Committee on Earth Observation Satellites

Draft ISO 19124-1 standard on EO products

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Working Group on Calibration and Validation

ISO WD 19159

WGCV review of ISO/TC 211 WD 19159 (2010-2011)

TC 211 (Geographic information/Geomatics) — ISO 19159: Geographic information — Calibration and validation of remote sensing imagery sensors and data — Part 1: Optical sensors

- comments contributed in 2011 through WGCV and national channels
  - in-depth review of terminology
  - Validation: focus on calibration validation, not on data and derived products
  - pre- and post-launch practices
  - consistency discussed with respect to:
    - ISO/IEC guide 99: International vocabulary of metrology (VIM)
    - ISO 19115: Geographic information — Metadata — Part 1: Fundamentals
    - ISO 19101: Geographic information — Reference model — Part 1: Fundamentals & 2: Imagery
    - ISO 19156: Geographic information — Observations and measurements
    - ISO 19157: Geographic information — Data quality
- report on TC 211 Plenary, March 2011, WGCV Chair (Greg Stensaas) attended

ISO WD 19124

ISO WD 19124-1: Geographic information — Calibration and validation of remote sensing data and derived products

TC 211 vision for ISO 19124 series

- Part 1: Fundamentals
- Part 2: Optical sensors
- Part 3: Hyperspectral sensors
- Part 4: Lidar
- Part 5: SAR/InSAR
- Part 6: Microwave
- Part 7: Thematic Data
- Part 8: Cal/Val site

ISO WD 19124-1

ISO WD 19124-1: Geographic information — Calibration and validation of remote sensing data and derived products — Part 1: Fundamentals

- Terminology
- Pre-launch calibration (1 page)
- Post-launch calibration (7 pages)
- Validation (4 pages)
  - Main process: Loew et al., *Rev.Geophys.* 2017 (WGCV co-authors)
  - Validation steps
  - Validation hierarchy: old version of LPV hierarchy
  - Validation site requirements: land/biomass focused
  - Data product
  - Recommendations for setup of validation process: some specific, some general
- Specific parts of the ISO 19124 series of standards

ISO WD 19124-1

ISO WD 19124-1: Geographic information — Calibration and validation of remote sensing data and derived products — Part 1: Fundamentals:

- **WGCV comments (Spring 2021)**
  - **terminology**
  - **advocacy for an open, holistic glossary (see also WGCV-49 talk by P. Strobl)**
  - **specific technical comments**
  - **questions regarding universality of the recommendations**
  - **validation hierarchy & validation maturity matrix**
- **report on TC 211 Plenary (31 May 2021, WGCV attendance)**

Validation Hierarchy & Maturity Matrix

Validation Hierarchy

Ranks the extent of validation:

- Number of data pairs
- Representativeness of locations and time periods
- Community-agreed-protocols
- Ex-post uncertainty assessment
- Reporting
- Fiducial references for Stage 4

7.3 Validation hierarchy

Validation improves the quality of a data product. The achieved quality level depends on the applied validation method. These methods are grouped in four stages which are explained in Tab. 6.

Tab. 6: Validation hierarchy

	Validation Stage - Definition and Current State	Variable
0	No validation. Product accuracy has not been assessed. Product considered beta.	
1	Product accuracy is assessed from a small (typically < 30) set of locations and time periods by comparison with in-situ or other suitable reference data.	Snow Fire Radiative Power Biomass
2	Product accuracy is estimated over a significant (typically > 30) set of locations and time periods by comparison with reference in situ or other suitable reference data. Spatial and temporal consistency of the product, and its consistency with similar products, has been evaluated over globally representative locations and time periods. Results are published in the peer-reviewed literature.	fAPAR Phenology Burned Area LAI
3	Uncertainties in the product and its associated structure are well quantified over a significant (typically > 30) set of locations and time periods representing global conditions by comparison with reference in situ or other suitable reference data. Validation procedures follow community-agreed-upon good practices. Spatial and temporal consistency of the product, and its consistency with similar products, has been evaluated over globally representative locations and time periods. Results are published in the peer-reviewed literature.	Vegetation Indicies Albedo Soil Moisture LST & Emissivity Active Fire
4	Validation results for stage 3 are systematically updated when new product versions are released or as the interannual time series expands. When appropriate for the product, uncertainties in the product are quantified using fiducial reference measurements over a global network of sites and time periods (if available).	Land Cover

Validation Hierarchy & Maturity Matrix

CEOS WGISS Data Management & Stewardship Maturity Matrix

Usability criteria: encoding, documentation, traceability, validation, data uncertainty, QA/QC

not managed

fully managed

	DISCOVERABILITY	ACCESSIBILITY							PRESERVATION		CURATION	
	MMP1 Metadata for Discovery	MMP2 Online Access	MMP3 Data Encoding	MMP4 Data Documentation	MMP5 Data Traceabi	MMP6 Data Validation	MMP7 Data Uncertainty	MMP8 Data Quality Control	MMP9 Data Preservation	MMP10 Data Verification	MMP11 Data Processing/Reprocessing	MMP12 Persistent & Resolvable Identifier
Level-0 Not Managed	1) No catalogue available 2) No advertising available	Data and metadata are not accessible online	1) Data Not Structured 2) Non-standard or proprietary data format, or, poorly-documented standard file format.	Partial and incomplete mission documentation	Limited produ information available (not online)	1) Reference Data Representativeness - No validation 2) Reference Data Quality - No validation 3) Validation Method - No validation 4) Validation Results - No validation	1) Uncertainty Method: Uncertainty characterisation not performed, or metho not documented. 2) Uncertainty Sources: Uncertainty characterisation not performed, or source analysed not documented. 3) Uncertainty Values: No uncertainty information provided.	) No control and onitoring check) No quality indicator in etadata) No procedures ocumentation	1) Uncontrolled storage location. 2) Only data are stored 3) Data Records archiving not managed 4) Relevant information on Product Details Assessment not made available	No Data/Associated information integrity, authenticity and readability check	1) No reprocessing activities planned 2) Pre-flight calibration & characterisation not documented or information not available. 3) Post-launch calibration & characterisation not documented or not available. 4) Processing: Additional processing steps not documented.	No persistent and resolvable identifiers available
Level-1 Partially Managed	1) Advertising available 2) Catalogue search available at product level	Basic online services available for data and metadata access	1) Basic schema for automated data use 2) Data in documented standard file format. Non-standard naming conventions used.	1) Already existent mission documentation available and preserved for the long term 2) No link between mission documentation and data records	Product information available (not online)	1) Reference Data Representativeness: measurements assessed to be mostly representative of the satellite measurements 2) Reference Data Quality: single uncertainty for the entire dataset. 3) Validation Method: simple uncertainty estimated 4) Validation Results: Validation results show good agreement between satellite and reference measurements within uncertainties in most cases.	1) Uncertainty Method: Limited use of GUM approach, and/or, an expanded comparison to measurements by other sensors. 2) Uncertainty Sources: Most important sources of uncertainty included. 3) Uncertainty Values: Single uncertainty value provided for subsets of data	Basic data quality ontrol and monitoring heck Minimal set of quality ontrol procedures ocumented and vailable	1) Basic archiving for original data records preservation 2) Assessment of SW preservation 3) Product Details Assessment: Any required information missing	Data Records/Associated information integrity basic check	1) Minor updates and bugs corrections of data records implemented 2) Data Records repackaging and/or reformatting 3) Pre-flight calibration & characterisation misses some important aspects 4) Post-launch calibration & characterisation misses some important aspects of instrument behaviour and/or is not entirely of a level of quality to be judged fit for purpose. 5) Additional processing steps documented. Some important additional processing steps may not be fit for stated purpose.	1) Persistent identifier assignment only for particular Data Records Collections 2) Basic landing pages management
Level-2 Managed	1) Detailed catalogue search available at product level 2) Product metadata oriented towards an international standard 3) Data Collection and Associated Information searchable. 4) International standard for Collection metadata	1) Simple Access Architecture through metadata 2) Data access system oriented towards an international standard	1) Use of non-proprietary international standards encodings for syntactic interoperability. 2) Periodicaly repackaging/ reformatting of archived data. 3) Data in well-documented standard file format, community naming convention standards.	1) Documentation produced, published and well described 2) Link between mission documentation and data records created and managed	Dataset teste for presence c correct provenance metadata. W described product information available onli	1) Reference Data Representativeness: measurements assessed to be well representative of the satellite measurements 2) Reference Data Quality: full uncertainty information 3) Validation Methods assess satellite measurements 4) Validation Results show excellent agreement between satellite and reference measurements, within uncertainties.	1) Uncertainty Method: GUM approach to estimate measurement uncertainty with full breakdown of components and separated as Type A or B classification. 2) Uncertainty Sources: All important sources of uncertainty included. 3) Uncertainty Values: Total uncertainty per pixel is provided, with basic breakdow of key components no error-covariance.	Quality indicator post- rocessing available Quality control rocedures documented nd available online	1) Preservation repository certified internally 2) Community-standard for archiving metadata 3) Product Details Assessment: All required information available, any recommended information missing	1) Data Records/Associated information content integrity check and verification 2) Media readability and accessibility testing	1) Reprocessing for calibration and/or algorithm improvement 2) Pre-flight calibration & characterisation covers all reasonable aspects 3) Post-launch calibration & characterisation covers all reasonable aspects of instrument behaviour to a quality that is "fit for purpose" in terms of the mission's stated performance and uses appropriate community infrastructure/methods (CEOS/FRMs). 4) Additional processing steps documented.	1) Persistent identifier assignment to all disseminated Data Records Collections and metadata 2) Automatic landing page generation and extensive management of landing pages
Level-3 Fully Managed	1) International standard for Product metadata 2) International standard for Collection metadata 3) Catalogue accessible via international or community agreed standards protocol 4) Data policy available in metadata 5) Periodic updates of metadata in the catalogue 6) Quality indicator metadata available and discoverable 7) Search results reinvancy. 8) Seamless transition from discovery to access	1) International standard for Data and metadata access system 2) Data policy available in the metadata. 3) Visualisation services 4) Reporting system 5) Hosted processing 6) Quick adoption to new technologies and standards evolution 7) Data and metadata accessible through a free and open access protocol	1) Accepted and Available semantic encoding standards for complete interoperability 2) Data and metadata uses FAIR-compliant vocabularies 3) Analysis Ready Data standard	1) Standards based metadata for documentation 2) Link between mission documentation and data records published	1) Automatic metadata generation fo provenance documentatic 2) Complete a updated data provenance available onli	1) Reference Data Representativeness: Reference measurements independently assessed to be fully representative of the satellite measurements, covering the satellite's full range of measurements and with full assessment of uncertainties and carried out on a regular basis determined by product performance. 2) Reference Data Quality: full uncertainty and error-correlation information, assessed following the GUM and traceable to SI 3) Validation Methods assess satellite measurements and reference data w.r.t. their error- covariance and validates those uncertainties. 4) Validation Results show excellent agreement between satellite and reference measurements, within uncertainties.	1) Uncertainty Method: GUM approach to estimate measurement uncertainty, including a treatment of error-covariance. 2) Uncertainty Sources: All reasonable sources of uncertainty included. 3) Uncertainty Values: Uncertainties per pixel provided with error-covariance information for all appropriate components.	Data quality control lly compliant with an ternational standard Quality indicator pre d post processing ailable in the etadata Quality metadata ssessed	1) Preservation repository officially certified 2) Periodic technology refreshment 3) Identify and manage the basic preservation of relevant mission SW, ensuring that preserved data can be recreated. 4) Continuity of service availability 5) Product Details Assessment: All required and recommended information available	1) Automatic Data Records/Associated information content integrity check and verification 2) Data authenticity verifiable internally and by the final user 3) Automatic verification process, including monitoring and reporting	1) Reprocessing for time-series creation 2) Roadmap for technology evolution 3) Plurality of accurate and relevant attributes are provided to allow reuse 4) Metadata includes information about the licence 5) Pre-Flight: As Level-2, additionally calibration and characterisation includes the measurements needed to assess uncertainties at component level and their impact on the final product. 6) Post-launch calibration & characterisation covers all reasonable aspects of instrument behaviour to a quality that is "fit for purpose" in terms of the mission's stated performance. 7) All additional processing steps fully documented and state-of-the-art.	1) Persistent identifier created for all accessible data records and metadata 2) Metadata includes the identifier for the data 3) Metadata is offered in such a way that it can be harvested and indexed

https://ceos.org

Validation Hierarchy & Maturity Matrix

Maturity of validation

Four important aspects, from not managed to well managed

- Reference data representativeness
- Reference data quality
- Validation method
- Validation results

Note: better “stage” or “tier” than “level”

CEOS WGISS DMSMM v1.3, 2020

Stage	Description
Level-0 Not managed	- **Reference Data Representativeness:** No validation activity performed. - **Reference Data Quality:** No validation activity performed. - **Validation Method:** No validation activity performed. - **Validation Results:** No validation activity performed.
Level-1 Limit managed	- **Reference Data Representativeness:** Reference measurements assessed to be mostly representative of the satellite measurements, covering a primary range satellite of measurements and at ad-hoc opportunities (no formal documented regular timescale). - **Reference Data Quality:** Reference data comes with a single uncertainty estimate for the entire dataset. - **Validation Method:** Methodology assess satellite measurements, simple uncertainty estimated (e.g. from statistical spread for results). - **Validation Results:** Validation results show good agreement between satellite and reference measurements within uncertainties in most cases.
Level-2 Managed	- **Reference Data Representativeness:** Reference measurements assessed to be well representative of the satellite measurements, covering a reasonable range of the satellite’s measurements and carried out using FRM or community approved methods. Carried out on a regular timescale of approximately annual basis but not necessarily based on need. - **Reference Data Quality:** Reference data comes with full uncertainty information, assessed following the GUM and traceable to community reference or SI (e.g., FRM) - **Validation Method:** Methodology assesses satellite measurements and reference data w.r.t. their uncertainties - **Validation Results:** Validation results show excellent agreement between satellite and reference measurements, within uncertainties. Analysis performed independently of satellite mission owner.
Level-3 Well managed	- **Reference Data Representativeness:** Reference measurements independently assessed to be fully representative of the satellite measurements, covering the satellite’s full range of measurements and with full assessment of uncertainties and carried out on a regular basis determined by product performance. - **Reference Data Quality:** Reference data comes with full uncertainty and error-correlation information, assessed following the GUM and traceable to SI (e.g., FRM). - **Validation Method:** Methodology assess satellite measurements and reference data w.r.t. their error- covariance and validates those uncertainties. - **Validation Results:** Validation results show excellent agreement between satellite and reference measurements, within uncertainties. Uncertainty validated. Analysis performed independently of satellite mission owner.

WGCV & ISO WD 19124-1: Way forward

Status of representation in ISO/TC 211 (Geographic information/Geomatics)

Liping Di as CEOS / TC 211 liaison, Cindy Ong as WGCV POC for 19124-1

Participation in next review phase (tight schedule)

- ✓ April 30: Inputs from CEOS WGCV and WGISS
- ✓ May 31: project team meeting to discuss the draft
- July 2021: New version of working draft to project team
- August 2021: Final version of working draft (WD) ready
- September 2021: Sending out final WD for DTS voting and comments by TC211 member countries and liaison organizations
- December 2021: Editing committee meeting to edit the document based on DTS voting comments
- Feb 2022: Second round voting and comments
- June 2022: Second editing committee meeting
- December 2022: Publish as ISO Technical Specification

WGCV & ISO WD 19124-1: Way forward

Proposal for immediate WGCV recommendation to TC 211 / WD 19124-1

- Referring to the WGISS maturity matrix in the main text (Section 7.3), with a clause that the work is currently underway on more quantitative parameters
- Giving more specific examples in Section 8 (community specific examples, e.g., LPV Validation Hierarchy)

Further work

- Continuation of WGCV-wide work towards harmonized hierarchy/maturity and objective (quantitative) criteria
- Proposed action: WGCV and WGISS nominate liaison PoCs in an attempt to consolidate and harmonise all CEOS internal terminology and to reach out to OGC and ISO for launching a joint effort (based e.g. on the 'Geolexica')