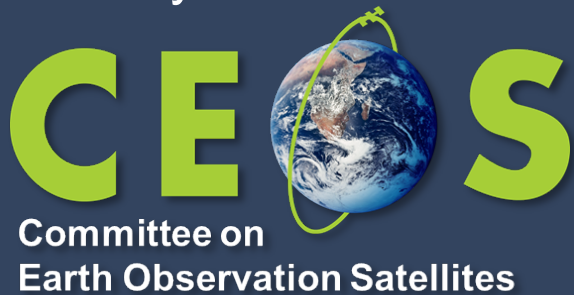
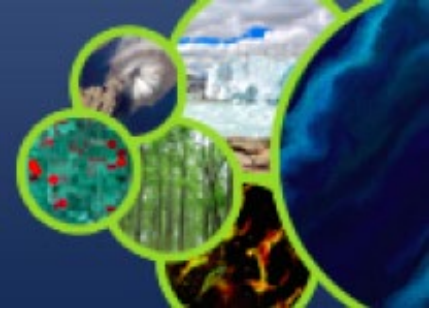


# CEOS Strategy for Analysis Ready Data

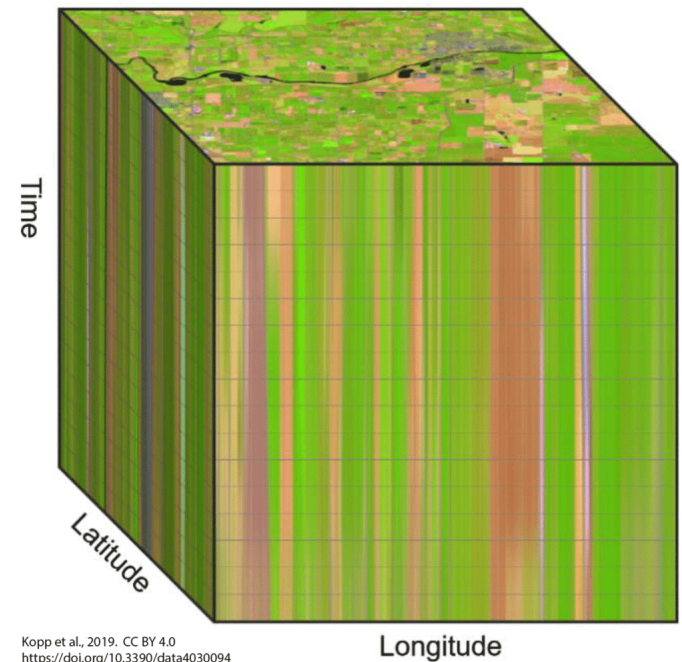
Ferran Gascon, Mathew Steventon, Adam Lewis, Zoltan Szantoi,  
Andrea Siqueira, Peter Strobl, Steven Labahn

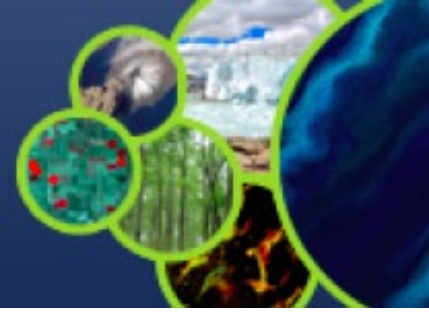
ESA Living Planet Symposium 2022  
27 May 2022





- **Big data - exponential growth, needs automated processing that frees the user to focus on the applications.**
- **Time-series analysis needs data that are comparable through time.**
- **Operational continuity through time needs comparability between sensors (e.g. Landsat, Sentinel-2).**





## In response:

- Rather than working with images that need extensive and specialised pre-processing, we work with geophysical measurements as the basic data point
- E.g. *Surface reflectance, aquatic reflectance, surface temperature, and normalised radar backscatter.*
- ‘analysis-ready’
- Measurements are inherently intercomparable

**Geophysical measurements are the core information behind CEOS Analysis Ready Data (CEOS-ARD)**

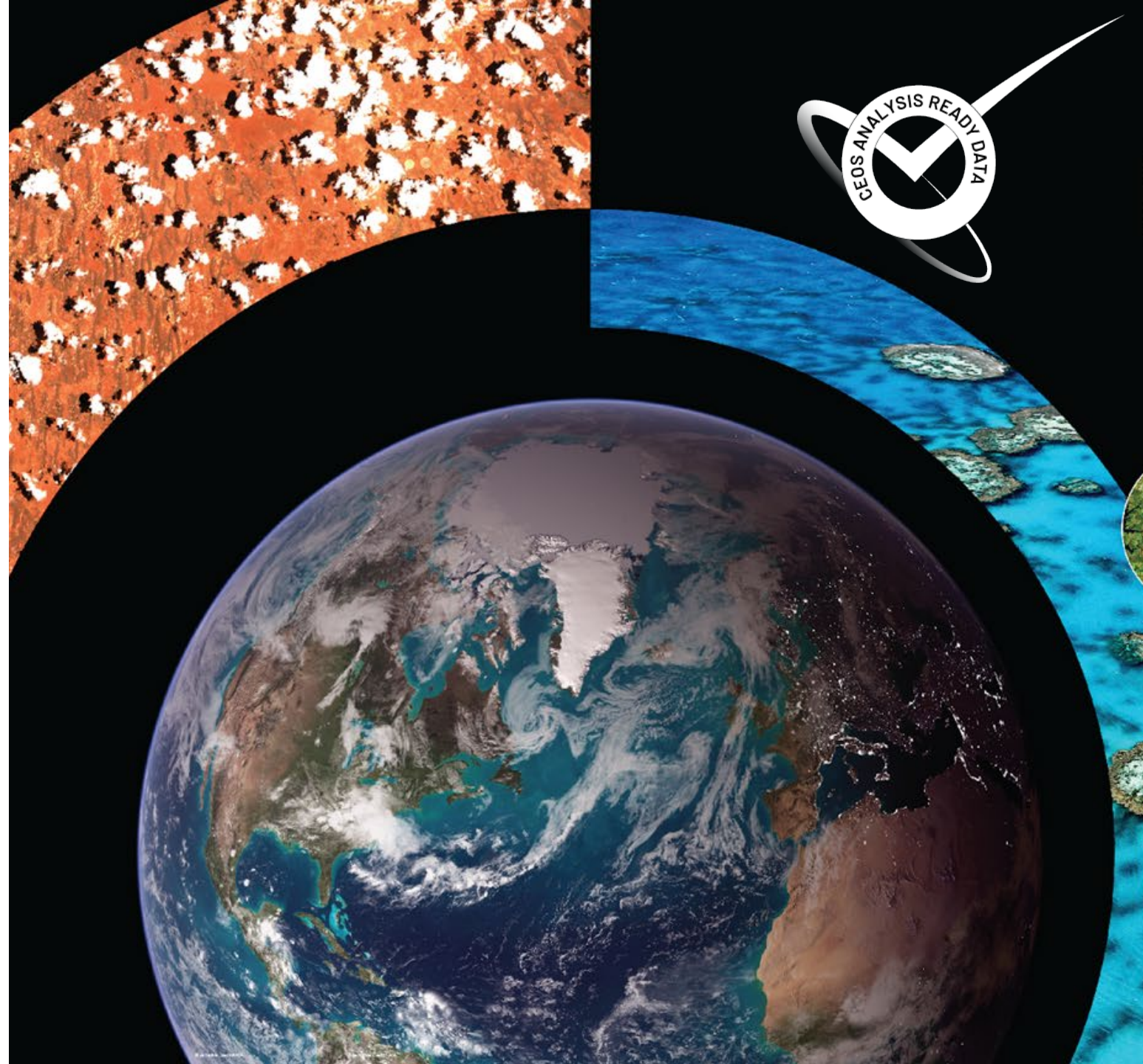


**CEOS Analysis Ready Data**  
(CEOS-ARD) are satellite data  
that have been **processed to a**  
**minimum set of requirements**  
and organized into a form that  
allows:

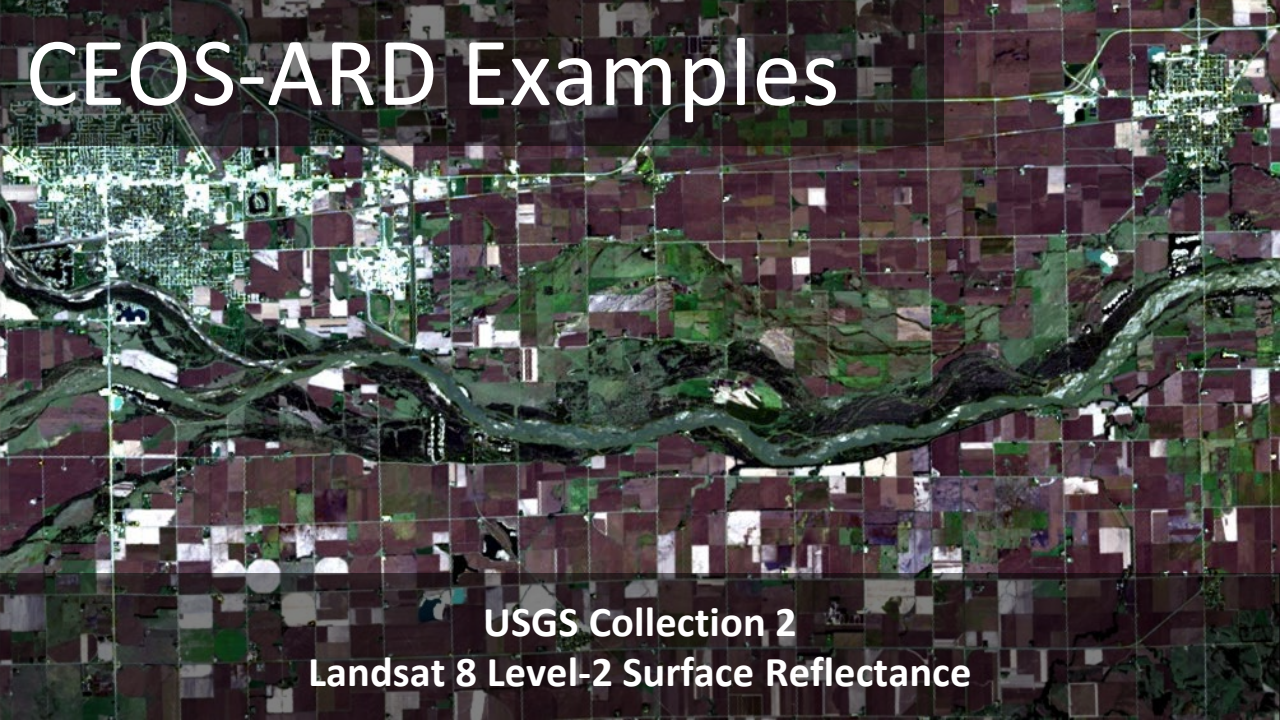
**immediate analysis** with a  
minimum of additional user  
effort

**interoperability** both  
through time and with other  
datasets

*<http://ceos.org/ard>*





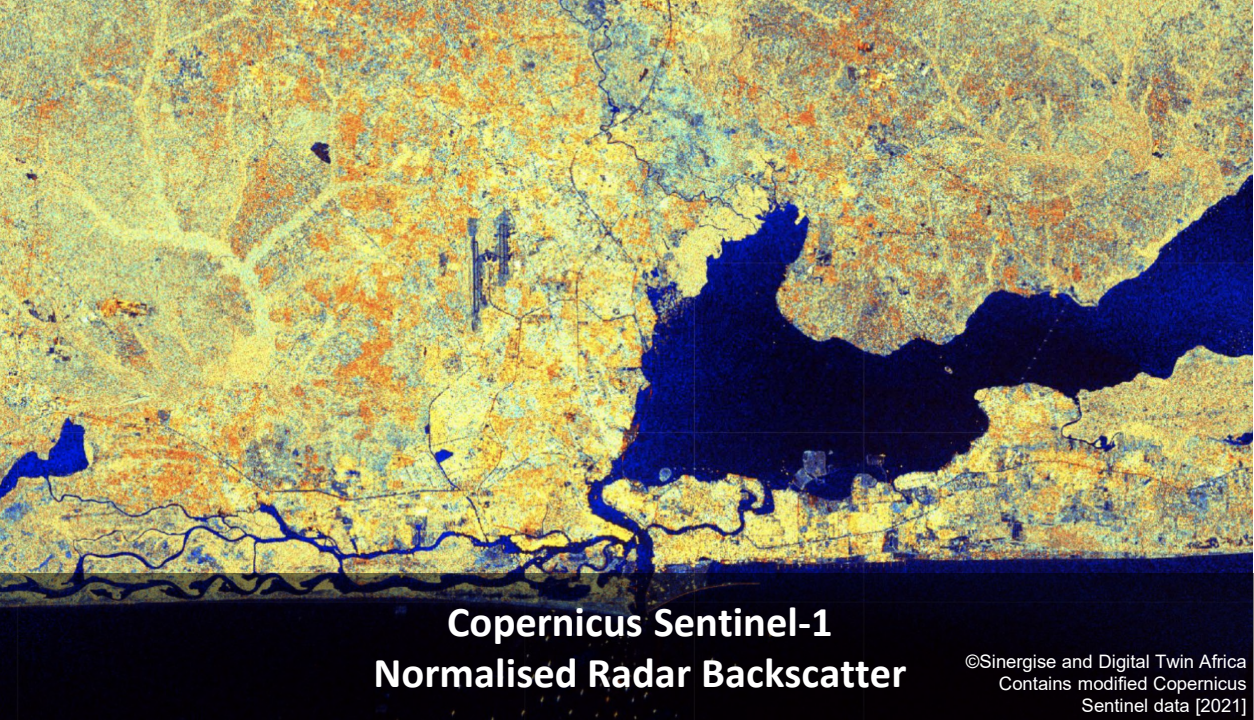


**EnMAP  
Surface Reflectance**

©DLR

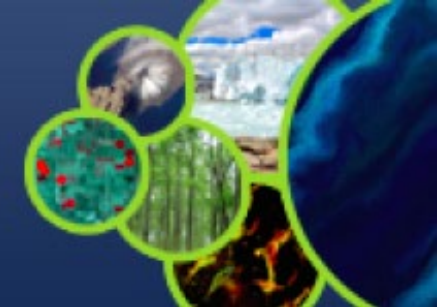


**Copernicus Sentinel-2  
Level-2A Surface Reflectance**



**Copernicus Sentinel-1  
Normalised Radar Backscatter**





## 1) CEOS-ARD Definition



**CARD4L DEFINITION**  
Satellite data that have been processed to a minimum set of requirements

CARD4L Developed and Endorsed by LSI-VC / User Consultation

**CARD4L PRODUCT FAMILY SPECIFICATION**  
(e.g. Surface Reflectance, Surface Temperature)  
*Threshold and Target:*

- General Metadata
- Per-pixel Metadata
- Radiometric and atmospheric corrections
- Geometric corrections



**PRODUCT ALIGNMENT ASSESSMENT**  
(e.g. Surface Reflectance, Surface Temperature)  
*Assesses how well the specific product complies with each of the metadata & calibration criteria in PFS.*  
*Includes description of 'how' it complies.*

PAA Developed by Agency Seeking CARD4L Brand  
Peer Review in collaboration with LSI-VC with WGCV



## 2) Product Family Specifications (PFS)



## 3) Product Alignment Assessment

- *Providers self -assessment*
- *Peer-review assessment*



CEOS-ARD compliant stamp!



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.

Information for:

- Data Producers
- Data Distributors
- Data Users

### Current Product Family Specifications

PFS	Type	Version	Download	Metadata Spec	Last Updated
Surface Reflectance	Optical	5.0	PDF   Word		8 June 2020
Surface Temperature	Optical	5.0	PDF   Word		8 June 2020
Normalised Radar Backscatter	Radar	5.5	PDF   Word	XLSX	13 May 2022
Polarimetric Radar	Radar	3.5	PDF   Word	XLSX	13 May 2022
Aquatic Reflectance	Optical	1.0	PDF   Word		23 February 2022

### In-progress Product Family Specifications

PFS	Type	ETA
Nighttime Lights Surface Radiance	Optical	Q3 2021
Ocean Radar Backscatter	Radar	Q3 2022
Geocoded Single-Look Complex (GSLC)	Radar	2023
Interferometric Radar (INSAR)	Radar	2023
LIDAR Terrain and Canopy Top Height	Optical	2023

### CEOS Analysis-Ready Datasets

The following table summarises all of the satellite EO datasets that have been assessed as CEOS Analysis Ready Data (CEOS-ARD). DOI links are provided for access, along with links to further information, sample products, and the completed CEOS-ARD self-assessment and peer review outcome documents.

Product	CEOS-ARD Type	PFS Version	Agency	Mission(s)	Threshold Specification	Target Specification	Access (DOI)	Info	Self Assessment	Peer Review	Sample Products
Landsat Collection 2	Surface Reflectance	v5.0	USGS	Landsat 4, 5, 7, 8, 9	100%	81%	Landsat 4-5, 7, 8	Link	PDF	PDF	Link
Landsat Collection 2	Surface Temperature	v5.0	USGS	Landsat 4, 5, 7, 8, 9	100%	83%	Landsat 4-5, 7, 8	Link	PDF	PDF	Link
Sentinel-2 Level-2A	Surface Reflectance	v5.0	ESA	Sentinel-2A, 2B	100%	Not assessed	Link	Link	PDF	PDF	Link
EnMAP	Surface Reflectance	v5.0	DLR	EnMAP	100%	Not assessed	TBA	Link	PDF	PDF	Link
Sentinel-1 RTC	Normalised Radar Backscatter	v5.5	Sinergise & Digital Earth Africa	Sentinel-1 (A, B)	100%	Not assessed	Link	Link	PDF	PDF	Link
Landsat Collection 2 U.S. ARD	Surface Reflectance	v5.0	USGS	Landsat 4, 5, 7, 8, 9	100%	Not assessed	Landsat 4-5, 7, 8	Link	PDF	PDF	Link
Landsat Collection 2 U.S. ARD	Surface Temperature	v5.0	USGS	Landsat 4, 5, 7, 8, 9	100%	Not assessed	Landsat 4-5, 7, 8	Link	PDF	PDF	Link

### Under Peer Review

Product	CEOS-ARD Type	PFS Version	Agency	Mission(s)	Access (DOI)	Info	Self Assessment	Peer Review	Sample Products
Sentinel-2 Level-2A (E84)	Surface Reflectance	v5.0	Element 84	Sentinel-2A, 2B	TBA	TBA	TBA	TBA	TBA

### Under Development / Assessment

Product	CEOS-ARD Type	PFS Version	Agency	Mission(s)	Access (DOI)	Info	Self Assessment	Peer Review	Sample Products
---------	---------------	-------------	--------	------------	--------------	------	-----------------	-------------	-----------------

<http://ceos.org/ard>

# CEOS-ARD Story So Far...



- Initially (2016-2019) lead by the CEOS Land Surface Imaging Virtual Constellation (LSI-VC)
- Definition
- Product Family Specifications
- Assessment Procedure
  - CEOS Working Group Cal/Val Peer Assessment
- Product assessments
- [ceos.org/ard](http://ceos.org/ard)
- Branding
- Various outreach activities, conferences, meetings
- Webinars





# Beyond Land



- CEOS Analysis Ready Data broadened to be ‘beyond land’ in 2021.
- Governance framework for CEOS Analysis Ready Data (CEOS-ARD) endorsed at CEOS Plenary 2021
  - [Available here](#)
  - Formalises the process LSI-VC has used for CARD4L and generalises it
  - References the CEOS-ARD Oversight Group, which was also initiated at CEOS Plenary 2021 as a result
- Other key documents:
  - [Template for Product Family Specifications](#)
  - [CEOS-ARD Strategy 2021](#)



# New Product Family Specification!



 [ceos.org/ard](http://ceos.org/ard)

 @CEOSdotORG

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-ARD Product Family Specifications (PFS) have "Threshold" and "Target" requirements for both general and per-pixel metadata, and radiometric, atmospheric and geometric corrections.

This new Aquatic Reflectance (AR) PFS, specifically targeted to inland and coastal waters, was derived from CEOS land surface ARD with certain modifications and additions, by GEO-AquaWatch, Water-ForCE, and other subject matter experts.

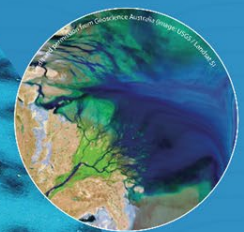
There are two modified and ten new per-pixel metadata requirements, as well as one modified and eight new radiometric and atmospheric correction requirements.

**2 per-pixel metadata requirements modified:**

- Per-pixel Assessment
- Sea/Lake/River Ice Mask

**10 new per-pixel metadata requirements identified:**

- Adjacency Effects
- Altitude (ASL)
- Optically Deep or Optically Shallow Assessment
- Bidirectional Reflectance Distribution Function
- Deep/Shallow Water
- Floating Vegetation/Surface Scum Mask
- Whitecap/Foam Mask
- Sky Glint
- Turbid Water Flag
- Sun Glint



**Product Alignment Assessment**

**Self-assessment:** data providers self-assess their products to understand how well they meet the CEOS Analysis Ready Data Aquatic Reflectance Product Family Specification (PFS).

**Peer-review:** an independent assessment to confirm the CEOS-ARD AR product.

**Conclusion**

Earth observation of coastal and inland waters is maturing. The CEOS-ARD AR PFS facilitates:

- Operationalisation of this EO information.
- Comparisons of providers' ARD outputs.
- Increased professionalism of providers and therefore trust by end users.
- Identification of optimal areas of R&D.



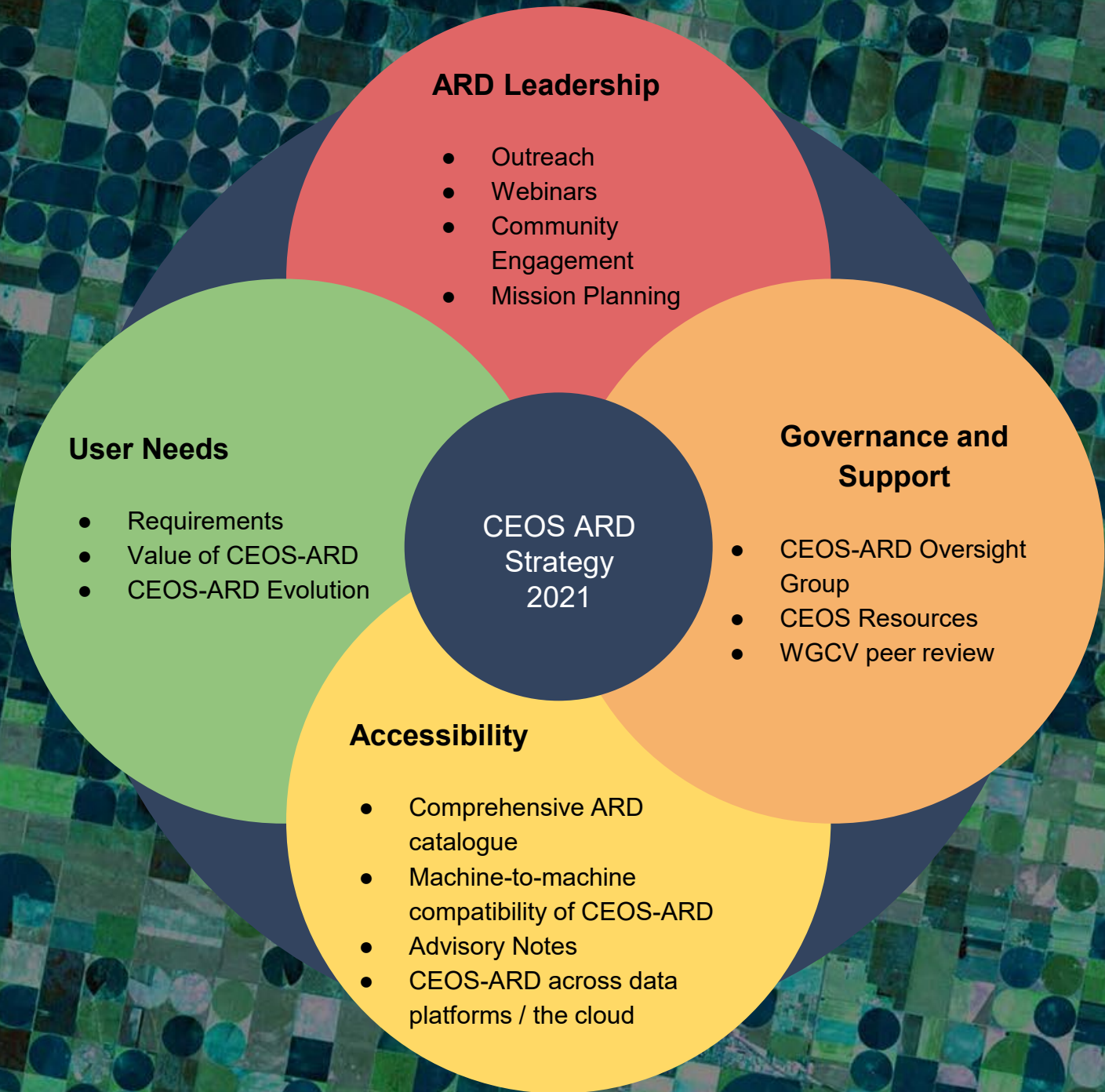
NEW! CEOS Analysis Ready Data for Aquatic Reflectance

## AQUATIC CEOS-ARD

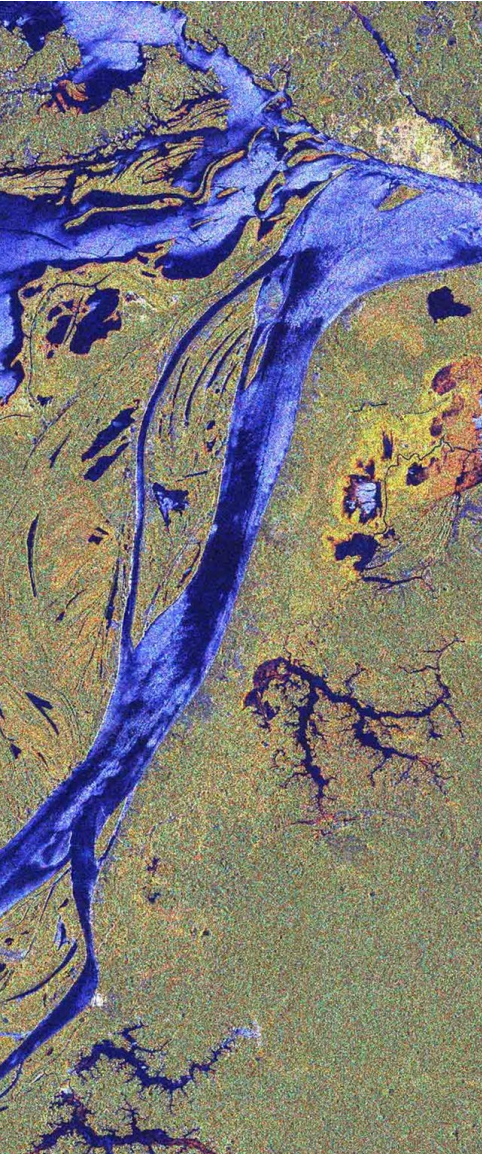




Available [here](#)



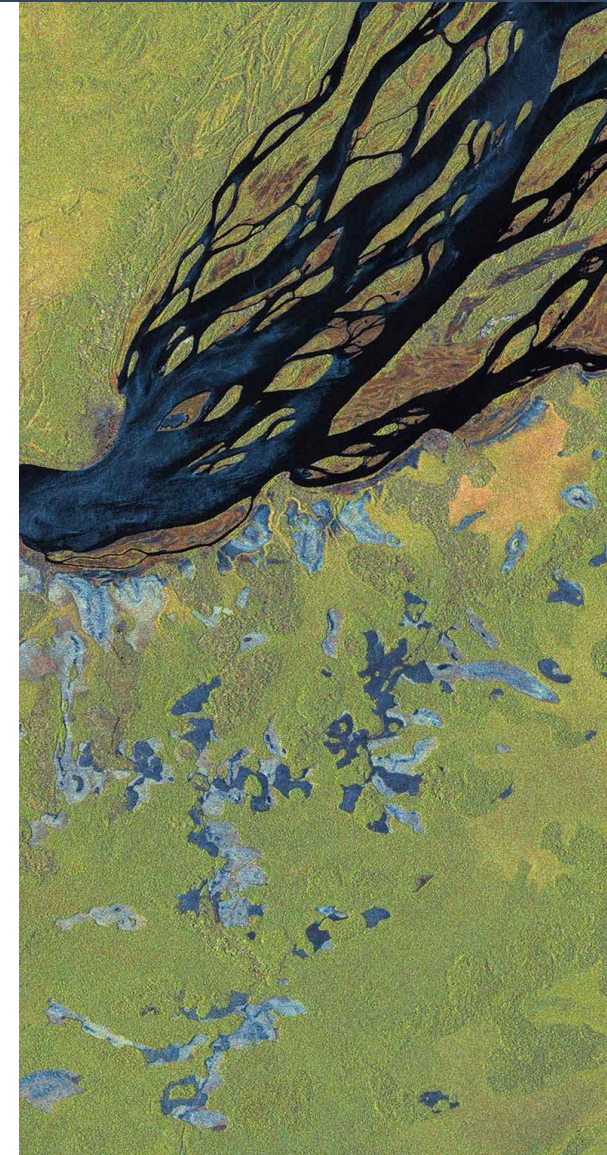




- Core component of the CEOS-ARD Governance Framework
- Forum for all matters related to CEOS-ARD
- Representatives from CEOS Virtual Constellations and Working Groups
  - integral to the effort
    - CEOS entities with the technical expertise to recommend, develop and maintain Product Family Specifications
- Coordination across CEOS
- Promote CEOS-ARD in a unified way



- CEOS coordination on ARD
- CEOS-ARD Strategy
- CEOS-ARD Governance Framework
- Support and guide
- Coordination of CEOS-ARD Product Family Specifications (PFS)
- Template PFS
- Technical topics: accessibility, utilisation, discovery, formats, STAC, pilots, etc.
- Community representation
- Outreach activities
- Champion ARD concept
- ARD Standards
- Primary focal point for CEOS-ARD





## ARD Standardisation

- Clear request from government and commercial sectors
- Likely necessary for widespread engagement
- Taking discussion forward with ISO, OGC, IEEE, etc.

## CEOS-ARD STAC Sprint (March 1-3)

- **SpatioTemporal Asset Catalog (STAC):** *common specification to describe a range of geospatial metadata, so it can more easily be indexed and discovered by building interoperable catalogues*
- Work ongoing on CEOS-ARD extension (mapping CEOS-ARD requirements to STAC fields)
  - Also covers processing provenance and validation

Revising template PFS for atmospheric/ocean/land product consistency

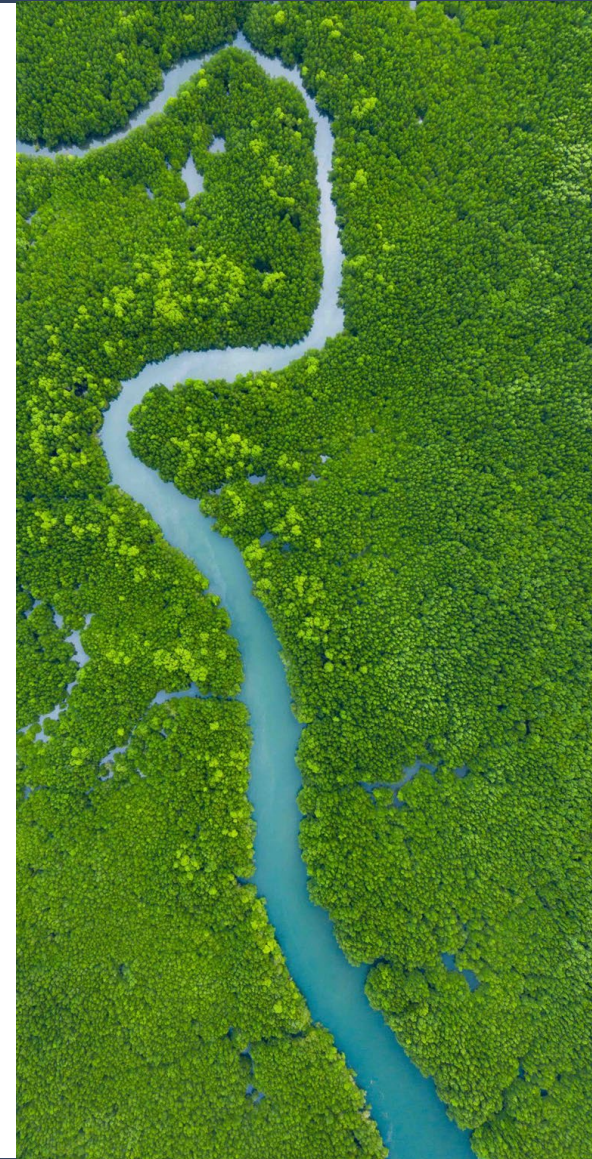
EUMETSAT providing input on atmospheric composition ARD



# How to get involved?



- ❖ Uptake beyond CEOS is key!
- ❖ **Any data provider can submit a self-assessment**
- ❖ Regular PFS updates – all feedback goes into the process
- ❖ **Involvement in the CEOS Virtual Constellations**
  - Development of new Product Family Specifications
  - Technical inputs and discussions
  - Contact: [matthew@symbioscomms.com](mailto:matthew@symbioscomms.com)
- ❖ **Standardisation discussion**
  - Based on the foundation of CEOS-ARD
  - Opportunity to input to that process



[ceos.org/ard](https://ceos.org/ard)

[CEOS-ARD Newsletter Sign-up](#)

[CEOS ARD Webinar #1 – July 1, 2020](#)

[CEOS ARD Webinar #2 \(SAR\) – February 1 & 2, 2021](#)



# Thank you!

# Questions?

