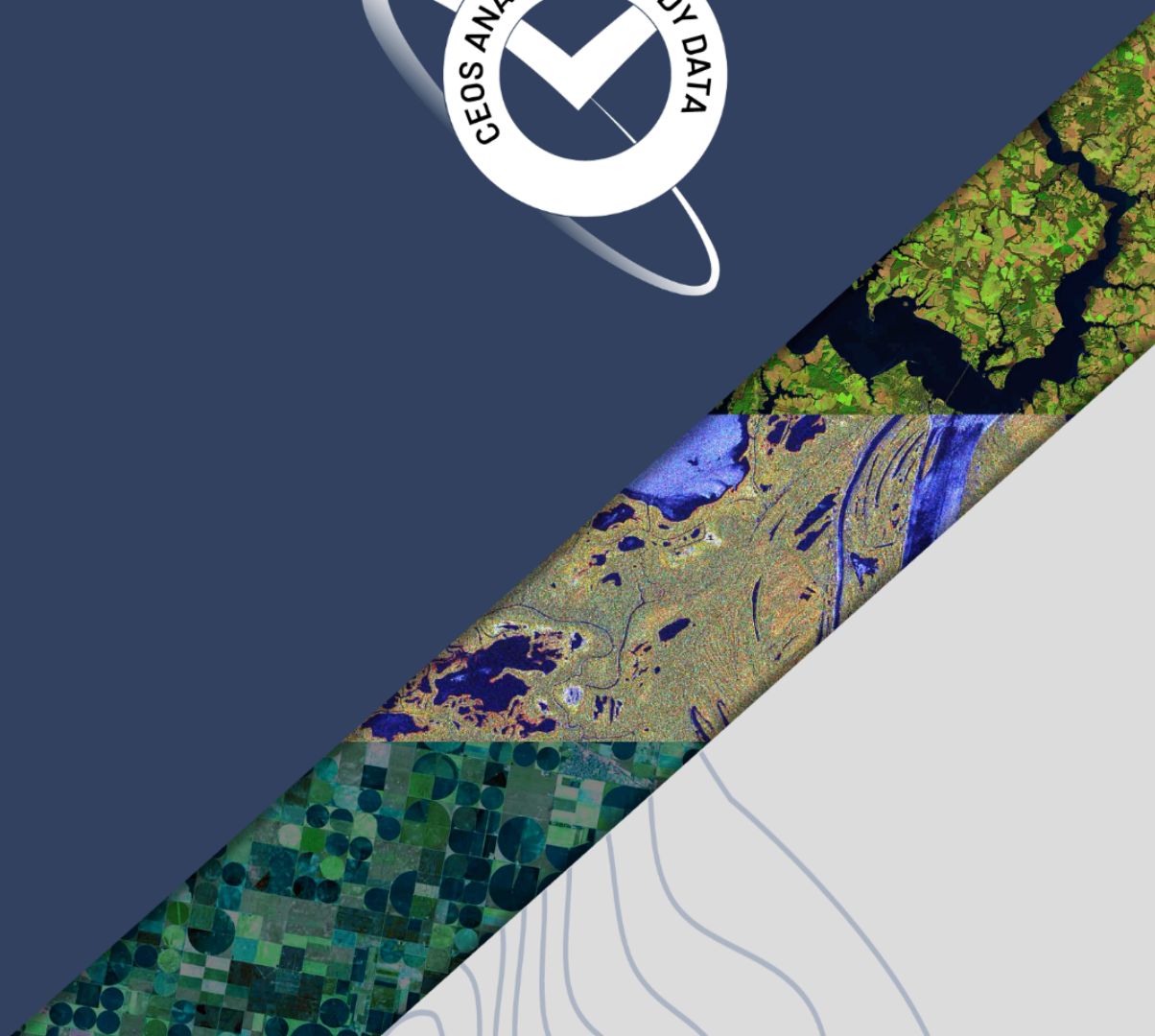
Committee on Earth Observation Satellites

CEOS Analysis Ready Data (CEOS-ARD) Strategy 2024

October 2024



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Background

CEOS-ARD has been a great success. It has catalyzed a growing movement and recognition of the importance of providing satellite EO data that is easier to use and doesn't require a scientific background in remote sensing to derive impact.

CEOS-ARD datasets have become some of the most popular types of products served up by CEOS Agencies (e.g., Landsat Collection 2, Copernicus Sentinel-2 Collection 1), reflecting the appeal to both existing users as well as a new and growing user base. This impact can be seen in some of the large online platforms CEOS-ARD underpins, such as Digital Earth Africa and various Open Data Cube instances around the world.

CEOS-ARD requirements help maintain the value of public EO programme data, ensuring datasets keep pace with rapidly evolving user expectations regarding ease of use and access, and provide a useful benchmark for all data providers.

The expertise present in CEOS has been critical to the development of CEOS-ARD, allowing us to take the first steps and propose a concrete definition of what constitutes a reasonable level of 'analysis-readiness'.

CEOS must continue to use its expertise to lead and strategically shape the satellite EO landscape. CEOS has the critical mass of scientific expertise, technical capacity, thematic diversity, EO mission/programme managers and decision makers, and a convening power that makes it the ideal forum to develop and implement new ARD concepts.

We seek to maintain leadership of the satellite Earth observation Analysis Ready Data concept through CEOS-ARD, which should serve as the basis for more formal standards at the appropriate time.

It is an important time for the CEOS community to reflect on the progress to date, take stock of future directions and needs, and confirm our strategy for the next few years.

CEOS-ARD Objectives

CEOS Analysis Ready Data (CEOS-ARD) are:

> *Satellite data that have been processed to a minimum set of requirements and organized into a form that allows immediate analysis with a minimum of additional user effort and interoperability both through time and with other datasets.*

CEOS Agencies have committed to the goal of producing the CEOS-ARD framework, specifications and datasets with the overall aims of:

- Supporting the mainstreaming of satellite EO data in society through removal of user burden and data complexity.
- Expanding the user base for EO data, including from academic and research communities to commercial and non-governmental organizations.
- Ensuring continued value to users of public satellite EO programme data and information.
- Increasing the amount of satellite EO data available to support the major global development agendas and priorities of CEOS (e.g., climate, sustainable development, disaster response) and the user community at large.
- Enhancing quality and traceability of EO products and awareness of users to the importance of these factors.

Strategy

To achieve our stated objectives, a broad portfolio of CEOS-ARD that is easily discovered, accessed and utilized is the ultimate goal. We seek to do this by:

- Establishing a broad understanding of, and participation in, CEOS efforts to define, produce, apply, and promote CEOS-ARD in support of societal needs.
- Engaging all CEOS Agencies in the CEOS-ARD activity and encouraging self-assessments for all relevant datasets.
- Promoting the inclusion of systematic CEOS-ARD production into mission planning at inception/design stages and major archive reprocessing opportunities.
- Fostering a vibrant CEOS-ARD Oversight Group with broad participation from the CEOS Virtual Constellations (and other CEOS entities as applicable) to ensure all types of users and applications are covered.
- Continually improving and streamlining the process for self-assessments to make it as easy as possible for data providers and others to work through the CEOS-ARD process.
- Getting CEOS-ARD into the cloud as easily identifiable and discoverable products in cloud-optimized and machine-readable states to improve 'in-cloud' analysis.
- Advancing interoperability of CEOS-ARD by leveraging the work of WGISS and the CEOS Interoperability Framework.
- Ensure broader community efforts on ARD remain compatible with the specific needs of the satellite EO community and CEOS member agencies.
- Capturing and communicating the benefits of CEOS-ARD. This will serve as a feedback mechanism to encourage further activity.
- Maintain a practical and results-oriented focus which is underpinned by a culture of openness and inclusivity.

The Strategy is elaborated below, with activities categorized into six broad themes:

1. **CEOS-ARD Availability, Product Diversity, and Representation**
2. **Framework and Specification Advancement**
3. **Discovery, Access, Utilisation, and Interoperability**
4. **Community Engagement**
5. **Research, Test Cases, and Pilot Activities**
6. **Commercial Engagement**

1. CEOS-ARD Availability, Product Diversity, and Representation

1.1. CEOS Agencies should review their offering of data products, identifying those of relevance to CEOS-ARD Product Family Specifications and prioritize self-assessments of these products.

CEOS Agencies should aim to offer CEOS-ARD compliant products for all relevant datasets. Agencies that have already done so report that these datasets are now some of their most popular, reflecting the strong demand generated by a lowered barrier to entry and an expanded user base. CEOS Agencies should commit to reviewing the available and upcoming CEOS-ARD Product Family Specifications (PFSs) and consider which datasets would be candidates for assessment, and commit staff to undertake those self-assessments.

Applicable to: CEOS member agencies

1.2. Support a strong CEOS-ARD Oversight Group with broad representation of the CEOS Virtual Constellations

The CEOS-ARD Oversight Group is an important cross-cutting CEOS forum for all matters related to CEOS-ARD, particularly the management of the CEOS-ARD framework and development of new PFSs. Ensuring participation of all Virtual Constellations means the group has diverse thematic representation.

Applicable to: CEOS member agencies

The CEOS Analysis Ready Data Oversight Group (CEOS-ARD OG)

Entity	Representative(s)	CEOS-ARD Related Activities
Lead	Ferran Gascon (ESA)	
Secretariat	Matt Steventon	
Land Surface Imaging (LSI-VC)	Christopher Barnes (USGS) Peter Strobl (EC-JRC) Andreia Siqueira (GA) Takeo Tadono (JAXA) Ake Rosenqvist (JAXA)	• Surface Reflectance PFS • Surface Temperature PFS • Synthetic Aperture Radar PFS • Nighttime Lights Surface Radiance PFS • Aquatic Reflectance PFS
Ocean Colour Radiometry (OCR-VC)	Maycira Costa (UVic) Ewa Kwiatkowska (EUMETSAT)	• Ocean Reflectance PFS *(in development)*
Precipitation (P-VC)	Chris Kidd (NASA)	• Precipitation PFS *(in development)*
Sea Surface Temperature (SST-VC)	Edward Armstrong (NASA)	
Ocean Surface Topography (OST-VC)	Mark Higgins (EUMETSAT) Julia Wagemann (ECMWF) Federico Fierli (EUMETSAT)	
Working Group on Calibration & Validation (WGCV)	Philippe Goryl (ESA) Medhavy Thankappan (GA) Peter Harrison (GA) Clement Albinet (ESA)	• Leading peer reviews of CEOS-ARD self-assessments
Working Group on Information, Systems & Services (WGISS)	Makoto Natsuisaka (JAXA) Tom Sohre (USGS) Nitant Dube (ISRO)	• CEOS Interoperability Framework and Handbook
Working Group on Capacity Building & Data Democracy (WGCapD)	Jorge Del Rio Vera (UNOOSA)	
CEOS Systems Engineering Office (SEO)	David Borges (NASA)	• Pilot self-assessments • External stakeholder engagement
Observers	Marie-Claire Greening (ESA) Jonathon Ross (GA) Alexandre Constantin (CNES) Patrick Quinn (NASA) Steven Ramage (CEO)	

1.3. Encourage the CEOS Virtual Constellations to work on CEOS-ARD

In the CEOS-ARD framework, Virtual Constellations are the fora where new PFSs are developed in response to existing or foreseen user needs and trends. Virtual Constellations are also the appropriate place to engage external stakeholders, including representatives from the New Space / commercial sector. CEOS Virtual Constellations should be tasked with bringing all stakeholders together to look for new opportunities.

The activities of the CEOS Virtual Constellations often take place in conjunction with external science teams and other bodies across the community. CEOS-ARD however is a unique CEOS activity, and one that the Virtual Constellations should be encouraged to take on as standard business, and which may act as a catalyst for increased activity in these CEOS teams.

The Virtual Constellations are also unique in the CEOS structure as they provide a more open environment that allows external stakeholders to be represented directly. This is a great benefit to CEOS-ARD and the development of Specifications that are intended to be built on strong user/community demand. CEOS Agencies should encourage broad representation in the Virtual Constellations for the purposes of developing thematicPFSss and overseeing self-assessments, and this may have additional benefits for the Virtual Constellations in terms of level of participation.

CEOS-ARD started in the land domain, where it has gained great traction. All Virtual Constellations should be encouraged to consider the new, 'non-expert' user angle that has proven effective in the land domain, and consider the potential for expanding the user base and applications of their EO products.

New PFSs in development as of writing include Interferometric Radar (INSAR) (LSI-VC), LiDAR Terrain and Canopy Top Height (LSI-VC), Ocean Reflectance (OCR-VC), and Precipitation (P-VC). The VCs should be supported and encouraged to bring these to completion.

Applicable to: CEOS member agencies supporting leadership of Virtual Constellations

1.4. CEOS-ARD at mission inception and planning stages and in archive reprocessing plans

CEOS Agencies should strive to include systematic CEOS-ARD production into their plans at the mission inception and design stages and, for missions that are ongoing/ended, at major archive reprocessing opportunities. Having CEOS-ARD available from the outset of a mission will avoid the need for costly reprocessing or retrospective adjustments.

Mission inception and collection / archive reprocessing are also key opportunities for cross-organisational / mission alignment with respect to the definition of ARD surface reflectance and other ARD quantities / measurands (refer to equivalence activity in Section 5.3).

Applicable to: CEOS member agencies

2. CEOS-ARD Framework and Specification Advancement

2.1. CEOS-ARD GitHub

It has been generally agreed that the best way forward for further development of the CEOS-ARD PFSs is via GitHub, for transparency, version control, and most importantly as a means to facilitate consistency across the different PFSs and alignment with SpatioTemporal Asset Catalogs (STAC) (see 2.2 and 3.2 below). The CEOS-ARD GitHub repository has now been established under the CEOS Organizational GitHub account and is in the process of being populated with content. The CEOS-ARD team will define a clear roadmap and timeline for transition to GitHub, as well as a set of implementation practices/guidelines and governance framework.

Applicable to: CEOS-ARD Oversight Group, LSI-VC, SEO

2.2. Modularisation of the CEOS-ARD Product Family Specifications

The CEOS-ARD team has long grappled with how to ensure consistency between Product Family Specifications and their parameters and requirements, and also how to make the definition of new Specifications easier. Prior work on a PFS 'template' sought to introduce such consistency, but it proved to be a challenging proposition.

With the migration to a GitHub based approach described in 3.1, we will aim to revisit the idea of a 'building block' approach to CEOS-ARD Specifications. Ideally, CEOS-ARD would be defined in smaller blocks that individual Product Family Specifications can pick from, minimizing the development time of new Product Family Specifications. These building blocks could even match STAC extensions. Another reason to split Product Family Specifications into smaller building blocks is that it allows smaller groups of experts to more easily work on individual building blocks.

We believe the time is right, with the increased traceability and version control offered by GitHub, to seek to parameterise the CEOS-ARD Specifications and introduce an inherent consistency across the requirements. The CEOS-ARD Oversight Group and relevant Virtual Constellations need to be resourced to undertake this substantial task.

Applicable to: LSI-VC

2.3. Clarify the CEOS-ARD functional taxonomy/ontology/hierarchy and combination of CEOS-ARD Product Family Specifications accordingly

Related to 2.2 above, the CEOS-ARD team will seek to clarify the functional taxonomy/ontology/hierarchy of CEOS-ARD. We will seek to clarify the top-level categorisation of PFS (by sensor/wavelength/geophysical product/etc.) and add a logical structure into the way CEOS-ARD is classified and described. This will require discussion on the 'Processing Level' of CEOS-ARD.

To date, CEOS-ARD has loosely focused on the development of Product Family Specifications for products that are typically referred to as 'Level 2'. However, there are issues:

- The definition of Levels is not consistent across agencies or thematic domains.
- Moving beyond the land domain, there are new questions about the appropriate target for new types of CEOS-ARD products, for example, precipitation ARD might concentrate upon Level 3 (gridded, aggregated) data products, although similar ARDs for Level 2 (instantaneous, footprint resolution) and the Level 1 (unprocessed instrument data at native resolution) data are also possibilities.

- The LiDAR Terrain and Canopy Top Height PFS under development may be considered Level 3.

The CEOS-ARD Framework should be updated to include a common definition of 'Levels' to provide clarity and consistency across the Product Family Specifications. We should aim to leverage the latest thinking on consistent terminology in this space, e.g.: *A Revised Processing Level Scheme For Earth Observation Data (Strobl, 2023)*(http://doi.org/10.2760/46796).

Applicable to: LSI-VC

2.4. Replica datasets, authenticity, traceability, and inherited CEOS-ARD compliance

The CEOS-ARD Framework should be updated in recognition of the fact that there are often replicas of CEOS-ARD datasets mirrored in multiple locations and that there needs to be a mechanism for these mirrored datasets to inherit CEOS-ARD compliance, as well as an agreed means for testing the authenticity and compliance of these copies (e.g., potentially changed formats, metadata files renamed, or content otherwise altered), and clearly identifying the original source of the CEOS-ARD compliance.

Applicable to: LSI-VC, WGISS

2.5. CEOS-ARD product version control and incremental compliance updates

The CEOS-ARD Framework should be updated with a new mechanism to streamline the process of updating a product's compliance in response to PFS updates (i.e., a delta compliance process). Open questions include:

- What happens if existing CEOS-ARD datasets are made non-compliant by an update to a PFS?
- Are self-assessments tagged with a version number to clarify with which CEOS-ARD PFS version they are compliant?
- Could there be a fast-tracked reassessment process so previously compliant datasets can be easily updated to the latest version of compliance?
- How are changes to Specification parameters and requirements best communicated to data providers?
- What is the appropriate interval between updates of the PFS, particularly those that have the potential to disrupt past compliance?

Broadly, CEOS-ARD product version control needs to be formalized in the CEOS-ARD Framework. This will be an area of work for the CEOS-ARD Oversight Group.

Applicable to: CEOS-ARD Oversight Group, LSI-VC

2.6. Metadata specifications for optical products

Consider the expansion of the CEOS-ARD metadata specification concept (which is currently implemented exclusively for the SAR Specification) to be a core piece of the CEOS-ARD Framework. Ideally this would be a mapping / alignment of the PFS parameters to existing metadata specifications (e.g., STAC – see 3.2 below). The point is to replicate the effective SAR CEOS-ARD metadata specifications, which greatly ease CEOS-ARD self-assessments and peer reviews by providing a direct mapping between the metadata and the PFS parameters.

Applicable to: LSI-VC

2.7. Terminology

CEOS-ARD will seek to have consistent terminology and parameter names across all of the PFS and Framework, leveraging conventions established by the CEOS Working Group on Calibration and Validation

(WGCV) and Working Group on Information Systems & Services (WGISS) and the CEOS Interoperability Framework/Handbook.

Applicable to: WGCV, WGISS, CEOS-ARD Oversight Group

2.8. Continual update and refinement of the CEOS-ARD Product Family Specifications

CEOS-ARD must remain flexible and adaptable to the evolving expectations of the user base and data provider needs. Refining existing specifications where necessary to make them more fit for purpose and inclusive must be an ongoing responsibility of the Virtual Constellations.

Applicable to: Virtual Constellations that have published CEOS-ARD PFS

3. Discovery, Access, Utilisation, and Interoperability

3.1. Embrace the CEOS Interoperability Framework

CEOS-ARD is a step towards interoperability, but it is not sufficient on its own. There are various factors that must be considered in order to move further along the interoperability spectrum, and these are captured by WGISS in the CEOS Interoperability Framework and subsequent Interoperability Handbook v2.0. CEOS-ARD should be aligned with the principles developed in the CEOS Interoperability Framework/Handbook in order to make it more interoperable.

WGISS support is needed to ensure CEOS-ARD development is aligned with broader efforts to advance interoperability.

Applicable to: WGISS, CEOS-ARD Oversight Group

3.2. Alignment of CEOS-ARD and SpatioTemporal Asset Catalogs (STAC)

Community adoption of the SpatioTemporal Asset Catalogs (STAC) metadata specification is an important consideration and opportunity for CEOS-ARD. The STAC specification is a common language to describe geospatial information, so it can more easily be worked with, indexed, and discovered. STAC was designed to be flexible and has an intentionally small core that can be added to via extensions. Many STAC extensions have been developed, including one for the optical CEOS-ARD specifications.

Natively expressing CEOS-ARD metadata in STAC could be beneficial because it provides the metadata in a form that people already use and is supported by a vibrant software ecosystem. CEOS will explore further alignment of CEOS-ARD with STAC.

Applicable to: CEOS-ARD Oversight Group, LSI-VC, WGISS, SEO

3.3. Incorporate additional cloud native approaches and facilitate machine-to-machine access and utilization

Work with the CEOS Working Group on Information Systems and Services (WGISS) to investigate changes to the CEOS-ARD Framework that will make CEOS-ARD datasets more suited to the cloud environments on which EO data is increasingly stored and processed. Seek to ensure the suitability of CEOS-ARD for the machine-to-machine processes employed for the application of remote sensing data and propose changes as necessary to the CEOS-ARD Framework, definition or Specifications to ensure continued relevance and utility of CEOS-ARD. Considerations should include introducing mechanisms for 'pushing' updates about CEOS-ARD datasets.

Applicable to: CEOS-ARD Oversight Group, LSI-VC, WGISS, SEO

3.4. CEOS-ARD discoverability and branding

Undertake efforts to increase the visibility of and access to CEOS-ARD datasets, through various means, leveraging individual CEOS Agency data platforms as well as shared infrastructure such as that maintained by WGISS, the CEOS MIM Database, and others across CEOS. Better promote the availability of CEOS-ARD in a consistent manner, with clear branding, supporting documentation, etc.

Applicable to: CEOS-ARD Oversight Group, LSI-VC, WGISS, SEO, CEOS MIM Database Team

Figure 1: Concept for an updated CEOS-ARD catalog with improved information on access options

3.5. CEOS-ARD in the commercial cloud

CEOS Agencies should engage with key cloud providers to ensure CEOS-ARD is promoted on their platforms where applicable and appropriately tagged using the CEOS-ARD logo and branding. This should be done in a coordinated fashion. We seek to leverage existing agency relationships with these providers, which are hosting an increasing amount of CEOS Agency data and aim to increase the momentum behind CEOS-ARD, which is mutually beneficial to data providers, hosts, and users. CEOS Agencies are increasingly customers of these providers, so should have some leverage to make requests and work closely with these platforms to promote CEOS-ARD. Seek to establish dialogues with key data distributors and cloud operators to coherently promote CEOS-ARD via their platforms.

Applicable to: CEOS member agencies, particularly those with existing relationships with cloud providers, WGISS, CEOS-ARD Oversight Group

3.6. Technical Advisory Notes

Publish CEOS-ARD Technical Advisory Notes to provide more specific implementation guidance while retaining flexibility in the non-prescriptive baseline provided by the Product Family Specifications. Provide additional technical guidance to the user community, CEOS Agencies, and other data providers, without compromising the nature of CEOS-ARD. For example, these Advisory Notes might recommend data provision in cloud-friendly formats (e.g., STAC, COGs, HDF5/netCDF, Zarr), suggesting certain algorithms/methods, providing guidelines for source code, etc.

Applicable to: Virtual Constellations, WGISS

4. Community Engagement

4.1. Monitor, guide and advise community efforts to define broader geospatial ARD standards, ensuring compatibility and consistency with CEOS-ARD

CEOS must continue to use its expertise to lead and strategically shape the satellite EO landscape. CEOS has the critical mass of scientific expertise, technical capacity, thematic diversity, EO mission/programme managers and decision makers, and a convening power that makes it the ideal forum to develop and implement new ARD concepts.

We seek to maintain strong leadership of the satellite Earth observation Analysis Ready Data concept through CEOS-ARD, which should serve as the basis for more formal standards at the appropriate time.

Applicable to: CEOS-ARD Oversight Group

4.2. Support higher level products for CEOS priority areas

As highlighted by the CEOS Ecosystem Extent Task Team (EETT; reference, page 6) and GEOGLAM (Essential Agriculture Variables), users are seeking 'higher-level' / 'value-added' products from space agencies. While a broader CEOS response might be necessary, within CEOS-ARD we will seek to engage our partners across CEOS and understand specific requirements with regard to higher-level products and the needs of their user communities, such that CEOS-ARD Product Family Specifications might be tailored appropriately. CEOS-ARD should be constructed in a form that facilitates work further downstream.

Summary of Challenges
Limited availability of value-added products. These include Essential Biodiversity Variables and other derived products that would advance ecosystem mapping and monitoring.
Combining data from different types of sensors. Although sensors of different types have complementary characteristics needed to discriminate ecosystems, availability of such "fused" products is very limited.
EO data accessibility, usability and technical capacity of users. Technical capabilities (both knowledge & infrastructure) to process and utilize EO data is often limited.
Ecosystem condition. Condition can affect the ecosystem characteristics used to discriminate ecosystems and thus complicates mapping.
Reference data for training and validation. Insufficient reference data is often the biggest limiting factor to mapping ecosystems.
Scale. The characteristics of ecosystems vary depending on the scale being observed, some being found at a rather local scale while others are at the landscape scale.

Table ES2 from the 2023 EETT White Paper

An open question to be explored with CEOS partners is whether CEOS-ARD Specifications are also warranted specifically for these higher-level / value-added products.

Applicable to: LSI-VC, EETT, LSI-GEOGLAM Subgroup, COAST-VC, CEOS SDG Coordination Group, WGDisasters

4.3. Foster an active CEOS-ARD GitHub community and discussion forum

Take steps to encourage more contributors and active dialogue on the CEOS-ARD GitHub, including the issues forum, as means to better engage external stakeholders including the New Space sector. Eliminate perception that CEOS-ARD is developed in isolation by CEOS Agencies. Critically, increased discourse via an open forum like the CEOS-ARD GitHub will provide the bandwidth needed to make progress on increasingly complex issues.

CEOS Agencies should assign experts to track and participate in the CEOS-ARD GitHub issues forum.

Applicable to: CEOS-ARD Oversight Group, LSI-VC, CEOS member agencies

4.4. Cloud-Native Geospatial Foundation

The Cloud-Native Geospatial Foundation encourages adoption of highly efficient and accessible approaches to working with geospatial data over the Internet. The CEOS SEO has been working with the Cloud-Native Geospatial Foundation to ensure CEOS-ARD is connected to their broad network and on technical development topics such as SpatioTemporal Asset Catalogs (STAC) and Source Cooperative. We will continue to work with the Cloud-Native Geospatial Foundation on topics of common interest.

Applicable to: SEO, CEOS-ARD Oversight Group

4.5. Engage partners with strong networks to the commercial sector and other communities to help increase the reach of CEOS-ARD and its principles

The CEOS Systems Engineering Office has engaged the Cloud Native Geospatial Foundation as a partner to help promote the CEOS-ARD effort in the broader community, including the commercial sector. CEOS has also worked with the Open Geospatial Consortium as a means to try and reach a broader community of users and data providers. CEOS Agencies should seek to make additional connections of this nature to further the impact and uptake of CEOS-ARD.

Applicable to: SEO, CEOS-ARD Oversight Group

4.6. Communications and capturing the benefits of CEOS-ARD

Collaborate with the CEOS Communications Team to continue spreading the word on CEOS-ARD and its benefits, through activities such as:

- CEOS-ARD communication campaigns.
- Document case studies on the value of CEOS-ARD (in conjunction with the SEO and the CEOS Analytics Lab).
- Continue CEOS Newsletters and social media engagement.
- Conduct public webinars on the use of CEOS-ARD endorsed products, and gather feedback/input on PFS requirements, assist with self-assessments, etc.

The @CEOSARD X/Twitter account

Applicable to: CEOS Communications Team, CEOS-ARD Oversight Group

4.7. Support key events and other major external stakeholder engagement opportunities

Events such as JACIE, LPS, ARD2x, and VH-RODA have proven to be key opportunities to engage with the commercial sector, including 'New Space', and other community stakeholders. CEOS should continue a coordinated representation and presence at such meetings, and where possible run events/workshops dedicated to CEOS-ARD. In-person self-assessment workshops might be effective and should be explored.

Applicable to: CEOS-ARD Oversight Group, LSI-VC, CEOS member agencies

5. Research, Test Cases, and Pilot Activities

5.1. Support and use the CEOS Analytics Lab as a key platform for pilot studies of CEOS-ARD and interoperability

The CEOS Analytics Lab is offered by the Systems Engineering Office to CEOS as a means for developing prototypes and running experiments in a cloud-based environment. CEOS agencies should commit to supporting the CEOS Analytics Lab with funding, in-kind support, and provision of CEOS-ARD to implement test cases and pilots, including the 'New Space' interoperability case study proposed in the CEOS New Space Task Team's white paper. Such activities will yield useful feedback on the suitability of the Product Family Specifications and guidance on measures that will make CEOS-ARD more discoverable, accessible, and interoperable.

Applicable to: SEO, CEOS-ARD Oversight Group

The CEOS Analytics Lab (ceos.org/cal)

5.2. Support follow-on activities of the CEOS Ecosystem Extent (Biodiversity) Demonstrators with the provision of CEOS-ARD

The Ecosystem Extent Demonstrators and their follow-on work, some of which utilize the CEOS Analytics Lab, are a key opportunity to demonstrate the utility of CEOS-ARD, guide the development of new Specifications, and serve as an incentive for agencies to undertake self-assessments for their data. CEOS Agencies should take advantage of this opportunity to develop and test CEOS-ARD, and gather valuable feedback from expert users.

Applicable to: EETT, CEOS member agencies

5.3. Surface Reflectance Quality, Equivalency and Consistency Project

While good progress has been made with CEOS-ARD datasets, currently multi-source ARD are not quite interoperable due to considerable differences in how they are processed, even though they comply with the PFS. Surface Reflectance equivalence seeks to take the next steps to move along the interoperability continuum.

CEOS Agencies should commit to advancing the Surface Reflectance Quality, Equivalency and Consistency project under LSI-VC. The Surface Reflectance Quality, Equivalency and Consistency project seeks to establish a set of equivalent inputs, corrections and associated metrics for ARD Surface Reflectance that maximize the quality of results from multi-provider multi-sensor analyses.

Fundamental to progress would be community agreed definition of what constitutes Surface Reflectance in the context of CEOS-ARD. Once we agree on the definition, we may be able to explore all the parameters that need to be considered for equivalence between multi-source Surface Reflectance datasets.

Applicable to: LSI-VC, WGCV

5.4. CSA Radarsat-2 Archive Research & Science Challenge over Circumtropical Forests (R2TF Challenge)

Through the Radarsat-2 Archive Research & Science Challenge over Circumtropical Forests (R2TF Challenge), CSA aims to provide the research and scientific community with free access to the extensive Radarsat-2 archive, which includes 80,000 scenes of circumtropical forests, to support research on tropical forests, carbon offsets, biodiversity, etc.

CSA will first process this data to be compliant with the CEOS-ARD Combined Specification for Synthetic Aperture Radar, meaning that the subsequent challenge projects will also serve as test cases for the CEOS-ARD specifications.

Additionally the R2TF Challenge will include the following specific research areas of direct relevance for CEOS-ARD and interoperability:

- How can Radarsat-2 data interoperability with other sensors be enhanced?
- What are the best practices for integrating SAR data with other remote sensing and in-situ data to improve our understanding of circumtropical rainforests?

Applicable to: LSI-VC

5.5. COAST Virtual Constellation

The Coastal Observations Applications Services and Tools (COAST-VC) focuses on the land-sea interface of coastlines and is implementing a number of pilot projects, some of which plan to use CEOS-ARD.

The COAST-VC pilots present a unique opportunity to encourage the assessment of datasets against the CEOS-ARD Aquatic Reflectance Product Family Specification (PFS), which was specifically for coastal and inland waters and to trial compliant products and collect feedback that can help refine this specification and datasets. The six pilot regions (the arctic, LaPlata Estuary, Bay of Bengal, Chesapeake Bay, Western coast of Africa, and Small Island Nations (Caribbean and Pacific)) where stakeholders are engaged in co-design of COAST products can provide valuable user community feedback.

COAST-VC input would also be valuable to the effort to expand the Aquatic Reflectance PFS to cover the oceans, and we will engage the COAST-VC community in those efforts.

Applicable to: COAST-VC, LSI-VC, SEO

5.6. WGDisasters Pilots

We will explore opportunities to promote the use of CEOS-ARD within the WGDisasters pilot activities as a means for gathering real-world feedback on the utility of CEOS-ARD products and the suitability of the existing specifications. It is also worth noting that WGDisasters has a long history of commercial data use/facilitation, and CEOS-ARD and commercial engagement are increasingly overlapping. These existing relationships could prove useful in our efforts to encourage CEOS-ARD uptake.

Applicable to: WGDisasters, CEOS-ARD Oversight Group, LSI-VC

6. Commercial Engagement

6.1. CEOS-Industry ARD workshops alongside key CEOS meetings

Opportunities to co-locate CEOS-Industry ARD workshops alongside key CEOS meetings should be used wherever possible to engage industry, including 'New Space' companies, in CEOS-ARD and to follow up the recommendations from the CEOS New Space Task Team white paper.

Applicable to: LSI-VC, CEOS-ARD Oversight Group

Figure 2: LSI-VC-15 Satellite Earth Observation Commercial Engagement Workshop, Tokyo, Japan, with AxelSpace, New Space Intelligence, Synspective, Tellus, Mitsubishi Research Institute

6.2. Conduct trial CEOS-ARD self-assessments with commercial data

The CEOS SEO is undertaking trial self-assessments of commercial datasets as a means for engaging with commercial providers. This is a follow-on to the SEO's CEOS Work Plan deliverable OUT-24-6: *Integrate New Space data into the CEOS Analytics Lab*, which is a response to the CEOS New Space Task Team white paper.

Applicable to: SEO, LSI-VC

6.3. CEOS-ARD Development Sprints

Development or code sprints are a common method used across the technology and commercial sector to harness community inputs and feedback at technical levels towards common objectives. Sprints often include specific goals such as making improvements to existing specifications and to improve community awareness and educational ecosystems around rapidly evolving technologies. Sprints intentionally attract target audiences at technical levels, which could complement traditional CEOS meetings which often do not allocate dedicated time for collaborative, technical development on specific topics, to include CEOS-ARD Product Family Specifications, transition plans to a 'building block' approach to Specifications, and migration to the new CEOS organizational GitHub format. It is notable that the SpatioTemporal Asset Catalog (STAC) movement was developed through a series of well organized, in-person Sprint events.

Applicable to: SEO, LSI-VC, CEOS-ARD Oversight Group, WGISS