



Shared Collection Lifecycle Management Principles for Earth Observation Data

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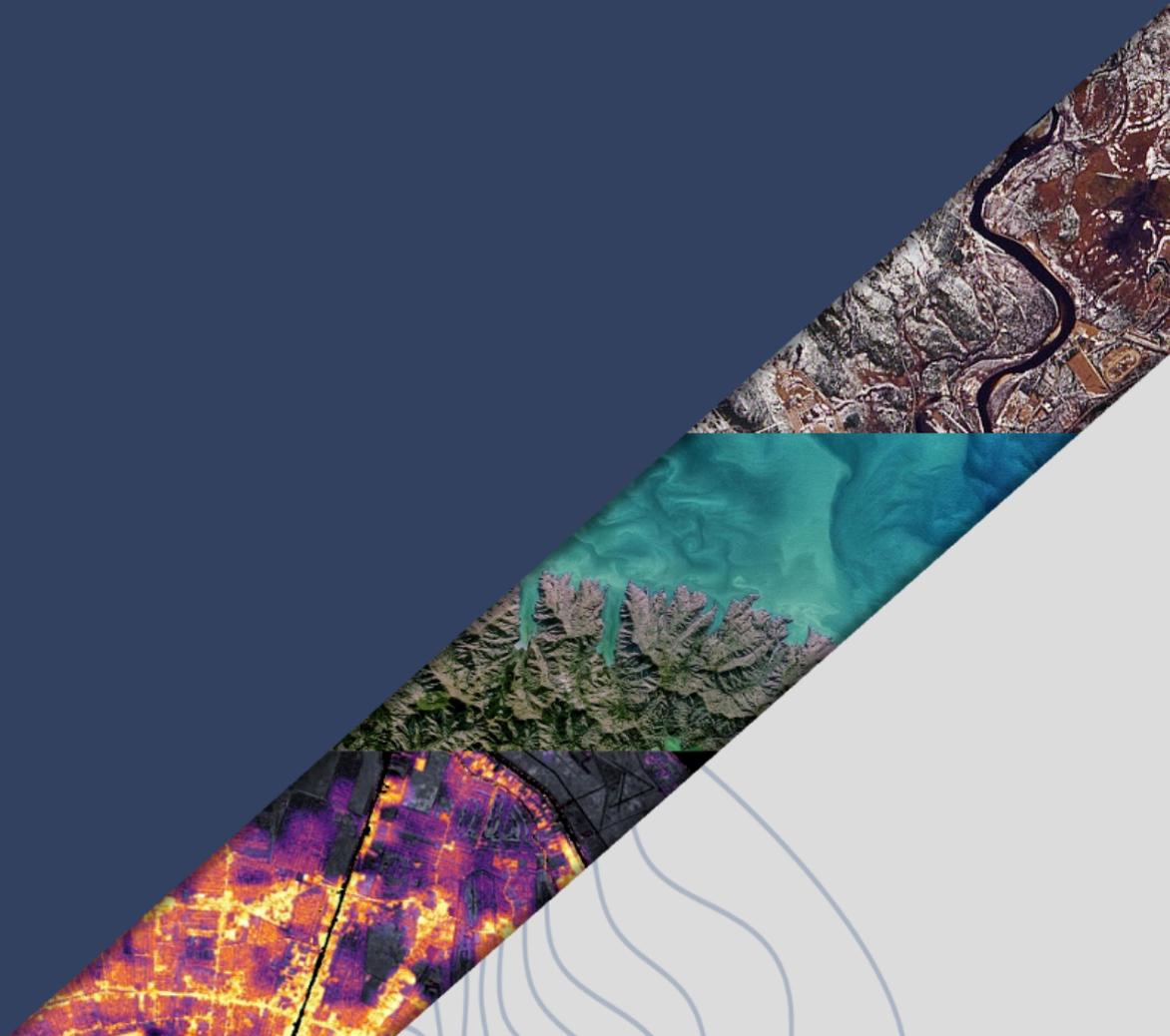


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1. Introduction

1.1. Purpose and scope of the document

In an era when large volumes and varieties of Earth Observation (EO) data are proliferating across many different providers, it is important to document where fundamental approaches to the lifecycle management of EO collections broadly converge.

The Data Collection management highlights challenges including data integrity, data authenticity, data replica management (in the cloud and/or archived), data reproducibility and citation. A controlled collections management enables collections (including metadata) to be properly handled and documented, and to become a resource for the user community.

The benefits of Data collections include:

- Consistent data accessibility, usability, and long-term preservation;
- FAIR (Findable, Accessible, Interoperable, and Reproducible) scientific practices;
- Facilitate the reanalysis of satellite measurements.

Collections are often generated through the reprocessing of data from the archive.

The purpose of this document is to describe a set of core Earth Observation (EO) Collection lifecycle management principles shared by CEOS organisations.

The principles were collaboratively derived in consideration of current agency practices and framed by a generalised collection lifecycle as represented by the Data collection Stewardship Model [AD 7] (figure 1). In the figure below, the major related activities are reported for each ECSS mission phase. The Data collection Stewardship process starts during the initialization phase and continues until the Operations and Maintenance phase. For each new data reprocessing the process needs to be restarted.

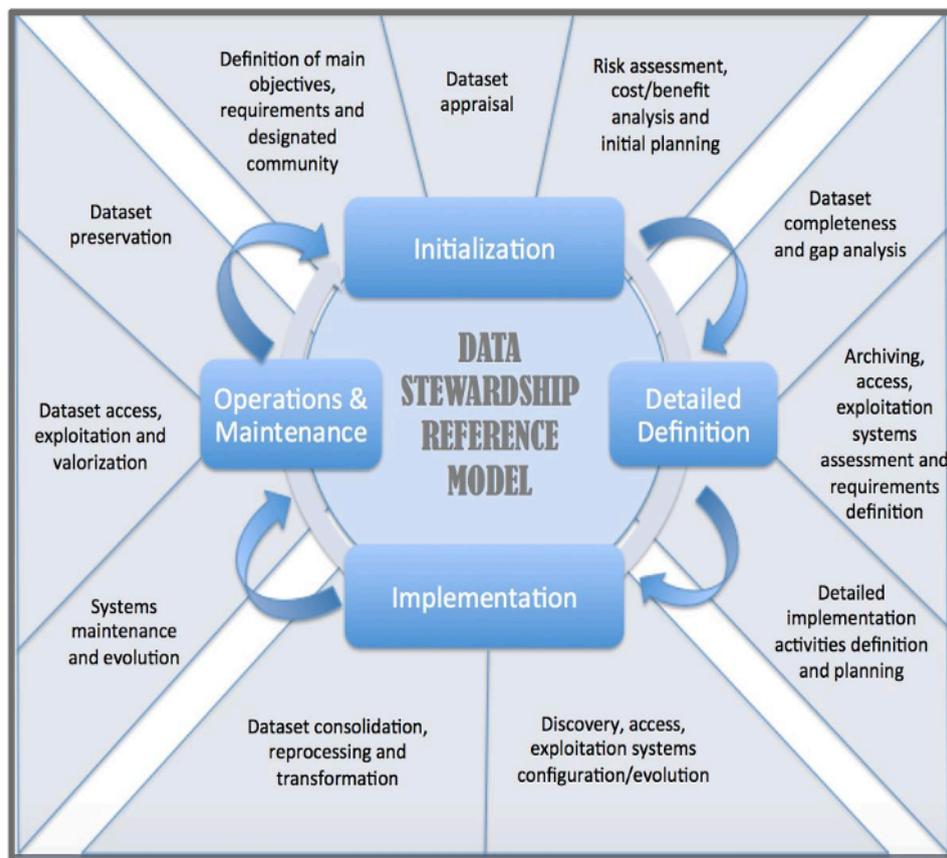


Figure 1 Data Collections Stewardship Workflow

A significant body of work exists in the public domain relating to EO data management and preservation processes (1.3 Applicable and Reference Documents), but not always with collection lifecycle management as the animating concept. However, we sought to ensure general alignment of the shared collection lifecycle management principles with concepts contained in these references. Key terms of reference can and do vary amongst organizations and often pose impediments to shared understanding. Appendix A sources and clarifies the terms of reference used in this document.

1.2. Project Members

This document has been developed with oversight from the CEOS Working Group on Information Systems and Services (WGISS), Data Stewardship Interest Group (DSIG).

The project team members are listed below.

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1.3. Applicable and Reference Documents

ID	Resource
[AD 1]	CEOS. 2015a. EO preserved dataset content. Retrieved from https://ceos.org/publications-key-documents/#best-practices-guidelines
[AD 2]	CEOS. 2015c. Long term preservation of earth observation space data: Preservation workflow. Retrieved from https://ceos.org/publications-key-documents/#best-practices-guidelines
[AD 3]	CEOS. 2016. EO data purge alert procedure. Retrieved from http://ceos.org/document management/Working Groups/WGISS/Interest Groups/Data Stewardship/Recommendations/WGISS DSIG Data%20Purge%20Alert WP.pdf
[AD 4]	CEOS. 2017b. EO data glossary of acronyms and terms. Retrieved from https://ceos.org/document management/Working Groups/WGISS/Interest Groups/Data Stewardship/White Papers/EO-DataStewardshipGlossary.pdf
[AD 5]	CEOS. 2018. Measuring of earth observation data usage. Retrieved from https://ceos.org/document management/Working Groups/WGISS/Documents/WGISS%20Best%20Practices/Measuring%20Earth%20Observation%20Data%20Usage%20-%20Best%20Practice.pdf
[AD 6]	CEOS. 2019b. EO data preservation guidelines best practices. Retrieved from https://ceos.org/document management/Working Groups/WGISS/Interest Groups/Data Stewardship/White Papers/EO-DataStewardshipGlossary.pdf
[AD 7]	WGISS Data Stewardship Reference Model White Paper. Retrieved from https://ceos.org/document management/Working Groups/WGISS/Interest Groups/Data Stewardship/White Papers/WGISS Data%20Stewardship%20Reference%20Model%20White%20Paper.pdf

[AD 8]	CEOS Persistent Identifier Best Practice. Retrieved from https://ceos.org/document_management/Working_Groups/WGISS/Documents/WGISS%20Best%20Practices/CEOS%20Persistent%20Identifier%20Best%20Practice.pdf
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Table 1. Applicable Documents

ID	Resource
[RD 1]	Brobia, A., Voidrot, M.-F., Bye, B. L., and Maso, J., "GEO Data Management Principles: Updated Implementation Guidelines to increase the value of Earth Observation data", 2022.
[RD 2]	Mirko Albani & Iolanda Maggio (2020) Long time data series and data stewardship reference model, Big Earth Data, 4:4, 353-366, DOI: 10.1080/20964471.2020.1800893

Table 2. Reference Documents

2. Collection Lifecycle Management Principles

The principles and supporting rationale outlined in this section provide guidance to entities on recommended Collection Lifecycle Management practice from the perspective of CEOS data stewards. The principles are intended to be generally applicable, though the authors understand that some of the principles may not be able to be adhered to due to budgetary or political constraints.

2.1. Initialization Stage

PRINCIPLE 1: Products should be consistent within Collections

Since a Collection represents a set of products that are processed using common specifications, products within a Collection are expected to be consistent. Minor revisions or updates to relatively small numbers of products within a Collection are expected in order to fix non-routine issues or errors that bring the products into a state of consistent quality. If updates or corrections are made to products, users should be able to reference the nature and magnitude of those changes and identify updated products.

PRINCIPLE 2: Collection Upgrades should be deliberate, meaningful and well considered

A Collection Upgrade is characterized by a full reprocessing campaign to introduce major improvements or enhancements to all products. Changes are expected to break

the consistency and continuity of product specifications between Collections. Therefore, major recalibration efforts, major algorithmic advances, and other changes to the structural specification of the Collection are held until upgrade time.

Decisions about starting a new Collection are of strategic nature and are made only infrequently at the higher level of the producing organisation. Decisions about the specification and timing of a Collection upgrade will depend on factors such as budget, producer priorities, designated user communities requirements and needs, advancements of scientific algorithms, cost/benefit analysis, complexity, and other technical considerations.

PRINCIPLE 3: At conception of a Collection Upgrade, cost storage, computation requirements, open-sourcing of production code and end-of-life preservation costs should be considered

Initiation of a new collection should consider:

- estimates of storage requirements and growth rate over time (including periods of overlapping collection data persistence);
- computational resource required for back processing and ongoing production;
- end-of-lifecycle preservation options (archiving or disposal).

This information is needed to adequately estimate the cost of activities associated with the development, production, and dissemination of the proposed data product and to ensure that sufficient resources are provided for the project.

PRINCIPLE 4: Consider opportunities for interoperability and alignment with products in other organization's collections

One of CEOS's primary objectives is to optimise the benefits of space-based Earth observation through cooperation of CEOS Agencies in the development and management of compatible data products. Additionally, CEOS has the goal of encouraging complementarity and compatibility among space-based Earth observation systems and the data received from them. The upgrade of a collection represents an infrequent opportunity to align product specifications to fulfil these objectives.

2.2. Detailed Definition Stage

PRINCIPLE 5: Provisional products are part of the development process and their management and control are expected to differ from those of standard products within a collection

Products with provisional status may be available in the public domain for research and development purposes (e.g., community assessment) and may not always lead to a final product. The nature of such products means they may be made available on-demand or

in temporary data stores which are deleted at some point and are not archived. Provisional products may in fact change during their availability due to algorithm advancements or other factors during development. The provisional nature of these products must be communicated and caveated to users. Provisional products are normally superseded with the final version of products published into a given collection. In addition to publicly available provisional products, there may also be internal development product versions at various stages of completion but these would not be considered part of the Collection.

2.3. Implementation Stage

PRINCIPLE 6a: Ensure Collection infrastructure providers enable disaster recovery

Supporting infrastructure should sustain the operational requirements of the Collection archiving/discovery/access/management (e.g. offsite copies, redundant storage / disk technology, business continuity, cyber security, and communication) in alignment with CEOS Best Practice [AD 6]. Programs may rely on storage service providers (e.g., AWS, NARA) for backing up current collections. This means that, although there are system integrity preservation measures implemented by the vendors ensuring some data recovery capabilities, neither the responsible program nor entity may have an active backup procedure in place.

PRINCIPLE 6b: Ensure Collection data integrity.

Supporting infrastructure should enable and implement appropriate measures to ensure Data Integrity during the Collection lifecycle.

PRINCIPLE 7: Confirm archive or disposal at end-of-life of an old Collection at publication stage of the new one

The decisions about archive or disposal at the end of the collection lifecycle should be reconfirmed and well communicated with sufficient lead time to enable a tactical response from users.

If disposal is the selected option, then it is expected that all relevant documentation and metadata required by organizational policy are preserved and made available to end users.

PRINCIPLE 8: Do not delete or modify Collections without appropriate review, authorisation, and end user communication

Once formally published, final Collections cannot be deleted or modified without proper authorisation (with exception of minor bug fixes with no potential to impact users) and end user communication.

Bugs in final products: Sometimes a subset of the final Collection may be affected by subtle changes in input or auxiliary data that were not announced in advance, or due to interruptions in production. This may lead to the generation of faulty products which, when discovered, are deleted from the current collection and are replaced with the corrected products when available. Minor updates affecting relatively few individual data products within a collection are expected and corrections are expected. These updates do not "break the Collection" since they are not of the scope requiring a full reprocessing, or major version upgrade of a Collection.

New products may be added to a collection without the need for reprocessing a Collection. For example, as the result of addition of data from a new mission.

PRINCIPLE 9: Assignment of a Persistent Identifier at collection level

A Persistent Identifier (PID) should be added at Collection level in line with the CEOS Persistent Identifier Best Practice [AD 8]. It allows to make your Collection uniquely identifiable and simple for people to cite it.

PRINCIPLE 10: Maintain accessible records of product files that have been removed or replaced within a collection

Records should be kept which allow users to identify affected products/files and indicate whether they have been modified, removed and / or replaced.

PRINCIPLE 11: Consider approaches that authenticate replicas of collections

Collection data may be replicated across multiple independent repositories (e.g. Physical Storage, Cloud Storage systems, etc.). Understanding how well a replica represents the original source collection is important in building user confidence. Ensuring users are able to confidently access authenticated copies of a collection is essential in providing user trust in a particular source of data. Different approaches could grant the data integrity and authenticity of the collections like the insertion of the Persistent Identifier [PRINCIPLE 9] in the product metadata which point to a landing page, HASH code embedded in any replicated and disseminated product, digital signature (e.g. watermark).

2.4. Operations & Maintenance Stage

PRINCIPLE 12: Maintain accessible metadata and documentation for decommissioned Collections.

There are two types of metadata:

1. those related to collections, baseline and derived products or web services, and;
2. those related to a set of files comprising the individual product.

The higher-level metadata information (e.g., the first type) is generated and never deleted, even if the products they refer to are no longer available. Instead, they are marked as 'deprecated' or their status similarly noted. This way, old and decommissioned products can still be referenced meaningfully in historical scientific publications and online resources despite the data no longer being accessible.

The lower-level metadata generated for each product are deleted at the time of product decommission (no archiving).

At the collection/product decommission stage, public access to the data is disabled. Although ongoing production may be discontinued, the data is preserved for a period of time in its original location.

Removal of public access means this data will no longer be referenced in catalogue applications and therefore, relevant indexes supporting those applications should be preserved (as snapshots in time). See also PRINCIPLE 15 regarding obsolete collections.

PRINCIPLE 13: Communicate early and as required with stakeholders on pending decommission to the Collection

Stakeholders should be consulted about the intention to decommission a collection and provided with an opportunity to feedback on potential impacts and preparedness in case changes in decommission timelines may be accommodated. Communication should include reference to the decision and whether the data will be archived and any period of availability during transition to the new collection.

PRINCIPLE 14: Source, ancillary, custom auxiliary data, algorithms and production software, and associated documentation should be retained indefinitely

Both source and auxiliary/ancillary data are copies of data, often generated, and distributed by third parties. This data is typically of long-term strategic importance and hence, should be retained and preserved indefinitely except when another agency has preservation responsibilities.

Source, ancillary, custom auxiliary data, algorithms and production software, and associated documentation should be archived for long-term preservation. Each organisation should ensure source and auxiliary/ancillary data preservation according to own applicable policies and in alignment with CEOS Best Practices [AD 6].

Retention of these data enables reproduction of superseded versions of products. It is worth noting that reproduction of old product versions may not always be possible (e.g. if the licences for the proprietary software used in the production expire or if the software / code used is no longer supported).

Auxiliary/ancillary data is generally reusable across various collections and various versions of these collections. When newer substitutes are available, the old version is preserved and the current version is maintained for production purposes.

PRINCIPLE 15: Obsolete collections should be disposed of in line with relevant entity and government regulations, policies or procedures

Custodians of geoscientific data acquired on behalf of the government are responsible for managing the data through its lifecycle, including archiving.

Preserving obsolete collections in full may be cost-prohibitive due to the volume of data involved, hence old collection data and products are deleted when the upgraded collection data and products are published.

A representative example of a deleted collection can be retained for preservation purposes. See also PRINCIPLE 10.

In deletion of a product version or entire collection, consideration should be given as to whether updated products will be a sufficient and acceptable substitute for the older version and/or whether the older version can be recreated from input and ancillary data and preserved algorithms (code, or the documented methods to produce the product).

Although the products can be legally disposed of, special consideration needs to be given as to whether this act will put an entity into disrepute. For example, products are used in “life and death” decisions (e.g., in support of emergency response efforts of other federal and state agencies) then the information pertaining to such events may need to be made available to post-event commissions of enquiry or similar legal requests if there was a loss of human life.

If product use may give rise to legal proceedings in the future then at least relevant information bits should be retained for a time. Also, if data was specifically provided for use during natural disasters, a copy of that specific data should be preserved by the supplying section (the group doing the specific work/application/study).

At the final stage collections/ products marked for disposal cannot be deleted before a formal authorisation to do so is obtained from the relevant authority. Only upon authorisation, should the orderly deletion of the data from all relevant locations take place.

PRINCIPLE 16: Only one version of a baseline data product should be discoverable within a collection

Multiple versions of a product may exist at any point in time due to active maintenance processes. Therefore, at any time, there ideally should be only one version of baseline

data available to users, per collection. However, there may be more than one version of derived product generated over time from a given baseline data.

The issue of archiving of baseline / unenhanced mission data is dealt with only at the time of collection upgrade. For individual products, the decision to decommission a version of a product or to distribute concurrent versions of the product is vested with the respective product owner.

Archiving of obsolete versions of products may be undertaken on a temporary basis but generally, it is avoided since newer versions are of better quality and fully replace their predecessors. See Principle 8 for additional guidance.

Appendix A: Terms of Reference

Note: CEOS source documents referenced in the table below are currently being reviewed

Term	Definition	Source
ancillary (data)	Data which are not obtained from the sensor itself (usually provided in the science telemetry) and have the primary purpose to serve the processing of instrument data. This can be divided into data referred to as spacecraft 'engineering', 'core housekeeping' or 'subsystem' data obtained from other parts of the platform and includes parameters such as orbit position and velocity, attitude and its range of change, time, temperatures, pressures, jet firings, water dumps, internally produced magnet fields, and other environmental measurements. Ancillary refers to data that exist purely to serve the data processing.	https://ceos.org/document management/Working Groups/WG ISS/Interest Groups/Data Stewardship/White Papers/EO-Data StewardshipGlossary.pdf
archive	The archive stores data products, guaranteeing their preservation for future use. This function includes all operations to identify, store and retrieve the data and ensure their integrity.	https://ceos.org/document management/Working Groups/WG ISS/Interest Groups/Data Stewardship/White Papers/EO-Data StewardshipGlossary.pdf

<p>auxiliary (data)</p>	<p>Data which enhances processing and utilization of remote sensing instrument data. The auxiliary data are not captured by the same data collection process as the instrument data. Auxiliary data include data collected by any other platform or process, preferably in georeferenced digital format. Examples are meteorological data received from ECMWF or NCEP. Auxiliary data help in data processing but are also collections in their own right.</p> <p>Auxiliary refers to any additional information which is required in production of an EO Collection. Examples include TLE (two-line element set) files to compute precise orbits of satellites, or water vapour estimates or BRDF MODIS (Bidirectional Reflectance Distribution Function) data for atmospheric corrections, also DEM (Digital Elevation Model) data for terrain corrections.</p>	<p>https://ceos.org/document management/Working Groups/WG ISS/Interest Groups/Data Stewardship/White Papers/EO-Data StewardshipGlossary.pdf</p> <p>Second paragraph from this document.</p>
<p>backup</p>	<p>Backup refers to a general practice of making copies of current <u>baseline and derived products</u> of EO Collections, in specified time intervals, and storing those copies in a manner that will not affect the data if the primary distribution environment is compromised. The emphasis is on the ability to retrieve a copy of the entire EO Collection on demand if the original data is lost or compromised.</p>	<p>This document</p>
<p>baseline (data)</p>	<p>Baseline data are source data that has been processed to a common set of requirements and organised into a form that allows immediate analysis and interoperability through time and with other collections.</p>	<p>This document</p>
<p>business continuity</p>	<p>Business continuity is an organization's readiness to continue functioning during times of disruption.</p>	<p>This document</p>

catalogue (noun)	The Catalogue provides the discovery of information to the user on which EO products can be obtained, i.e. a “Product Catalogue”. Products can be organized in collections with restricted access depending on product and user type.	https://ceos.org/document management/Working Groups/WG ISS/Interest Groups/Data Stewardship/White Papers/EO-Data StewardshipGlossary.pdf
collection (specific)	A group of products that have been processed using a consistent radiometric calibration, geometric registration base, data / metadata format, and version of processing algorithms.	This document
custodians/s towards	Data custodians are responsible for the safe custody, transport, storage of the data and implementation of business rules.	This document
data	Scientific or technical measurements, values calculated therefrom, observations, or facts that can be represented by numbers, tables, graphs, models, text, or symbols which are used as a basis for reasoning and further calculation.	https://ceos.org/document management/Working Groups/WG ISS/Interest Groups/Data Stewardship/White Papers/EO-Data StewardshipGlossary.pdf
dispose	To dispose of data is to permanently and irrecoverably remove all copies held by an organization.	https://ceos.org/document management/Working Groups/WG ISS/Interest Groups/Data Stewardship/White Papers/EO-Data StewardshipGlossary.pdf
decommissioned	Products and collections that have been superseded by new versions and are no longer available. Decommissioned products are no longer supported i.e corrections will not be made, new data will not be added, support is not available.	This document

deprecated	Products and collections that have been superseded by a version and are still available, but whose use is discouraged since they will be decommissioned in the future.	This document
derivative (products)	Derivative products are additionally processed from baseline or unenhanced mission data and generally are either a compilation of time-series data (e.g., all time, annual, monthly or seasonal summary data, > Level 3) or thematic versions of each individual data tile of baseline data. Derived products are citable via a Digital Object Identifier (DOI).	This document
entity	A government or business organization that is formed to conduct business or represent the government of the day.	This document
final (version of product)	A product version that is not expected to be updated within an EO Collection. In its production, all of the prerequisite auxiliary data were input.	This document
granule	The smallest aggregation of data which is independently managed (i. e. described, inventoried, retrievable). Granules may be managed as logical granules and/or physical granules. See also <i>product</i> .	https://www.earthdata.nasa.gov/learn/glossary
index	Database entry linking to location of product. Indexed products are discoverable and visible in a catalogue.	This document

<p>instrument data</p>	<p>1) Data specifically associated with the instrument, either because it was generated by the instrument or included in data packets identified with that instrument. These data consist of instrument science and engineering data, and possibly ancillary data. Instrument engineering data is produced by engineering sensor(s) of an instrument, used either for operating the instrument or for processing the science data generated by the instrument. Instrument science data is produced by the science sensor(s) of an instrument, usually constituting the basic reason for existence of an instrument. (2) Data created by an instrument including scientific measurements and any engineering or ancillary data which may be included in the data packets. (3) Data produced and transmitted by the science and engineering sensors of an instrument, and, in the spacecraft environment, any additional data packaged with the instrument's sensor data by virtue of services provided</p>	<p>https://ceos.org/document management/Working Groups/WG ISS/Interest Groups/Data Stewardship/White Papers/EO-Data StewardshipGlossary.pdf</p>
<p>Long Term Preservation</p>	<p>The act of maintaining information in a correct and independently understandable form over the long term (i.e., a period of time long enough to be concerned with the impact which changing technologies, including support for media and data formats, and changing user communities will have on the information being held in a repository.) See also preservation.</p>	<p>https://ceos.org/document management/Working Groups/WG ISS/Interest Groups/Data Stewardship/White Papers/EO-Data StewardshipGlossary.pdf</p>

Metadata	Data about data, which provides an understanding of the content and utility of the product or collection. Metadata may be used to select on data for a particular scientific investigation. Metadata is intended as information describing significant aspects of a resource (Earth Observation space data in this context). They are created for the purposes of data search, discovery and access management and may exist at various levels, typically from data collection through to the individual variables of each product in a collection.	https://ceos.org/document management/Working Groups/WG ISS/Interest Groups/Data Stewardship/White Papers/EO-Data StewardshipGlossary.pdf
NRT Near-Real-Time (data)	NRT Data are those that are available for use with a specified (small and application dependent) latency, which is typically 3 hours for meteorological applications.	https://ceos.org/document management/Working Groups/WG ISS/Interest Groups/Data Stewardship/White Papers/EO-Data StewardshipGlossary.pdf
obsolete (products or collections)	Obsolete products and collections have been superseded by later versions of a product or collection.	This document
preservation	Preservation covers all processes and operations for ensuring data technical and intellectual survival through time. It grants data integrity, its discoverability and accessibility, and facilitates its (re)-use in the long term. Preservation is one of the tasks of data curation.	https://ceos.org/document management/Working Groups/WG ISS/Interest Groups/Data Stewardship/White Papers/EO-Data StewardshipGlossary.pdf
Collection lifecycle management principle	High level guidance used within idealised EO collection lifecycle management.	This document

product	The term is used in various Earth observation contexts and with different meanings. Electronic data package distributable to users; content is derived from instrument data via processing involving ancillary and auxiliary data. Products may be accompanied by metadata and browse images. A product may be part of a collection – a distinction useful for archiving and cataloguing purposes. The term product may be used to denote a product type, such as e.g. ENVISAT_ASAR_L1B_PRI data products. End users may distinguish between (input, "raw") data and products, i.e., the derived geophysical parameters. See also <i>granule</i> .	https://ceos.org/document management/Working Groups/WG ISS/Interest Groups/Data Stewardship/White Papers/EO-Data StewardshipGlossary.pdf
provisional	Products in a research and development phase not yet been published into a standardized collection.	This document
source (data)	Data required for production of an EO Collection (e.g., unenhanced satellite mission data) as well as further processed Level-1 data (precision geometrically and radiometrically corrected radiance at the sensor), or any other pre-processed format that suppliers are providing access to that meets program requirements.	This document
EO Space Data (CEOS term)	Earth Observations Data generated by spaceborne missions or instruments owned by public or private organizations. See <i>Instrument data</i> .	https://ceos.org/document management/Working Groups/WG ISS/Interest Groups/Data Stewardship/White Papers/EO-Data StewardshipGlossary.pdf

update (Collection)	An EO collection update makes minor revisions to a relatively small number of products within a collection for the purpose of correcting errors and maintaining consistent quality.	This document
upgrade (Collection)	An EO collection upgrade is a new and improved major version of all products within a collection due to comprehensive reprocessing.	This document
user	External person, institution or system that consumes user services (Data Access or Science and Service Exploitation Platform) provided by the payload data ground segment.	https://ceos.org/document management/Working Groups/WG ISS/Interest Groups/Data Stewardship/White Papers/EO-Data StewardshipGlossary.pdf
version (control)	Data version control is a method of working with collections. It is similar to the version control systems used in traditional software development but is optimized to allow better processing of data and collaboration in the context of data analytics, research, and any other form of data analysis.	Data version control - Wikipedia