginning in 2019, based on the results of the Concept phase, for the regions where proposed pilots are ready for implementation. The first GEO-DARMA project had challenges integrating data into workflows in 2018, and will be addressing these issues in early 2019, to ensure that new data sets can bring added benefit to project objectives.

2020-**2021**: GEO-DARMA is expected to have several other projects operating by 2020, including two new projects planned for Asia. The first project proposals for Latin America/Caribbean will be developed in 2020 once the regional assessment framework is in place. By 2021, the first GEO-DARMA project will have completed its prototyping phase and will be considered for sustained implementation.

III. Continue support to the GEO Geohazard Supersites and Natural Laboratories Initiative.

The Geohazard Supersites and Natural Laboratories initiative was established in 2007 and was integrated into the work of the Group on Earth Observation (GEO) in 2010. It is organized as an international partnership between the CEOS, geohazard scientists, and in-situ (seismic, geologic, geodetic, etc.) data providers, aiming to promote advancements in geohazard science over selected sites , the Supersites, and the Natural Laboratories. The partners cooperate by sharing data, knowledge and capacities, and the enhanced scientific results stimulated by this increased amount of data, are provided to public end-users and decision makers to support activities for Prevention (through geohazard assessment analyses) or Emergency management (through information for situational awareness and event scenarios). All the Supersite Coordinators are part of the national frameworks for risk management, and have a mandate to provide scientific information to government agencies with decision-making authority. Thus GSNL ensures rapid and effective uptake of EO data and scientific information in DRR, complying with Priority 1 of the Sendai Framework.

The CEOS WG Disasters is involved in GSNL through the Data Coordination Team; the DCT receives the request for satellite data support from the Supersites, then collects the various space agencies' commitments to fulfill the Supersite image requests (with archive data and/or new acquisitions). The space agencies then independently provide access to their satellite imagery for the Supersite scientific community. The in-situ data providers (which in most cases are the Supersite Coordinators) commit to provide open access to ground-based data. The Supersite data and resources are open for the international scientific community (licensing may apply), and this stimulates collaboration, knowledge transfer, capacity building, and generation of new scientific results, which are shared within the community. Eventually the scientific results which are relevant to geohazard assessment or emergency management are communicated by the Supersite Coordinator to the end-users and decision makers, using the national institutional channels already in place. CEOS has officially endorsed 10 Permanent Supersites, one Natural Laboratory, and a set

of Event Supersites.

2019-2021:

- continue to fulfil the data needs for the Supersites according to the quotas established by the single space agencies;
- obtain and evaluate the 2019 biennial reports from the San Andreas Fault Natural Laboratory, the Virunga, Southern Andes and Iceland Supersites. and present to the CEOS Plenary for endorsement;
- obtain and evaluate biennial reports from Other Supersites in 2020 and 2021, according to the schedule updated in 2019 by the GSNL Chair;
- receive and evaluate for approval further Supersite proposals submitted through the GSNL Chair;
- discuss and review intermediate results from the Supersites at the Working Group Disasters face to face meetings;
- coordinate with other CEOS initiatives to exploit synergies.

Observations for Disasters Objectives/Deliverables: 2019-2021			
Objective/Deliverable	**Projected Completion Date**	**Background Information**	**Responsible CEOS Entity**
DIS-10: Implementation of data coordination for the GEO-GNSL initiative	Q4 2020	Potential proposals for new GSNL activities (i.e. new permanent & event Supersites) aiming at expanding the objectives of the current pilots will be assessed by the Data Coordination Team and the various pilot teams in due time. The assessment will be done by WG Disasters following the procedures endorsed by CEOS. The status of implementation of the plan, of the pilots and supersites being supported, and the coordination relating to the GSNL initiative will be reported at CEOS SIT and Plenary meetings.	WGDisasters
DIS-12: Report on Haiti RO Early Evaluation by local users and international organizations	Q3 2019	WGDisasters will develop a survey of initial results of the Recovery Observatory from the perspective of institutional donors, and include outlooks on possible inclusion of additional hazards and the sustainability of Recovery Observatory activities for 2018 onwards. The findings of this survey will be presented in a lessons learned report in mid 2019 (after 3rd Series of User Workshops) to enable timely consideration by CEOS Agencies.	WGDisasters
DIS-15: Support for GEO-DARMA identification of major hazards and DRR issues for each selected region	Q2 2019	GEO-DARMA will seek independent identification of disaster risk management priorities at regional level by authoritative regional institutions in line with the priorities from the *Sendai Framework for Disaster Risk Reduction 2015-2030*. This task will require the active support of major stakeholders in the field of disaster risk management at global, regional and national levels in order to implement a series of pilot projects.	WGDisasters

Observations for Disasters Objectives/Deliverables: 2019-2021			
Objective/Deliverable	**Projected Completion Date**	**Background Information**	**Responsible CEOS Entity**
DIS-16: Report on Landslide Pilot and follow-on actions.	Q4 2019	A report will be prepared to summarize the learnings from the landslide pilot, and to recommend pathways forward.	WGDisasters
DIS-18: Volcano Demonstrator Reports	Q4 2021	Three annual reports (preliminary, progress and final) will be generated by the Volcano Demonstrator	WGDisasters
DIS-19: Expanding the use of EO data for monitoring, measuring and understanding disasters	Q3 2019	Develop e-collaboration with EO practitioners to promote further utilisation of CEOS data	WGDisasters
DIS-20: Pursue the standardization of geohazards EO-products	Q1 2020	Identify a framework for standardization of geohazards related EO-products to achieve acceptance by the EO community and decision makers	WGDisasters
DIS-21: Deliver and report on the results of the Sesimic Demonstrator	Q1 2020	Deliver and report on the results of the period Q3 2018-Q4 2019, including report on the newly-reached geoscience centers and end users supported by the Demonstrator.	WGDisasters
DIS-22: Final Haiti RO Report	Q1 2021	Final report on Haiti RO results	WGDisasters

3.5. Observations for Water

I. Implement the CEOS Strategy for Water Observations from Space

At the 29th CEOS Plenary Meeting, CEOS adopted the *CEOS Strategy for Water Observations from Space*. This strategy describes what CEOS will do in support of water observations generally, and GEO-identified water observation requirements specifically. At the end of 2015, GEO entered its second decade under a new Strategic Plan with new organizational arrangements. In 2016, GEO endorsed a new Work Programme which highlights that water-related activities within GEO are evolving rapidly, potentially creating a need for CEOS to clarify the 'reference point' for its water-focused actions over coming years.

2019: Following discussions throughout 2017 and an action taken at the 31st CEOS Plenary meeting, CEOS organised a Freshwater from Space workshop in November 2018 with users of space EO data from the Water community. In 2019, the objective is to develop an ongoing dialogue with Water community users of EO data in order to better understand the overall contribution of space data to understanding and better monitoring of key components of the Water cycle, in particular addressing both water quantity and quality.

2020-2021: In the 2-3 year timescale, CEOS's objective is to establish a Freshwater from Space Architecture document describing how various space assets and data infrastructures can synergistically contribute to understanding and monitoring the water cycle. In addition, individual agency and collective actions will be encouraged to progress the key infrastructure elements in this architecture, including integration with ground observation

components, as required, will be undertaken.

Observations for Water Objectives/Deliverables: 2019-2021			
Objective/Deliverable	**Projected Completion Date**	**Background Information**	**Responsible CEOS Entity**
WAT-4: Updates on implementation of the CEOS Strategy for Water Observations from Space, including consideration of required adjustments based on activity in GEO	Q4 2019	CEOS, through the 2020-2021 SIT Chair, will continue to monitor progress on GEO water-related activities. The SIT Chair will also engage with GEO to determine when, and if, the strategy should be revisited. Regular updates will be provided at SIT meetings.	SIT Chair
WAT-6: Response to satellite-related aspects of the GEO AquaWatch Initiative Implementation Plan	Q1 2020	CEOS support for implementation of GEO AquaWatch (monitoring and forecasting of water quality of inland and coastal waters) is crucial, as satellite observations are an integral component for this international effort. AquaWatch is now a GEO Initiative and submitted its Implementation plan to GEO in February 2019.	OCR-VC, WGCapD

3.6. Data Quality

The 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.

2019-2021: 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.

A similar effort will be undertaken related to GHG data products by developing a set of standards for CO2 and CH4 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 web site 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.

2019: 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 SST as a test case.

2020-2021: 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.

Data Quality Deliverables: 2019-2021			
Objective/Deliverable	**Projected Completion Date**	**Background Information**	**Responsible CEOS Entity**
CV-3: Workshop on state of the art for pre-flight calibration techniques	Q3 2019	Hold an open-invitation workshop to discuss and promote best practices on pre-flight and onboard calibration of sensors, initially focusing on optical.	WGCV
CV-14: Report on application of approaches for cloud masking	Q2 2020	The WGCV task team "Cloud Masking" will research different cloud masking approaches for different sensors and spectral areas in order to deliver a report about their findings including recommendations for the applications of cloud	WGCV
CV-15: L1 top-of-atmosphere interoperability	Q4 2019	Develop an initial recommendation of a community reference in collaboration with GSICS.	WGCV
CV-17: Continental scale surface reflectance validation	Q3 2019	Provide guidance for development of methodologies to validate the results of the recent ACIX work leading to protocols for determining uncertainties for interoperable reflectance products.	WGCV
CV-18: Greenhouse gas reference standards for interoperability	Q4 2019	Develop list of reference standards for CO2 and CH4 products that are suitable for use in intercomparison of multiple missions	WGCV
CV-19: Biomass validation protocols	Q2 2020	Development of an initial set of guidance for validation of biomass products using near-term missions such as NISAR, GEDI, and BIOMASS	WGCV
FDA-12: Inventory of space data product formats used by CEOS agencies.	Q4 2019	Develop an inventory of current product format used in CEOS agencies and identify recommendations to facilitate interoperability.	WGCV

3.7. Capacity Building and Data Democracy

I. Advance CEOS Data Democracy activities.

Through the 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 and VCs undertake their own capacity building initiatives, by providing guidance on best practices.

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 2018, this working group held training workshops on SAR and GEE in support of the AfriGEOSS Symposium (June) and on INPE and ESA tools and data in support of the AmeriGEOSS Symposium (August). A webinar was held jointly with the SDG AHT to build awareness regarding the value of EO to SDGs (December).

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 developed a plan that was endorsed to implement a common training calendar also used by VLab and WMO Global Learn.

2019-2021: WGCapD plans to continue delivering on-line and hands-on training for users in developing countries on data access, awareness, processing, and applications.

The WGCapD will continue to address a global need for the collection, coordination, and synergization of the world's diverse and often disparate capacity building and training resources related to satellite Earth observations. As such, the group plans to develop and implement approaches to work with UNOOSA, UNESCAP, and other UN Agencies to highlight the value and benefits of EO tools and services and explore existing methods and tools (and the resources required) to identify and implement a sustainable solution for these problems.

The WGCapD also plans to continue collaborating with GEO to strengthen AmeriGEO, AfriGEO, and Asia-Oceania GEO (AO GEO) 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 and 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 3 GEOSS initiatives' 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 UN-SPIDER mission needs as possible.
    - Strengthen our understanding of national needs in other thematic areas.

Capacity Building, Data Access, Availability and Quality Objectives/Deliverables: 2019-2021			
Objective/Deliverable	**Projected Completion Date**	**Background Information**	**Responsible CEOS Entity**
CB-21: Explore future options for providing portal-based access to capacity building and training resources	Q4 2020	Conduct a study of existing and potential new approaches to collect, coordinate, and synergize available capacity building and training resources related to satellite Earth observations, e.g. GEOCAB, VLab training calendar and methods, and other alternate approaches.	WGCapD
CB-27 Provide CB support to regional and thematic AOGEOSS initiative	Q4 2020	Engage with AOGEOSS initiative and find out the needs of the region for possible training initiatives WGCapD could support	WGCapD
CB-28 Conduct global capacity building courses through a multi-lingual MOOC (Massive Online Open Course) on radar backscatter	Q1 2019	DLR's SAREDU project by FSU Jena will provide a multi-lingual MOOC (German, English, French, Spanish, Portuguese-tbc) on radar backscatter through the EO-College portal in Q4 2018 or 2019	WGCapD
CB-29 Conduct global capacity building courses through Webinar on Asia-GEOGLAM, SAR Missions – Present and future, Disaster Risk Reduction (UNOOSA) (global training-interactive)	Q3 2019	ISRO with support of NASA, DLR and other theme specialists will plan to conduct these webinar series on these specialised topics.	WGCapD
CB-30 Conduct global capacity building courses through a MOOC (Massive Online Open Course) on SAR	Q1 2019	ESA with support of DLR's SAREDU project by FSU Jena and CSA will provide a second run of an improved ECHOES IN SPACE SAR MOOC extended by additional application examples	WGCapD
CB-31 Conduct global capacity building courses a MOOC (Massive Online Open Course) on Land Cover and Land Use Changes	Q2 2020	ESA with support of other WGCapD members will provide a MOOC (Massive Online Open Course) on Land Cover and Land Use Changes, if feasible through the EO-College portal in cooperation with DLR	WGCapD

Capacity Building, Data Access, Availability and Quality Objectives/Deliverables: 2019-2021			
Objective/Deliverable	**Projected Completion Date**	**Background Information**	**Responsible CEOS Entity**
CB-32: Provide regional hands-on training in land cover land use change topics in GEOSS regions in conjunction with related meetings.	Q4 2019	WGCapD will build on the successful NASA-ESA Trans-Atlantic Training program to provide hands on training in land cover land use change topics, starting in Asia to leverage existing NASA investments.	WGCapD
CB-33: Provide SAR and other EO data training in support of VNSC Chair initiative.	Q4 2019	WGCapD will provide basic and applied SAR training for VNSC and stakeholders based on their needs.	WGCapD
CB-34: Provide webinar on LCLUC theme	Q3 2020	Focus will be on Land Cover/Land Use Change theme. Deliver lectures/training materials relating to Land Use/Cover Change in South/Southeast Asia countries either through Webinars or hands-on training to participants (in one of the South/Southeast Asian countries).	WGCapD
CB-35: Provide CB support to AmeriGEO Week 2019 in Peru.	Q3 2019	Provide training and capacity building support to AmeriGEO with training opportunities as part of their annual AmeriGEO Week.	WGCapD
CB-36: Provide CB support to AfriGEO Symposium 2019.	Q3 2019	Provide training and capacity building support to AfriGEO with training opportunities as part of their annual AfriGEO Symposium.	WGCapD
CB-37: Develop white paper describing approaches for capacity building networks supported by others, e.g. UN, can work together.	Q2 2019	Provide white paper for review at the SIT.	WGCapD
CB-38: Provide CB support to Hyperspectral Remote Sensing.	Q2 2020	The DLR funded HyperEDU initiative lead by the GFZ Potsdam will, provide free & open learning material for Hyperspectral remote sensing through the EO-College portal.	WGCapD

Capacity Building, Data Access, Availability and Quality Objectives/Deliverables: 2019-2021			
Objective/Deliverable	**Projected Completion Date**	**Background Information**	**Responsible CEOS Entity**
CB-39: Provide hands-on training on forest monitoring and Orfeo Tool Box for AEM.	Q1 2019	CNES will organize and implement training sessions on forest monitoring and Orfeo Tool Box for AEM. Participation of various national agencies from France (Office National des Forêts (ONF), Institut national de recherche et sciences et technologies pour l'environnement et l'agriculture (IRSTEA), ONF-I)	WGCapD
CB-40: Provide hands-on training for flood monitoring for Vietnam School of Earth Observation.	Q3 2019	CNES will support second Vietnam School of Earth Observation on the topic of flood monitoring. Participation of International Center of Interdisciplinary Science Education (ICISE), Quy Nhon, Vietnam (ICISE).	WGCapD
CB-41: Collaboration between AHT-SDG and WGCapD to organise SDG-related training and capacity building related to the use of space-based EO to meet the data challenges of the 2030 Agenda for Sustainable Development	Q3 2019	WGCapD and AHT-SDG collaboration to support GEO in promoting use of EO to track progress towards, and achieve, the Global Sustainable Development Goals (SDGs).	WGCapD (with the support of AHT-SDG)
FDA-5: Promote awareness of FDAs	Q3 2019	With growing interest in Future Data Architectures, WGCapD will identify ways of promoting the use of Future Data Architectures and possible outreach capacity building activities for end users and decision makers (e.g. webinars, workshops, etc).	WGCapD, WGISS, SEO

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

I. Continue to support the development and operationalization of the GEOSS Platform and its CEOS-related and supporting elements.

Through the Working Group on Information Systems and Services (WGISS), CEOS Agencies will foster the implementation, enhancement and population of the GEOSS Platform through continued development and coordination of tools that improve discovery, interoperability, and access to satellite data. Such tools include the CEOS WGISS Integrated Catalogue (CWIC), the CEOS International Directory Network (IDN) and the Federated Earth Observation (FedEO) gateway system which together constitute the WGISS Connected Data Assets Infrastructure.

WGISS will improve its standards and Connected Data Assets Infrastructure overall architecture and elements to support data access for the CEOS Virtual Constellations and Working Groups, and to provide 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. OGC CSW 2.0.2 and CEOS OpenSearch Best Practices) with the aim of connecting as many CEOS Agencies as possible into the federated system. In order to be effective, WGISS work shall be supported by CEOS agencies through the adoption of the defined standards, the implementation of the required interfaces and metadata formats, and the identification of experts joining the group activities.

WGISS will also work with the 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.

In addition, WGISS will continue its core activity of promoting and exchanging technical information and lessons-learned experience about current and trending data system technologies/services and data stewardship impacting CEOS Agencies, with the aim of preparing CEOS and CEOS Agencies for the future.

II. Continue to explore new architectures, tools and technologies for data management and exploitation.

CEOS has been examining since its 2015 plenary meeting how so-called "future data architectures" (FDA) will alter the way that agencies provide access and exploitation of their EO data. Following on from an interim FDA document submitted at the 2016 plenary, in 2017, CEOS engaged with this theme in more detail across a number of threads, through an extended and more strategically focused Ad Hoc Team on Future Data Architectures (FDA-AHT). The team developed a discussion document entitled "Future Data Access and Analysis Architecture Strategy for CEOS" for Plenary 2017 identifying a set of activities to be implemented by CEOS agencies to capitalize on the opportunities presented by future data architectures. CEOS Principals took the decision to focus in 2018 on the five core areas identified in the discussion document (and listed below) within the Future Data Architecture Ad-hoc team and the relevant CEOS groups.

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. CEOS 2018-20 work-plan included a set of deliverables and activities related to FDA which were assigned to the LSI-VC working group (Item I above) and to WGISS (items II to V). The FDA Ad-Hoc team ensured coordination across the above core initiatives until the CEOS plenary 2018 when it was decided to terminate the team activities and to transition all initiatives and activities directly under the responsibility of the relevant CEOS WGs.

WGISS will continue in the period 2019-21 its activities in the frame of the future data architectures with the goal to establish a common understanding of the functional blocks of a generic Future Data Architecture and of its internal and external interfaces, paving the way for the establishment of interoperability arrangements for CEOS agencies data and systems

interoperability and federation.

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.

Data Discovery/Access/Preservation/Usability/Exploitation Objectives/Deliverables: 2019-2021			
Objective/Deliverable	**Projected Completion Date**	**Background Information**	**Responsible CEOS Entity**
DATA-9: ECVs/CDRs Discovery and Access through WGISS Systems.	Q4 2019	Facilitate discoverability and accessibility of ECV Products and space-born CDRs relevant for the CEOS Carbon Action via WGISS Connected Data Assets Systems & Standards (FedEO/CWIC/IDN, OpenSearch).	WGISS
DATA-11: Data and Technology Exploration webinars and workshops.	Q4 2019	WGISS will host at least one workshop annually to serve as a forum for exchange of technical information and lessons-learned experience about current, trending and future data management approaches and technologies, services and other Internet-related technologies.	WGISS
DATA-13: Develop a White Paper on Single Sign-On (SSO) authentication.	Q2 2019	**Single sign-on** (**SSO**) allows user login with a single ID and password to gain access to connected (federated) systems. This capability is crucial for interoperability between different FDA platforms and systems. WGISS will develop a white paper on single-sign-on (SSO) authentication best practices to support machine- to-machine authentication for EO analysis services.	WGISS
DATA-15: Explore emerging trends and disrupting technologies (e.g. Artificial Intelligence), evaluate advantages / drawbacks for adoption in Earth observation and identify most relevant use cases. Summarise analysis in the form of white papers.	Q4 2020	There is a need to enable rapid transfer of new technologies, techniques and expertise from ICT domains and artificial intelligence communities to the world of EO research and application. Specific communities, such as the Artificial Intelligence (AI) community are already formulating specific requirements toward EO data and product providers. Improved data analysis is a key driver to increase the usability and use of Earth Observation data, in particular by user communities which have not been acquainted with EO. The action will survey existing/new Big Data technologies and techniques, and assess their applicability in Earth Observation.	WGISS
DATA-16: CEOS data holdings reported and accessible in GEO and other international relevant contexts.	Q4 2019	CEOS is often referred as the space arm of GEO. CEOS data holdings need to be reported and visible in GEO and accessible to the GEOSS Platform, GEO Regional Initiatives Systems and Community Portals through the WGISS connected data access infrastructure. This action and deliverable explicitly refers to the interaction with GEO and the GEOSS platform.	WGISS

Data Discovery/Access/Preservation/Usability/Exploitation Objectives/Deliverables: 2019-2021			
Objective/Deliverable	**Projected Completion Date**	**Background Information**	**Responsible CEOS Entity**
DATA-17: Mekong Data Cube.	Q4 2019	Develop and demonstrate a Mekong Data Cube supporting Vietnam, Laos, Cambodia and Thailand with stakeholder support from the Mekong River Commission (MRC). Datasets will include Landsat, Sentinel-1, Sentinel-2 and ALOS PALSAR Mosaics. Applications will focus on rice and forests. This project is a CEOS Chair initiative from VNSC/VAST.	CEOS Chair
FDA-2: Collaborative development of Open Data Cube technology.	Q4 2019	CEOS Agencies will develop and contribute to the Open Data Cube initiative which uses an open source data management technology that lowers the barriers to use satellite Earth observation data. Activity will be undertaken in accordance with the Open Data Cube Work Plan and include a full code release (with documentation and installation modules), a communications plan and an application library.	SEO
FDA-8: Establish a common description of Future Data Architecture functional blocks and identify interfaces and interoperability approaches.	Q3 2019	Based on the outputs of the inventory and review of existing standards and approaches at CEOS agencies, on the pilot projects and using the various workshops (listed below) where FDA activities are discussed, FDA-AHT will establish a common understanding and develop a white paper describing the functional blocks and typical interoperability approaches for a generic FDA.	WGISS
FDA-9: Inventory and characterise existing FDAs operated by both public and private entities including the standards and approaches they use (e.g. Data Cubes, Exploitation Platforms, Copernicus DIAS, etc).	Q4 2019	As CEOS agencies are defining their processing and data dissemination standards, they seek to apply and follow international standards and best practices, including those generated by WGISS. This does not only concern common standards in terms of catalogs, metadata, terminology, and semantics, but it also involves interoperability standards for data discovery and download and for EO data analysis Application Programming Interfaces (APIs), as well as common interface standards such as INSPIRE, OGC, and W3C, and interoperability with other data access services (e.g., European Data Portal, international, GEOSS). WGISS will inventory and characterise existing FDAs operated by both public and private entities including the standards and approaches they use (e.g. Data Cubes, Exploitation Platforms, Copernicus DIAS, etc).	WGISS

Data Discovery/Access/Preservation/Usability/Exploitation Objectives/Deliverables: 2019-2021			
Objective/Deliverable	**Projected Completion Date**	**Background Information**	**Responsible CEOS Entity**
FDA-10: Finalise inventory of Software and Tools available or used at CEOS agencies for EO data exploitation and use focusing on Open Source but remaining as broad and inclusive as possible and implement a mechanism for discovery and access.	Q3 2019	Each CEOS agency will continue to develop its data and computational infrastructures consistent with its capacity and user service mandates. CEOS has a role in identifying tools to support complementarity and interoperability across CEOS agencies in support of the FDA strategy objectives. WGISS will finalise the ongoing work of inventorying the software and tools available or used at CEOS agencies for EO data exploitation and use (e.g. EO data visualization, analysis, processing, readers/writers, etc), and implement a mechanism for discovery and access. Focus will be on Open Source but remaining as broad and inclusive as possible.	WGISS
FDA-14: Facilitate discovery and access for end users to data analytics and processing tools and services through the WGISS Connected Data Assets Infrastructure.	Q4 2020	Facilitate discovery and access for end users through the WGISS Connected Data Assets Infrastructure, to data analytics and processing tools and services available from CEOS agencies and members. Association to relevant datasets and additional associated information would also be of help.	WGISS

3.9. 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 MIM database, the WGISS Connected Data Assets or 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. Maintain the Missions, Instruments and Measurements (MIM) database as a key tool to enhance understanding of Earth observations from space missions and data.

2019-2021: 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 2019, 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.

II. Continued implementation of the Architecture for Climate Monitoring from Space

2019: WGClimate will update the ECV Inventory and present the second version of a gap analysis and action plan based on the third version of the ECV Inventory for endorsement. The gap analysis will monitor changes in the provision of data records for GCOS ECVs and improvements with respect to the implementation of satellite missions and products following the GCOS Climate Monitoring Principles and the Guideline for the Generation of Datasets and Products meeting GCOS Requirements. In addition, it will concentrate GCOS ECVs that are highlighted in the GCOS Implementation Plan and were not addressed before. The ECV Inventory will be continued to be located on the Joint CEOS/CGMS WGClimate web presence at www.climatemonitoring.info to ensure accessibility.

As a new element the coordination of CEOS and CGMS activities towards the definition and implementation of an integrated global carbon observing system including a targeted observing system for monitoring the column concentrations of CO2, CH4 and other greenhouse gases from space will be introduced into WGClimate as decided by CEOS Plenary. The first step is to establish a roadmap for the development of a GHG monitoring system. WGClimate will address the implementation of GCOS action T71 "Prepare for a carbon monitoring system" and the respective requirements as well as the communication with UNFCCC. In addition, it will be ensured that the CEOS and CGMS activities are integrated into a broader approach on greenhouse gas monitoring, i.e. WMO IG3IS, GCOS, and GEO-C.

2020-2021: The Joint CEOS/CGMS WGClimate continues updates of the ECV Inventory providing a new version every year. This will be accompanied by an annual version of an incremental gap analysis report and updated coordinated action plan. WGClimate will foster the implementation of the actions in agency collaborations. Building on lessons learnt from the ECV Inventory, an attempt will be made to promote the existence and usage of Fundamental Data Records for the delivery of ECV Climate Data Records. In addition, needs for and usages of Interim Climate Data Records that represent a consistent continuation of climate data records with much higher timeliness, e.g., as used in climate services, will be considered.

WG Climate will continue activities as outlined in CRMS-25 to implement GCOS-T71, in particular by realizing the implementation of the roadmap developed during 2019 leading to the development of a prototype and an operational GHG monitoring system. Specific actions in response to the Strategy will continue within the relevant CEOS Entities.

III. Publish the CEOS Newsletter

2019-2021: CEOS, through contributions of JAXA, will continue the publication of this valuable, long-standing communication tool. It will be issued twice per year.

CEOS Services Objectives/Deliverables: 2018-2020			
Objective/Deliverable	**Projected Completion Date**	**Background Information**	**Responsible CEOS Entity**
CB-10: CEOS MIM Database Update Survey and Release of Online Version	Survey Q2, release Q4, each year	CEOS Agencies to provide resources to support their responses to the survey issued in the April-May timeframe to update the CEOS MIM database; release of the updated CEOS MIM Database will be online prior to the annual CEOS Plenary Meeting.	ESA, with support from CEOS Agencies
DATA-2: Full representation and accessibility of CEOS Agency datasets through WGISS Standards and Connected Data Assets Infrastructure (i.e. IDN, CWIC, FEDEO)	Q2 every year	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 will allow accessing all CEOS agencies data from external clients (e.g. GEOSS Platform and Portal) through a single entry point.	WGISS and CEOS agencies / Working Groups
CV-9: Radiometric Calibration Network (RADCALNET)	Q4 every year	Operate an automated multiagency network of coordinated infrastructure and land-based test-sites for postlaunch traceable calibration of sensor radiometric gain.	WGCV
OUT-2: CEOS Newsletter	Q1 and Q3 of each year	Call for information input in December and June; newsletters released in February and August.	JAXA, with support from CEOS Agencies
Annual delivery of the Essential Climate Variable inventory			
CMRS-17: Collection, incorporation, and quality control of new & updated information from data providers	Q4 every year	Based on a stable questionnaire, with potential updates of the inventory structure, to accommodate, for example, requirements stemming from C3S and WCRP; and experiences from applicable projects.	WGClimate
CMRS-20: Gap analysis	Q4 every year	WG chairs will initiate 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 WG Chair team and support by several expert teams that will perform the gap analysis in parallel.	WGClimate
CMRS-21: Action plan	Q4 every year	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.	WGClimate

3.10. 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.

2019-2021: 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.

Advancement of the CEOS Virtual Constellations: 2019-2021			
Objective/Deliverable	**Projected Completion Date**	**Background Information**	**Responsible CEOS Entity**
VC-2: Ozone dataset validation and harmonization	Q4 2020	Production of peer-reviewed papers on ozone profile intercomparisons of data sets and long term (1979-now) combined data sets.	AC-VC
VC-3: Air quality constellation coordination	Q1 2019	Prepare document on validation needs for the AQ Constellation.	AC-VC
VC-9: Implementation of the International Network for Sensor InTercomparison and Uncertainty Assessment for Ocean Colour Radiometry (INSITU-OCR)	Q4 2019	Implementation of the International Network for Sensor InTercomparison and Uncertainty Assessment for Ocean Colour Radiometry (INSITU-OCR), including recommendations of the INSITU-OCR White Paper (www.ioccg.org/groups/INSITU-OCR_White-Paper.pdf) and establishment of the INSITU-OCR Secretariat (EUMETSAT, NASA and NOAA). Implementation is following a modular approach.	OCR-VC (with EUMETSAT, NASA and NOAA)
VC-14: Vision for an OSVW Constellation	Q4 2019	Short Paper describing and justifying the oceanography and climate requirements for an OSVW constellation. The International Ocean Vector Winds Science Team (IOVWST) meeting held in 2016 strongly recommended: at least three scatterometers in orbits designed to roughly meet the WMO requirements; and one instrument in a non-sun-synchronous orbit to help with the diurnal cycle, better sampling at mid-latitudes, and to improve inter-calibration. This “optimal constellation” will be revisited at the 2019 IOVWST meeting in May and will be endorsed as is or modified. A short report will then be delivered to CEOS by end 2019.	OSVW-VC
VC-17: Support to ECV precipitation parameters	Q4 2019	Precipitation ECV support: Provide the CEOS Response to GCOS Action A-8; ensure continuity of satellite precipitation products through five deliverables. Deliverables for 2019 are: reprocessing of TRMM data into GPM standard (IMERG) for longer term consistency (Q3), and operational availability of JPSS-1/NOAA-20 MIRS precipitation products (Q2).	P-VC

Advancement of the CEOS Virtual Constellations: 2019-2021			
Objective/Deliverable	**Projected Completion Date**	**Background Information**	**Responsible CEOS Entity**
VC-18: Programs for improvement of global precipitation products	Q4 2019	Precipitation products (with respect to algorithm development, outputs, and user requirements) using multi-satellite and multi-agency data through coordination between Precipitation Virtual Constellation (P-VC) partners. Deliverable for 2019 is expansion of GSMaP_NOW NRT multisatellite product to Meteosat region (Q2).	P-VC
VC-19: Documented plan for the SST Virtual Constellation	Q1 2019	Building on Donlon, et al (2010) *Successes and Challenges for the Modern Sea Surface Temperature Observing System,* the SST-VC will describe and justify the requirements and design for the modern virtual constellation for SST. This description of an optimal SST constellation will prove useful to CEOS Agencies in planning and implementing a globally coordinated and cost- effective observing capability for SST.	SST-VC
VC-31: Evaluate CARD4L supply and user access trials via pilot activities (e.g., with SDCG for GFOI, GEOGLAM)	Q4 2019	The completion of the CARD4L Product Family Specifications is just one 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. Unless CARD4L is produced systematically, easily accessible at volume, compatible with varied existing work flows, and guaranteed to be sustained into the future, the benefits of the Specifications will not be realised. This task is intended to cover aspects such as: – CARD4L production from multiple instruments across the spectrum of available PFS; – routine publishing of this CARD4L via agency data portals, cloud data stores, other data aggregators/platforms; and, – investigation and implementation of new data paradigms such as COGs and STAC for CARD4L usability and discoverability. Digital Earth Africa has been agreed as an initial focal point, however this task is by no means exclusive to this initiative. GFOI, GEOGLAM, and the CEOS GEO-LEO activity may also present opportunities for CARD4L supply and user access trials.	LSI-VC (with SDCG-GFOI, CEOS-GEOGLAM *ad-hoc* WG)
VC-33: Complete Annual Update of the CARD4L Product Family Specifications (PFS)	Q1 2019	The CARD4L Product Family Specifications are intended to be living documents, updated on an annual basis at the occasion of the first LSI-VC team meeting of the calendar year. In addition, new PFS are expected to periodically join the CARD4L portfolio. This task captures the ongoing effort of the LSI-VC in these regards.	LSI-VC

Advancement of the CEOS Virtual Constellations: 2019-2021			
Objective/Deliverable	**Projected Completion Date**	**Background Information**	**Responsible CEOS Entity**
VC-37: CEOS Information Tool Improvements	Q4 2019	Identify potential modifications to existing CEOS information tools that can be made to help improve their value for gap analyses. Including modifying the CEOS MIM database to allow complex queries and gap analyses through the addition of an API. Develop a prototype online user interface using an API connected to the MIM.	LSI-VC
VC-39: Formally define terms used in the context of the Moderate Resolution Interoperability (MRI) Initiative.	Q2 2019	There is a broad spectrum of definitions of 'interoperable'. An agreed and documented formal definition is needed before further work can be done on VC-30.	LSI-VC
VC-40: Complete Initial CARD4L Product Assessments	Q4 2019	LSI-VC and WGCV have agreed a process for the assessment of data products as CARD4L. There are two components to this process: a self-assessment against the CARD4L PFS by the data provider, and secondly, a peer review undertaken by WGCV in collaboration with LSI-VC. This task captures the ongoing effort of the WGCV and LSI-VC.	LSI-VC, WGCV
VC-41: Pursue CEOS ARD promotion	Q4 2019	LSI-VC will undertake a number of tasks regarding the promotion of CARD4L, including: 1. Develop an information pack capturing the key value of CARD4L, using the CARD4L information notes as a basis. 2. Communicate actively with the commercial sector using the information pack and networks including UK Catapult, DIAS providers, and EARSC. 3. Increase communication with remote sensing agencies, scientists, and commercial providers through the ESA Living Planet Symposium, IGARSS, the ESA Ground Segment Coordination Body (GSCB), and other forums such as the World Geospatial Forum. 4. Act on the suggestions from the CARD4L survey. 5. Promote datasets via the CEOS ARD website (i.e., the CARD4L stocktake) and also through the relevant WGISS systems (e.g., Connected Data Assets (CDA)). 6. Advocating that CEOS Agencies adopt CARD4L Specifications, as the specifications become available.	LSI-VC
VC-42: Open-source library for surface reflectance product generation	Q4 2020	Publish an open-source software library for the generation of CARD4L surface reflectance products. The main focus will be on sen2like/HLS type processing modules. Any agency can contribute to the library, and it could potentially be open to private sector contributions.	LSI-VC

Advancement of the CEOS Virtual Constellations: 2019-2021			
Objective/Deliverable	**Projected Completion Date**	**Background Information**	**Responsible CEOS Entity**
VC-43: Update of CEOS OST-VC User Requirements Document	Q4 2020	The current constellation User Requirement Document (URD) is the 2009 "Next 15 years of altimetry" report. An update is underway, with the objective to complete this work in 2020. This has been supported by early work by CNES phase 0 study (mix nadir/swath, global UR analysis), and coordination CNES-ESA (swath altimeter for operational oceanography => URD SAOO). The contents of the update will likely address: • Analysis of user needs: systematic + exploratory; • Swath altimetry + nadir altimetry: combined; • Recommendation for an "operational constellation" (targets: Copernicus Next Gen, China altimetry program); • Recommendation for additional science missions in complement; and, • Multiple applications: mesoscale monitoring, polar oceans, long-term record for sea level rise.	OST-VC
VC-44: Definition of an improved Precipitation CDR	Q4 2019	Provide the CEOS Response to ECV Inventory Gap Analysis Recommendation #14. Deliverables for 2019 include: update precipitation ECV inventory (Q2); study the situation on precipitation climate data records based on the findings of the WGClimate gap analysis report (Q3), to identify ways forward to stimulate the production of an improved precipitation CDR (Q4), and Engage with the CGMS-IPWG and WMO SCOPE-CM communities for best practices and current activities for the establishment of international collaborations for developing and producing such a CDR (Q3).	P-VC

3.11. Support to Other Key Stakeholder Initiatives

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

2019-2021: The CEOS Ad Hoc Team on SDGs (AHT SDG) will continue to:

- Support GEO in its SDG-related initiatives, mainly through the EO4SDG ("Earth Observation for Sustainable Development Goals") initiative but also with the relevant thematic GEO activities (flagships, initiatives and communities) active on SDGs, focusing on the unique role that CEOS should play as a coordination body of the Space community efforts.
- Represent CEOS in SDG-related working groups such as the Working Group on Geospatial Information (WGGI) of the Inter-Agency and Expert Group on the Sustainable Development Goal Indicators (IAEG-SDGs) and contribute with GEO to the WGGI Task Stream on application of satellite Earth Observation data for the SDG indicators.
- Produce, in cooperation with the GEO EO4SDG initiative, a "*SDG satellite data requirement Table*" for a number of SDG indicators that are already or can be supported by satellite

data. This table will help CEOS Agencies get more technical and precise information of what is needed in terms of satellite data, coverage, frequency, resolution, etc. for countries to achieve their SDG targets and report on SDG indicators. The table will also contribute to the work of the WGGI in their efforts to compile the satellite data needs for SDG indicators.

- Assist, in cooperation with the GEO EO4SDG initiative, the UN Statistical Division, the custodian agencies and the countries, with their satellite data requirements and acquisition for the implementation of EO-relevant SDG indicators.
- Liaise with CEOS permanent structures (VCs, WGs and SEO) on capacity building (with WGcapD), ARD (with VC-LSI), EO-enabling infrastructure (with SEO and WGGIS) and EO products validation /standardization (with WGCV) to harness CEOS collective expertise and maximize benefits from the use and integration of satellite data in SDG monitoring or reporting processes.
- Collect and centralize information from individual CEOS Agency activities relevant to the SDGs, and build and maintain a "*Compendium on the CEOS Agencies engagement on SDGs*", including CEOS Agencies' points of contacts on SDGs. The Compendium will be used for internal CEOS purposes, with the objective to identify strengths and gaps in CEOS collective engagement, and better coordinate the CEOS efforts on SDGs and support to GEO. Encourage CEOS space agencies to proactively contact their national governments in the SDG Voluntary National Review process
- Develop communications material (brochure, website content) with SEO team's support and in coordination with GEO when needed, to better inform CEOS space agencies and SDG stakeholders about the critical role of satellite data in the SDG systems and processes.

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.

2019-2021: The CEOS Biodiversity activity will continue to work closely with the GEO Biodiversity Observation Network (GEO BON), other organizations, and a variety of projects to foster the development of remote sensing-enabled Essential Biodiversity Variables (EBVs) and increase the use of remote sensing for biodiversity applications. This work primarily involves three types of activities:

- Prioritize candidate EBVs. Because a range of potential EBVs has been and continues to be suggested these must be evaluated and prioritized. An important step in this process is to identify the appropriate attributes (also called sub-variables) and organize them in an appropriate hierarchy. Much of this has already been accomplished but agreement and convergence in some areas (e.g., Ecosystem Structure variables) is still needed. This activity includes in-person discussion at the annual Implementation Committee meetings as well as online working group sessions and additional conversations.
- Develop and document. This activity focuses on development of the metadata for each

EBV and its attributes. This metadata consists of descriptive text and a variety of standard metadata that is under development by the GEO BON EBV Data Task Force.

- Outreach with the broader biodiversity community. Much of the GEO BON community is not focused on utilizing remote sensing data and lacks the needed technical skills. However, being under the same GEO BON "umbrella" provides a means to connect the remote sensing part of the GEO BON community with the others. One key aspect of this is communication with the Convention on Biological Diversity with which GEO BON works closely.

Additionally, there are a variety of ESA- and NASA-funded projects that support the above activities:

- ESA-funded GlobDiversity Project. This project focuses on development of several important EBVs: Fragmentation, Canopy Chlorophyll Concentration, and Land Surface Phenology.
- NASA-funded projects supporting GEO BON. These projects, listed below, facilitate development of particular EBVs and, more broadly, promote the use of remote sensing for biodiversity applications.
  - Expanding Wallace Biodiversity Modeling Software to Support National Biodiversity Change Indicator Calculations for GEO BON Assessment and Reporting
  - Activities to Advance, Build, and Deliver Remote-Sensing Supported Species Distribution and Species Abundance EBVs
  - Improving Linkages Between EO and Ecosystem Service Models with EBVs
  - Dynamic Seascapes to Support a Biogeographic Framework for a Global Marine BON
  - Integration of EO for Decision Making on Biodiversity Management and Conservation in Colombia: Consolidation of the Colombian BON
  - Ecosystem Functional Diversity of the Circumpolar Arctic Tundra
  - Quantifying Forest Vertical Structure Using Spaceborne Lidar: A GEO BON EBV Application in Colombia
  - Laying the Foundations of the Pole-To-Pole MBON of the Americas

IV. Continue dialogue on enhanced CEOS-level coordination to support improved research and monitoring of the Earth's Polar Regions.

2019-2021: CEOS Agencies will continue to maintain a dialogue with GEO, CGMS, and the WMO on their respective interests and coordination initiatives relating to polar observations. CEOS agencies, through their involvement in PSTG, will continue to facilitate acquisition and distribution of fundamental satellite datasets for the development of specific information products for polar research and applications (e.g. cryospheric, atmospheric, etc.). CEOS Agencies will support the development of key science products under their own respective science programs. The PSTG, charged with prioritizing requirements, engaging in a dialogue with polar science authorities, and supporting the development of satellite sensor derived products for cryospheric research and applications, will encourage formal submission of science requirements documents from the cryosphere communities (permafrost, sea ice, snow cover, ice sheets, and glaciers). CEOS, in conjunction with PSTG, will develop observation strategies to avoid observational gaps over polar regions.

V. 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 SIT32 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 MBON and Blue Planet. COVERAGE project development is comprised of four phases (A-D).

A phase A COVERAGE activity supported by NASA officially kicked off in November 2017 and is now complete. This first phase of COVERAGE, which extended through Q4 2018, focuses on important preliminary arrangements, including a detailed technical scoping exercise to drive subsequent development. The primary task of assembling the execution team and advisory board (COV-1) plus the establishment of the collaborative framework for stakeholder participation has been completed. Also now finalized, Phase A involved the compilation of use cases and functional requirements for the COVERAGE system, including development of an inventory of high value datasets for inclusion, derived through a process of ongoing stakeholder engagement and based on priority set of community driven applications (COV-2). A detailed COVERAGE project implementation plan and schedule for the Phase B activity (development of prototype COVERAGE system and MBON-related demonstration application) has been formulated (COV-3). Associated technical work has involved development of a system architectural design that identifies also source data streams and interfaces.

2019-21: COVERAGE Phase B (1 year duration, ending Q1-2020) will involve technical implementation of this prototype 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 (COV-4). Ongoing stakeholder engagement and the solicitation of feedback will be integral to this and subsequent phases of the project.

Phase C of the COVERAGE project will commence thereafter within the first quarter of 2020 and is also expected to be 1 year in duration. Technical work will address peer review comment and involve development of the fully featured COVERAGE system, demonstrating functionality for the suite of datasets in support of target GEO applications (COV-5).

The final phase of COVERAGE (D) is expected to last 6 months through Q3 2021 and will involve testing and evaluation of the assembled technical system (COV-6).

Support to Other Key Stakeholder Objectives/Deliverables: 2019-2021			
Objective/Deliverable	**Projected Completion Date**	**Background Information**	**Responsible CEOS Entity**
SDG-2: Compile and maintain a compendium of CEOS Agencies engagement on SDGs	Q2 2019	Collect and centralize information across CEOS Agencies on their SDG engagement and related activities, through online surveys and other consultation channels. The Compendium of CEOS engagement on SDGs is meant to be used for CEOS internal use only, to collect main points of contacts on SDGs in the various CEOS agencies, identify strengths and gaps in CEOS collective engagement, and better coordinate / align / optimize CEOS agencies' efforts on SDGs. The compendium will be made available to CEOS members only and regularly updated as soon as new information is available from the CEOS Agencies.	AHT SDG
SDG-3: Review and assess the contribution of EO to the SDG Targets and Indicators. Produce a compendium and policy brief.	Q3 2019	Assess the current and potential contribution of EO to the SDG Targets and Indicators (through the lenses of space-based EO) and identify areas of better EO uptake, with the objective to increase the effective use of satellite observations and products in the overall SDGs processes (targets achievement and indicators? monitoring) and by all key players (global to local)	AHT SDG
SDG-4: CEOS engagement plan on SDGs	Q2 2019	Develop a coherent, flexible and adaptive CEOS engagement strategy on SDGs to maximize CEOS efforts and available resources on SDGs for a higher impact (on the use of EO in SDGs) and for more tangible benefits for CEOS agencies. A specific emphasis will be placed on the development of national use cases of EO methods and applications for target setting and SDG indicator monitoring and reporting.	AHT SDG
SDG-5: Analyse the SDG satellite data requirements	Q4 2019	Produce, in cooperation with the GEO EO4SDG initiative, a “SDG satellite data requirement Table” for a number of SDG indicators that are already or can be supported by satellite data. The SDG satellite data requirement Table” will summarise the satellite data needs (satellite observations, geographical coverage, time frame, frequency of observations, spatial resolution, EO data products etc.) for countries to achieve their SDG targets and report on SDG indicators.	AHT-SDG
SDG-6 Open Data Cube algorithms for the SDGs	Q4 2019	Develop and demonstrate a set of Data Cube algorithms that use CEOS satellite data and can be applied to several SDGs (e.g. 6.6.1, 11.3.1, 15.3.1). Seek feedback from statistical agencies and other stakeholders to understand how to improve these algorithms.	SEO (with the support of AHT-SDG)

Support to Other Key Stakeholder Objectives/Deliverables: 2019-2021			
Objective/Deliverable	**Projected Completion Date**	**Background Information**	**Responsible CEOS Entity**
BP-4: CEOS Action Plan for GEO Blue Planet Initiative Working Group and Pilot Project activities as documented in the 2020-2022 Blue Planet	Q1 2020	Building upon the GEO Blue Planet Initiative 2020-2022 Implementation Plan (March 2019), the 4th Blue Planet Symposium (July 2018) and the 1st International Operational Satellite Oceanography Symposium (June 2019), coordinate efforts across the CEOS Ocean VCs, WGs and agencies and develop an action plan for CEOS contributions to Blue Planet Working Group activities.	CEOS Blue Planet Expert (with Ocean VCs and WGCapD)
BON-6: Develop a draft standardised approach for specifying satellite observation requirements and EBV metadata.	Q4 2019	The approach will act as a template to facilitate development of detailed requirements and metadata. The ESA GlobDiversity Project, the GEO BON EBV Data Task Force, and the relevant EBV working groups are the key players in drafting this approach.	CEOS Biodiversity Experts
BON-7: Develop an updated list of candidate RS-enabled EBVs.	Q2 2020	The original list of EBV candidates has been in flux as discussions have progressed. This updated list will feed into discussions at the GEO BON 2020 Open Science Meeting planned for June 2020 and lead to further refinement and consensus.	CEOS Biodiversity Experts
POL-1: Annual status report	Q4 2019	Facilitate communication between PSTG and CEOS through provision of an annual status report on polar activities and develop a formal collaboration approach with PSTG.	CEOS Polar Expert
COV-4: COVERAGE Phase B prototype system	Q1 2020	Development of prototype COVERAGE system demonstrating core functionality for limited datasets	COVERAGE lead (with Ocean VCs)
COV-5: COVERAGE Phase C system	Q1 2021	Implementation of fully featured COVERAGE system in support of designated GEO application	COVERAGE lead (with Ocean VCs)
COV-6: COVERAGE system evaluation (Phase D)	Q3 2021	Testing and evaluation of the COVERAGE system	COVERAGE lead (with Ocean VCs)

3.12. Organizational Issues and Outreach

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

2019-2021: 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.

Key 2018 meetings will be identified as they are announced, and the CEOS SEC will develop strategic plans to ensure CEOS is positioned to participate as appropriate.

II. Maintain the CEOS Website and enhance currency and relevance of content

2019-2021: CEOS released a new website, with a modern user interface and updated appearance, in 2014. CEOS, with coordination through the SEO, will build on the "content management" approach underpinning this new 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.

Outreach to Key Stakeholders: 2019-2021			
Objective/Deliverable	**Projected Completion Date**	**Background Information**	**Responsible CEOS Entity**
OUT-1: CEOS awareness and promotional material delivered at key meetings	Q4 2019	The CEOS calendar will be used to confirm CEOS representation at key international and stakeholder meetings, as updated throughout the three-year term.	CEOS Chair with support from CEO, SIT Chair and CEOS SEC
ORG-8: Review and update workings of the www.ceos-deliverables.org database / website	Q4 2019	Review, propose and implement an updated version of the ceos-deliverables database and the interface to this database via the web. This update should include the desired additional information necessary to monitor the CEOS Work Plan as discussed at 32nd CEOS Plenary.	CEO, SEO

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.