



Committee on Earth Observation Satellites

# A CEOS-GEO-AW aquatic reflectance analysis ready data framework: implications for atmospheric correction

**Daniela Gurlin & Arnold Dekker**

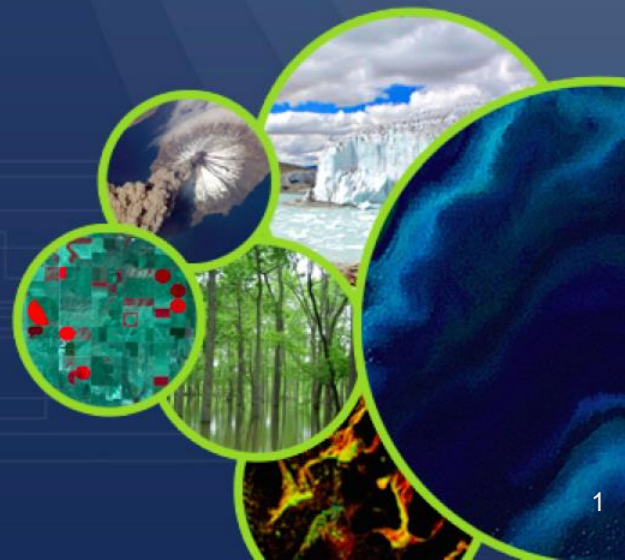
for GEO-AquaWatch

**Steve Labahn**

CEOS LSI-VC, USGS

**Christopher Barnes**

USGS/KBR



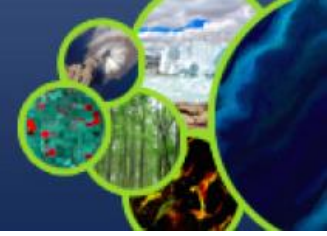


## With significant contributions from:

- Robert Woodcock (CSIRO)
- Andreia Siqueira (GA)
- Barbara Bulgarelli (JRC-EC)
- Carsten Brockmann (Brockmann Consulting)
- Joseph D. Ortiz (Kent State)
- Igor Ogashawara (IGB Berlin)
- Anthony Vodacek (RIT)
- Nima Pahlevan (NASA)
- Liesbeth de Keukelare (VITO)
- Ils Reusen (VITO)

- Steef Peters (WaterInsight)
- Claudia Giardino (CNR)
- Tiit Kutser (WaterForCE)

**and many others in  
Water-ForCE, GEO AquaWatch etc.**



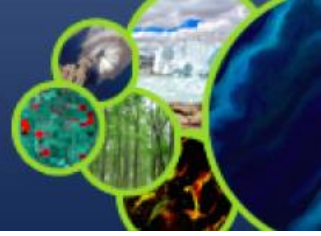
## What is Analysis Ready Data?

- Analysis Ready Data (ARD) from Earth observation (EO) has many interpretations
- Generated from raw data and processed so that it can be used without the need for further processing

In the context of water quality, we define it as the:

*Systematic radiometric, atmospherically, geometrically and spatially corrected full archive EO data sets of normalised water leaving radiance or reflectance*

- Interpretation Ready Data (IRD) represents derived products
- Generated from ARD data through the application of EO algorithms and processed to meaningful water quality indicators such as constituent concentrations, cyanobacteria counts, coloured dissolved organic matter absorption, and transparency measures



## Why do we need to discuss ARD data for water quality?

- Several data providers are demonstrating and implementing ARD data from the same EO data sources using differing ARD approaches and algorithms
- End users are confronted with different constituent concentrations for the same water body from the same EO image when they use derived products for water quality monitoring and assessment
- Differences may be due to variations in ARD processing as well as EO algorithm selection and IRD processing

## Why would we want to do this?

- To make sure end users (from educational through governmental to industrial entities) will not be exposed to confusing water quality information products due to different ARD approaches for their water bodies
- Make it easier to compare algorithms for translating ARD data to water quality indicators by having common ARD standards

## 1) CEOS-ARD Definition

## 2) Product Family Specifications (PFS)

- Optical product families
- Radar product families

## 3) Product Alignment Assessment

- Providers self-assessment
- Peer-review assessment

## 4) CEOS-ARD compliant stamp!

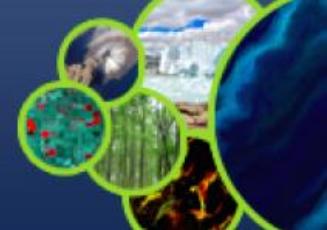
### **Definition:**

*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.*

### **Product Alignment Assessment process:**

*Self-assessment - data providers self-assess their products to understand how well their products meet the CEOS Analysis Ready Data specifications*

*Peer-review - an independent assessment to confirm the CEOS ARD product level*



- **Coordinated by** *Andreia Siqueira (GA) & Chris Barnes (USGS/KBR)*
- **Development initiated in March 2020 and endorsed in May 2021 at LSI-VC-10**
- Applies to data collected by multi- and hyperspectral sensors operating in the VIS/NIR/SWIR wavelengths over coastal and inland water bodies
- Used the CARD4L-SR PFS (version 5.0) as a baseline

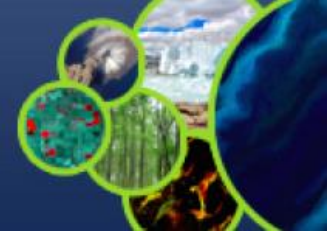
<https://ceos.org/ard/>

- Version 1.0 is available from the CEOS-ARD website to solicit community feedback

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
<b>Aquatic Reflectance</b>	Optical	1.0	PDF   Word	-	23 February 2022
Ocean Radar Backscatter	Radar	1.0	PDF   Word	XLSX	21 September 2022
Nighttime Lights Surface Radiance	Optical	1.0	PDF   Word	-	2 October 2022

- Sentinel-2 L2A/B AR Layer is being developed/assessed at ESA and an agreed-to plan and timeline are still being discussed at USGS




## Requirements summary of changes:

### General Metadata

- No requirement changes


### Per-Pixel Metadata

- 2 requirements modified
  - Per-pixel Assessment
  - Sea/Lake/River Ice Mask
- 10 new requirements identified
  - Adjacency Effects
  - Altitude (ASL)
  - Bidirectional Reflectance Distribution Function
  - Deep/Shallow Water
  - Floating Vegetation/Surface Scum Mask
  - Optically Deep or Optically Shallow Assessment



Analysis Ready Data  
For Land

Product Family  
Specification  
Aquatic Reflectance  
(CARD-LAR)



Analysis Ready Data  
For Land

Product Family  
Specification  
Aquatic Reflectance  
(CARD-LAR)

**Requirements**

**General Metadata**

These new metadata records describing a distributed collection of pixels. The collection of pixels referred to must be contiguous in space and time. General metadata should allow the user to assess the reliability of the dataset, and read over the following requirements:

#	Item	Desired (Minimum) Requirements	Target (Desired) Requirements	Required Self-Assessment	Target Self-Assessment	Self-Assessment/Justification	Comments
1.1	Traceability	Not required.	Not applicable to CARD-LAR. Note 1: Relationship to 2.2. Traceability requires an assessment of measurement accuracy. Note 2: Information on traceability should be available in the metadata or a single DOI linking page.				
1.2	Metadata Member Readability	Metadata is structured in a structure that enables a computer algorithm to be used consistently and to automatically identify and address each component part for further use.	As traceable, but metadata should be provided in accordance with consistently required standard that facilitates read the metadata, such as ISO 15924-2.				
1.3	Data Collection Time	The time of collection is identified in the metadata, expressed in UTC, with the time offset from UTC consistently identified.	Acquisition times for each pixel is identified (or can be reliably determined) in the metadata, expressed in date-time in UTC, to the second.				
1.4	Geographical Area	The geographic area to which the data relates is identified, spatially as a series of four corner	The geographic area covered by the observations is identified specifically, such as through a set of coordinates of a timely				

**Document Status**

March 2021, or no later than 2 weeks before 1.0 V1-20 meeting.

<https://ceos.org>

**Revision of Change**

Author

Review

Approved/Editor (Date/Ch): (revisiting with by Editors/Approved (Date/Ch) and Carlos Brockmann (Revisiting/Commenting)

1.0 A. Dekker 20 to 23

Shelley Curtis (Microsoft DNR), Joseph D. Osh (West Wind), Qingyun Du (Berkeley), and Anthony Hudson (PDS), Barbara Julgowski (JRC/EC), Steve Parkman (PDS), members of the Card-LAR (JRC) - approved and reviewed by Approved/Editor (Date/Ch) on 23 Feb 2021

Editorial notes by Walter CED-MW (approved on 23 Feb 2021, see glint, sky glint, etc)

Joseph D. Osh (West Wind), Anthony Hudson (PDS), Barbara Julgowski (JRC/EC), members of the Card-LAR (JRC/EC), Steve Parkman (PDS), members of the Card-LAR (JRC) - approved and reviewed by Approved/Editor (Date/Ch) on 28 Feb 2021

- Sky Glint
- Sun Glint
- Turbid Water Flag
- Whitecap/Foam Mask



## Requirements summary of changes continued:

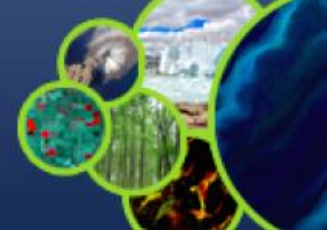
### Radiometric and Atmospheric Corrections

- *1 requirement modified*
  - Atmospheric Reflectance Correction
- *8 new requirements identified*
  - Adjacency Effects Correction
  - Bidirectional Reflectance Distribution Function
  - Floating Vegetation/Surface Scum Correction
  - Other Trace Gaseous Absorption Corrections
  - Sky Glint Correction
  - Sun Glint Correction
  - Turbid Water Correction
  - Whitecap and Foam Correction

### Geometric Corrections

- *No requirement changes*





### Per-Pixel Metadata

#### 2.13 Adjacency Effects

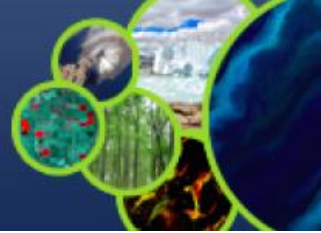
- *Threshold (Minimum) Requirements*
  - Not required.
- *Target (Desired) Requirements*
  - The metadata provides the risk of per-pixel adjacency effects contamination, through flagging to denote per-pixel minimum, medium or high adjacency effects contamination.

*Note 1: This effect often occurs in increased turbid or optically shallow waters near shorelines that may confuse this assessment.*

### Radiometric and Atmospheric Corrections

#### 3.11 Adjacency Effects Correction

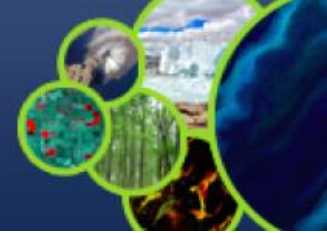
- *Threshold (Minimum) Requirements*
  - Not required.
- *Target (Desired) Requirements*
  - Information on adjacency effects correction (for example, citable peer-reviewed algorithm approach, technical documentation of the implementation, sources of ancillary data) should be available in the metadata as a single DOI landing page.



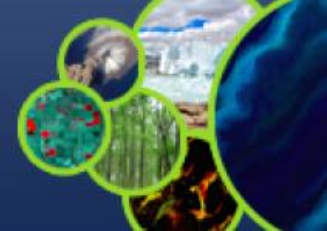
- **Earth observation of coastal and inland waters is maturing**
- **Having this CEOS-ARD framework for self assessment is a relevant step to ...**
  - Operationalise EO information
  - Compare providers ARD outputs
  - Further increase professionalism of providers and therefore trust by end users
- **Current gaps are mostly related to surface irradiance effects or atmospheric adjacency effects ...**
  - Measurement uncertainty
  - Measurement normalisation
  - Sun glint correction
  - Sky glint correction
  - Adjacency effects correction
  - Bidirectional reflectance distribution function correction



# The path to EO-based global water quality monitoring and assessment



- **Recommendations for meeting the target requirements are ...**
  - Provision of an estimate of the uncertainty of the values in measurement units
  - Development of approaches to normalise measurements for solar and viewing conditions, including BRDF correction (see also 3.14)
  - Indication of the surface contributions from Sun glint removed from the data if a pixel is assessed as being of correctable (moderate) Sun glint
  - Separate assessment and correction for sky glint in the data processing
  - Information on adjacency effects correction
  - Development of approaches to correct data for BRDF effects (see also 3.3.)
- **Recommendations for revising the CEOS-ARD AR PFS are ...**
  - Revision of the CEOS-ARD AR PFS as soon as feedback is obtained from agencies/institutions that have gone through the self review and peer review process



# CEOS ANALYSIS READY DATA

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