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Geographic information — Preservation of digital data and metadata —

Part 2: Content specifications for Earth observation data and derived digital products

Information géographique — Archivage des données numériques et des métadonnées

Partie 2: Spécifications de contenu pour les données d'observation de la Terre et les produits numériques dérivés

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Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 211, *Geographic information/Geomatics*.

A list of all parts in the ISO 19165 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Many agencies across the globe are generating important datasets by collecting measurements from instruments in-situ and on board aircraft and spacecraft, globally and constantly. The data resulting from such measurements and digital products derived from them are valuable resources that need to be preserved for the benefit of future generations. These observations are the primary record of the Earth's environment and are therefore the key to understanding how conditions in the future will compare to conditions today. Earth observational data, derived products and models are used to answer key questions such as "How is the global Earth system changing?", "What are the sources of change in the Earth systems and what are their magnitudes and trends?", "How will the Earth system change in the future?", and "How can Earth system science improve mitigation of and adaptation to global change?".

In the near-term, as long as the missions' data are being used actively for research and applications, it continues to be important to provide easy access to the data and services commensurate with current information technology. For the longer term, when the focus of the research community shifts towards new missions and observations, it is essential to preserve the previous mission data and associated information. This will enable a new user in the future to understand how the data were used for deriving information, knowledge and policy recommendations and to "repeat the experiment" to ascertain the validity and possible limitations of conclusions reached in the past as well as to provide confidence in long-term trends that depended on data from multiple missions.

Organizations that collect, process and utilize Earth observation data today have a responsibility to ensure that the data and associated content continue to be preserved by gathering this information and preserving it themselves, or by handing it off to other organizations. In order to ensure preservation of all the content necessary for understanding and reusing the data and derived digital products, a standard is needed that specifies this content. While there are existing standards that address archival and preservation in general, there are no existing international standards or specifications to address what content should be preserved.

Specifications for preservation of information content complement existing archive standards. Space agencies that are members of the International Consultative Committee for Space Data Systems (CCSDS) have long recognized the importance of developing information standards for use in long-term preservation of space-related data collections. Volunteers developed the Open Archival Information System Reference Model (OAIS-RM). Subsequent activities continue to expand through a range of related interests that reach towards more practical guidance for developing agency standards. An example of this is a recommended standard on packaging of data and metadata (XFDU), to facilitate information transfer and archiving[11]. The most recent update to the OAIS-RM is ISO 14721. The OAIS-RM provides a conceptual framework for archiving digital information. The CCSDS has also developed ISO 16363, which specifies requirements for certification of trustworthy digital repositories, based on the OAIS-RM, and ISO 16919, which describes how to audit archives for conformance with the requirements.

ISO 19115-1 provides a metadata model for describing geographic information and services, and ISO 19115-2 augments ISO 19115-1 with additional structure to describe the acquisition and processing of geographic imagery and gridded data. It provides the structure needed to represent properties of the instruments acquiring data, e.g. instrument geometry and production processes. The structure provided by ISO 19115-2 is useful for representing the preservation content intended to be specified with this document (ISO 19165-2).

ISO 19165-1 considers geographic information preservation in general and this document (ISO 19165-2) is its extension for Earth observation data and its derived products.

ISO 19165-1:2018, 7.3.1 indicates that specific content items needed to preserve the full provenance and context of data and associated data depend on the needs of the designated communities and types of datasets (e.g., maps, remotely sensed data from satellites and airborne instruments, physical samples). It also states that follow-up parts to ISO 19165-1 may be developed to provide details of content items appropriate to specific disciplines.

This document, as Part 2 of the ISO 19165 series, provides more detailed specifications for Earth observation data and derived digital products resulting from spaceborne and airborne remote sensing, as well as in situ observations.

This document benefits from the work performed by the Data Preservation and Stewardship Committee of the U.S. Earth Science Information Partners (ESIP)[5], NASA[6], ESA and CEOS WGISS[7]. The documents from these groups are integrated along with the ISO international standards mentioned above to provide specific content items to be preserved from Earth observing missions for the benefit of users. It is expected that if the content items specified by this document are preserved, users will have sufficient information to be able to understand, reuse, and, ideally, regenerate data products without the assistance of the original teams that were responsible for their initial generation.

Geographic information — Preservation of digital data and metadata —

Part 2:
Content specifications for Earth observation data and derived digital products

1 Scope

This document aims to extend the long-term preservation of digital geospatial data to provide details about content describing the provenance and context specific to data from missions that observe the Earth using spaceborne, airborne or in situ instruments.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 19115-1, *Geographic information — Metadata — Part 1: Fundamentals*

ISO 19115-2, *Geographic information — Metadata — Part 2: Extensions for acquisition and processing*

ISO 19115-3, *Geographic information — Metadata — Part 3: XML schema implementation for fundamental concepts*

ISO 19130-1, *Geographic information — Imagery sensor models for geopositioning — Part 1: Fundamentals*

ISO/TS 19130-2, *Geographic information — Imagery sensor models for geopositioning — Part 2: SAR, InSAR, lidar and sonar*

ISO 19157-1, *Geographic information — Data quality — Part 1: General requirements*

ISO 19157-2, *Geographic information — Data quality — Part 2: XML schema implementation*

ISO/TS 19159-1, *Geographic information — Calibration and validation of remote sensing imagery sensors and data — Part 1: Optical sensors*

ISO/TS 19159-2, *Geographic information — Calibration and validation of remote sensing imagery sensors and data — Part 2: Lidar*

ISO/TS 19159-3, *Geographic information — Calibration and validation of remote sensing imagery sensors and data — Part 3: SAR/InSAR*

ISO 19165-1, *Geographic information — Preservation of digital data and metadata — Part 1: Fundamentals*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 19165-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
analysis ready data
<earth observation> 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

Note 1 to entry: The definition from Committee on Earth Observation Satellites (CEOS) for CEOS Analysis Ready Data for Land (CARD4L) has been generalized here to include data other than satellite data by omitting the word "satellite" from the definition.

Note 2 to entry: Adapted from Reference [10].

3.2
ancillary data
<earth observation> 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

Note 1 to entry: Ancillary data refers to data that exist purely to serve the data processing. *Auxiliary data* (3.3), while helping the process, are also datasets in their own right.

Note 2 to entry: Ancillary data may be 'engineering', 'core housekeeping' or 'subsystem' data obtained from other parts of the measurement platform. It may include parameters such as position and velocity, attitude and its range of change, time, temperatures, pressures, internally produced magnetic fields, and other environmental measurements.

Note 3 to entry: Some missions may treat ancillary data as datasets in their own right, thus blurring the distinction being made here between ancillary and *auxiliary data* (3.3).

Note 4 to entry: The definition in the original source is tailored to spaceborne Earth observations. It has been slightly modified here to be more general. The concept is that ancillary data are those not collected by the sensor itself and that their primary purpose to serve processing applies to Earth observation data from airborne and in situ instruments as well.

Note 5 to entry: Adapted from Reference [8].

3.3
auxiliary data
<earth observation> data which enhance processing and utilization of the Earth observing instrument data

Note 1 to entry: 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. Auxiliary data help in data processing, but are also datasets in their own right.

Note 2 to entry: Adapted from Reference [8].

3.4
dataset
identifiable collection of data

[SOURCE: ISO 19115-1:2014, 4.3, modified — Note 1 to entry has been deleted.]

3.5
dataset series
collection of datasets sharing common characteristics

[SOURCE: ISO 19115-1:2014, 4.4]

3.6
granule
smallest aggregation of data which is independently managed

Note 1 to entry: Granules may be managed (i.e. described, inventoried, retrievable) as logical granules and/or physical granules.

Note 2 to entry: Granule is often equivalent to *dataset* (3.4).

3.7
mission
<earth observation> activity that uses spaceborne, airborne or in situ instruments

Note 1 to entry: Some organizations reserve the term "mission" for satellite observation activities and refer to airborne and in situ observation activities as "investigations" and "field campaigns", respectively.

3.8
product level
<earth observation> number indicating the degree of processing that has been performed on the observed data

Note 1 to entry: Product levels 0 through 4 indicate the degree of processing performed on the raw data to convert them into more useful parameters and formats. The Committee on Earth Observation Satellites (CEOS) defines product levels as follows:

— Raw Data: Data in their original packets, as received from a satellite.

— Level 0: Reconstructed unprocessed instrument data at full space time resolution with all available supplemental information to be used in subsequent processing (e.g. ephemeris, health and safety) appended.

— Level 1: Unpacked, reformatted level 0 data, with all supplemental information to be used in subsequent processing appended. Optional radiometric and geometric correction applied to produce parameters in physical units. Data generally presented as full time/space resolution. A wide variety of sub level products are possible.

— Level 2: Retrieved environmental variables (e.g. ocean wave height, soil moisture, ice concentration) at the same resolution and location as the level 1 source data.

— Level 3: Data or retrieved environmental variables which have been spatially and/or temporally re-sampled (i.e. derived from level 1 or 2 products). Such re-sampling may include averaging and compositing.

— Level 4: Model output or results from analyses of lower level data (i.e. variables that are not directly measured by the instruments but are derived from these measurements).

Note 2 to entry: The product levels defined here are derived from satellite remote sensing heritage. For the case of airborne and in situ observations, these do not necessarily apply, but may be used as appropriate for indicating the degree of processing performed on the observed data.

Note 3 to entry: Adapted from Reference [9].

3.9
stage
<earth observation> well-defined part of the lifecycle of a mission

4 Symbols and abbreviated terms

Doc	Document
CEOS	Committee on Earth Observation Satellites
ESA	European Space Agency

ESIP	Earth Science Information Partners
GNSS	Global Navigation Satellite System
ICD	Interface Control Document
L0	Product Level 0
L1	Product Level 1
L2+	Product Level 2 or higher, including Analysis Ready Data
NASA	National Aeronautics and Space Administration (United States)
QA4EO	Quality Assurance framework for Earth Observations
SI	International System (of units)
SW	Software
WGISS	Working Group on Information Systems and Services

5 Conformance

In order to conform to this document, the abstract test suite in Annex A shall be used.

6 Mission stages

6.1 General

This document covers missions that observe the Earth using spaceborne, airborne or in situ instruments. The preservation of observations (i.e. measurements from such instruments) and digital data products derived from the observations is important for the benefit of future users. In addition, it is also important to preserve metadata and other content items such as ancillary data, planning documents and associated knowledge in order for future users to be able to understand and reuse the data and possibly reproduce the results from the missions. Such content items are created and gathered at different stages of the missions (defined below). Annex B provides a mapping between the stages and satellite mission phases defined by NASA and ESA. These stages are conceptually applicable to any type of mission. Along with the definitions for each stage, a few examples of the types of activities appropriate to the stage are given to clarify the definition. However, the specific contents, number of items to be preserved, and the complexity of the preservation activities depend on the specific type of mission. While the focus of this document is the preservation content, i.e. "what" needs to be preserved, enumerating the content associated with the mission stages helps address "when" the content items need to be preserved, as well.

6.2 Mission concept stage

The mission concept stage is the period when ideas for a mission are developed and proposed to funding entities. At this stage, the mission is defined to a level sufficient to show the scientific/applications value and technical feasibility. During this stage, science and applications requirements are identified. Additional activities may include identification of plans and tools to be used in preliminary system level studies. Feasibility verification documents, mission technology and programmatic estimates for the future mission stages may also be generated.

6.3 Mission definition stage

The mission definition stage is the period when mission scientific/applications requirements are defined in detail and technical solutions are selected for the system concept. During this stage, types of scientific measurements (e.g. spectral analysis, temperature measurement) may be identified and defined.

6.4 Mission implementation stage

The mission implementation stage is the period when the detailed design, implementation, and testing of the mission system and its components are realized. These may include:

— sensors/instruments;

— algorithms and their interfaces;

— methods of measurement;

— any other context necessary to perform measurements.

6.5 Mission operations stage

The mission operations stage is the period when

— data are captured;

— algorithms are revised and improved;

— input are analysed;

— calibration and validation of sensor/instrument as well as activities concerned with qualification of processed data are performed; and

— higher level derived digital products are generated.

6.6 Post mission stage

The post mission stage is the period after mission operations are completed, and includes the post-operations and preservation. The post mission stage may start with the satellite end of life (e.g. for an Earth observation mission with the event of satellite disposal or failure), the completion of the last planned aircraft flight in a series that constitutes a mission, or the last planned activity in a series of in situ measurement activities. The post mission stage focuses on:

— consolidation and appraisal of datasets (data and information);

— reprocessing of datasets to align to the latest version;

— ground segment and media disposal (depending on specific mission);

— migration of data and associated information to a long-term preservation environment.

During the post mission stage, a limited set of functions (e.g. data discovery and access) may be provided by the mission operations team until data migration to a long-term preservation environment. This stage can extend beyond the point where the preservation package has been prepared and archived and involve updates to algorithms and reprocessing. This stage also focuses on:

— historical data reuse and exploitation;

— preservation of data and related information against aging and technological changes; and

— data curation and enrichment.

7 Preservation content

7.1 General

The content to be preserved is discussed below in one subclause for each of the mission stages described above. Each subclause provides the rationale for preserving the listed content items and a list of items recommended to be preserved. Each of the items listed in the tables may correspond to one or more documents (Doc), software (SW) objects or data records. It is also possible for some missions that some of the documents specified in the tables can be combined into a single document. The list shall be tailored to each mission and the specifics of which items will be preserved to satisfy the content requirements indicated in this clause shall be documented as preservation metadata. Also, it is to be noted that many of the content items in a given stage may need to be updated during subsequent stages. It is assumed that such updates are made and the resulting items are preserved in a version-controlled manner. In Tables 1 to 5, shown in the following subclauses, the column headings are:

— ID: a short identifier for the content item;

— Need for: indicates for which type of mission the specified item is needed (satellite: SAT, aircraft: AIR, field campaign: FLD, all types: ALL);

— Type: indicates whether the item is a document, data record, software, etc.;

— Identification: a phrase identifying the content item (longer than ID);

— Description: a brief description of the content item;

— Examples of types of quality information: indicates information to be contained in the content item for the item to be considered to be of high quality.

The standards in the ISO 19115 series, ISO 19130 series, ISO 19157 series, 19159 series and 19165-1 shall be considered as appropriate in representing the content items listed in the Tables 1 to 5. Annex C (informative) illustrates how the items can be organized in an ISO 19115-1 DS_Series that holds references to all preservation information for a mission.

7.2 Mission concept stage

7.2.1 Rationale

Information produced during this stage provides a snapshot of the framework in which the mission was born. Mission and sensor requirements, assessment studies, technology readiness review and cost analysis are performed during this stage. Documents generated during this stage show the objectives and plans for the mission. Preserving this information would allow future users to have reference material for evaluation and definition of new missions. Traceability to this information is also useful for comparing initial expectations with mission results and for understanding changes that may have occurred between this stage and the following stages.

7.2.2 Content

The content required to be preserved by the end of the mission concept stage is identified and described in Table 1.