# CEOS-ARD - Optical - Surface Reflectance

*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 Family Specification:** Optical, Surface Reflectance (SR)

**Applies to:** Data collected with multispectral optical sensors operating in the VIS/NIR/SWIR wavelengths at all ground sample distances and resolutions.

# Document History

Not available yet

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# Glossary

**ATBD**
: Algorithm Theoretical Basis Document

**Auxiliary Data**
: The data required for instrument processing, which does not originate in the instrument itself or from the satellite. Some auxiliary data will be generated in the ground segment, whilst other data will be provided from external sources, e.g., DEM, aerosols.

**CEOS-ARD**
: Committee on Earth Observation Satellites - Analysis Ready Data

**DOI**
: Digital Object Identifier

**GIS**
: Geographic Information System

**NIR**
: Near Infrared

**SI**
: International System of Units

**SR**
: Surface Reflectance

**SWIR**
: Shortwave Infrared

**URL**
: Uniform Resource Locator, a reference to a web resource that specifies its location on a computer network and a mechanism for retrieving it.

**UTC**
: Coordinated Universal Time

**VIS**
: Visible

# Introduction

## What are CEOS Analysis Ready Data (CEOS-ARD) products?

CEOS-ARD products 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. These products would be resampled onto a common geometric grid (for a given product) and would provide baseline data for further interoperability both through time and with other datasets.

CEOS-ARD are intended to be flexible and accessible products suitable for a wide range of users for a wide variety of applications, particularly time series analysis and multi-sensor application development. They are also intended to support rapid ingestion and exploitation via high-performance computing, cloud computing and other future data architectures. They may not be suitable for all purposes and are not intended as a *replacement* for other types of satellite products.

## When can a product be called CEOS-ARD?

The CEOS-ARD branding is applied to a particular product once:

- that product has been assessed as meeting CEOS-ARD requirements by the agency or other entities responsible for production and distribution of the product, and
- that the assessment has been peer reviewed by the relevant CEOS team(s).

Agencies or other entities considering undertaking an assessment process should consult the CEOS-ARD Governance Framework or contact ard-contact@lists.ceos.org.

A product can continue to use CEOS-ARD branding as long as its generation and distribution remain consistent with the peer-reviewed assessment.

## What is the difference between Threshold and Goal?

**Threshold** (or: minimum) requirements are the **minimum** that is needed for the data to be analysis ready. This must be practical and accepted by the data producers.

**Goal** (or: desired) requirements (previously referred to as “Target”) are the ideal; where we would like to be. Some providers may already meet these.

Products that meet all *threshold* requirements should be immediately useful for scientific analysis or decision-making.

Products that meet *goal* requirements will reduce the overall product uncertainties and enhance broad-scale applications. For example, the products may enhance interoperability or provide increased accuracy through additional corrections that are not reasonable at the *threshold* level.

Goal requirements anticipate continuous improvement of methods and evolution of community expectations, which are both normal and inevitable in a developing field. Over time, *goal* specifications may (and subject to due process) become accepted as *threshold* requirements.

# Requirements

## General Metadata

These are 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 *overall* suitability of the dataset, and must meet the requirements listed below.

### Traceability (`general-metadata-traceability`)

**Goal requirements:**

Data must be traceable to SI reference standard.

Notes:

1. Relationship to (**measurements/uncertainty?**) or item 3.5 (SAR). Traceability requires an estimate of measurement uncertainty.
2. Information on traceability should be available in the metadata as a single DOI landing page.

### Metadata Machine Readability (`general-metadata-machine-readability`)

**Goal requirements:**

As threshold, but metadata should be provided in a community endorsed standard that facilitates machine-readability, such as ISO 19115-2.

**Threshold requirements:**

Metadata is provided in a structure that enables a computer algorithm to be used consistently and to automatically identify and extract each component part for further use.

## Source Metadata

These are metadata records describing (detailing) **each** acquisition (source data) used to generate the ARD product. This may be one or mutliple acquisitions, depending on the ARD product.

### Data Collection Time (`source-metadata-time`)

**Goal requirements:**

Acquisition time for each pixel is identified (or can be reliably determined) in the metadata, expressed in date/time at UTC, to the second.

**Threshold requirements:**

The data collection time is identified in the metadata, expressed in date/time, to the second, with the time offset from UTC unambiguously identified.

# Product Metadata

Information related to the CEOS-ARD product generation procedure and geographic parameters.

## Geometric Correction Algorithm (`product-metadata-geometric-correction-algorithm`)

**Goal requirements:**

Metadata references, e.g.: - A metadata citable peer-reviewed algorithm, - Technical documentation regarding the implementation of that algorithm expressed as URLs or DOIs - The sources of auxiliary data used to make corrections such as elevation model(s) and reference chip-sets. - Resampling method used for geometric processing of the source data.

Notes:

1. Examples of technical documentation can include e.g., an Algorithm Theoretical Basis Document (ATBD) or a product user guide.

# Per-Pixel Metadata

The following minimum metadata specifications apply to each pixel. Whether the metadata are provided in a single record relevant to all pixels or separately for each pixel is at the discretion of the data provider. Per-pixel metadata should allow users to discriminate between (choose) observations on the basis of their individual suitability for applications.

## Example Requirement (`per-pixel-example`)

This is an example requirement.

**Goal requirements:**

This is a goal requirement.

Notes:

1. This is a note.

**Threshold requirements:**

This is a threshold requirement.

# Radiometric and Atmospheric Corrections

The following requirements must be met for all pixels in a collection. The requirements indicate both the necessary outcomes and the minimum steps necessary to be deemed to have achieved those outcomes. Radiometric corrections must lead to a valid measurement of surface reflectance.

## Measurement Uncertainty (`corrections-measurements-uncertainty`)

Note: In current practice, users determine fitness for purpose based on knowledge of the lineage of the data, rather than on a specific estimate of measurement uncertainty.

**Goal requirements:**

An estimate of the certainty of the values is provided in measurement units.

Notes:

1. This is a requirement for SI traceability. See also Section “general-metadata-traceability”.
2. Information on measurement uncertainty should be available in the metadata as a single DOI landing page.

# Geometric Corrections

The geometric corrections are steps that are taken to place the measurement accurately on the surface of the Earth (that is, to geolocate the measurement) allowing measurements taken through time to be compared. This section specifies any geometric correction requirements that must be met in order for the data to be analysis ready.

## Geometric Corrections (`geometric-corrections-corrections-geometric-corrections`)

**Goal requirements:**

Sub-pixel accuracy is achieved relative to an identified absolute independent terrestrial referencing system (such as a national map grid).

A consistent gridding/sampling frame is necessary to meet this requirement.

Relevant metadata must be provided under 1.8 and 1.9.

Notes:

1. This requirement is intended to enable interoperability between imagery from different platforms that meet this level of correction and with non-image spatial data such as GIS layers and terrain models.

## Threshold requirements:

Sub-pixel accuracy is achieved in relative geolocation, that is, the pixels from the same instrument and platform are consistently located, and thus, comparable through time.

Sub-pixel accuracy is taken to be less than or equal to 0.5-pixel radial root mean square error (rRMSE) or equivalent in Circular Error Probability (CEP) relative to a defined reference image.

A consistent gridding/sampling frame is used, including common cell size, origin, and nominal sample point location within the cell (centre, ll, ur).

Relevant metadata must be provided under item 1.8 and 1.9.

Notes:

1. The threshold level will not necessarily enable interoperability between data from *different* sources as the geometric corrections for each of the sources may differ.

# References

International Organization for Standardization. 2009. “Geographic information — Metadata — Part 2: Extensions for imagery and gridded data.” Standard. Geneva, CH: International Organization for Standardization.

Li, Fuqin, David L. B. Jupp, Medhavy Thankappan, Leo Lymburner, Norman Mueller, Adam Lewis, and Alex Held. 2012. “A Physics-Based Atmospheric and BRDF Correction for Landsat Data over Mountainous Terrain.” *Remote Sensing of Environment* 124: 756–70. https://doi.org/https://doi.org/10.1016/j.rse.2012.06.018.