WIGOS Metadata Standard

2017 edition

WEATHER CLIMATE WATER

WORLD
METEOROLOGICAL
ORGANIZATION

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CONTENTS

CHAPTER 1. PURPOSE AND SCOPE OF WIGOS METADATA

An important aspect of the World Meteorological Organization (WMO) Integrated Global Observing System (WIGOS) implementation is ensuring maximum usefulness of WIGOS observations. Observations without metadata are of very limited use: it is only when accompanied by adequate metadata (data describing the data) that the full potential of the observations can be utilized.

Two complementary types of metadata are required: discovery metadata and interpretation/description or observational metadata. Discovery metadata facilitate data discovery, access and retrieval. They are WMO Information System (WIS) metadata and are specified and handled as part of WIS. Interpretation/description or observational metadata enable data values to be interpreted in context. They constitute WIGOS metadata and are the subject of this WIGOS standard describing the interpretation metadata required for the effective utilization of observations from all WIGOS component observing systems by all users.

The WMO Integrated Global Observing System metadata should describe the observed variable, the conditions under which it was observed, how it was measured, and how the data have been processed, in order to provide users with confidence that the data are appropriate for their application. In the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160), Appendix 2.2, the Global Climate Observing System (GCOS) Climate Monitoring Principle 2.2.1(c) describes the relevance of metadata as follows: "The details and history of local conditions, instruments, operating procedures, data-processing algorithms and other factors pertinent to interpreting data (i.e. metadata) should be documented and treated with the same care as the data themselves."

The WMO Integrated Global Observing System observations consist of an exceedingly wide range of data, from manual observations to complex combinations of satellite hyper-spectral frequency bands, measured in situ or remotely, from single dimension to multiple dimensions, and those involving processing. A comprehensive metadata standard covering all types of observation is by nature complex to define. A user should be able to use the WIGOS metadata to identify the conditions under which the observation (or measurement) was made, and any aspects that may affect its use or understanding, that is, to determine whether the observations are fit for the purpose.

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CHAPTER 2. WIGOS METADATA CATEGORIES

Ten categories of WIGOS metadata have been identified. These are listed in Table 1 below. They define the WIGOS Metadata Standard, each category consisting of one or more metadata elements. All of the categories listed are considered to be important for the documentation and interpretation of observations made, and even for their use in the distant future. Hence, the standard currently declares many elements that are clearly not needed for applications focusing on more immediate use of observations. For these applications, such as numerical weather prediction, aeronautical or other transport sector applications and advisories, profiles of the standard may be developed. The categories are in no particular order but reflect the need to specify the observed variable; to answer why, where and how the observation was made; how the raw data were processed; and what the quality of the observation is.

A schematic composition of all categories, containing the individual elements is shown in Figure 1. Note that some of these elements will most likely be implemented using several individual entities (for example, geospatial location will consist of a combination of elements, such as latitude, longitude, elevation or a set of polar coordinates, as well as a reference to the geo-positioning methods used). Chapter 7 contains a set of tables detailing all the elements, including definition, notes and examples, obligations and implementation phase. Code tables enabling users to select from predefined vocabularies to facilitate the application of the WIGOS Metadata Standard and the exchange of metadata are presented in the *Manual on Codes* (WMO-No. 306).

Table 1. WIGOS metadata categories

Category	Description
1. Observed variable	Specifies the basic characteristics of the observed variable and the resulting datasets. It includes an element describing the spatial representativeness of the observation as well as the biogeophysical compartment the observation describes.
2. Purpose of observation	Specifies the main application area(s) of the observation and the observing programme(s) and networks the observation is affiliated to.
3. Station/platform	Specifies the observing facility, including fixed station, moving equipment or remote-sensing platform, at which the observation is made.
4. Environment	Describes the geographical environment within which the observation is made. It also provides an unstructured element for additional meta-information that is considered relevant for adequate use of the observations and that is not captured anywhere else in this standard.
5. Instruments and methods of observation	Specifies the method of observation and describes characteristics of the instrument(s) used to make the observation. If multiple instruments are used to generate the observation, then this category should be repeated.
6. Sampling	Specifies how sampling and/or analysis are used to derive the reported observation or how a specimen is collected.
7. Data processing and reporting	Specifies how raw data are transferred into the observed variables and reported to the users.
8. Data quality	Specifies the data quality and traceability of the observation.
9. Ownership and data policy	Specifies who is responsible for the observation and owns it.
10. Contact	Specifies where information about the observation or dataset can be obtained.

For example, an observation/dataset may have the following metadata categories associated with it:

(a)   One or several purpose(s) of observation;

(b)   Data-processing procedures associated with the instruments;

(c)   Instruments which have been used to make the observation;

(d)   A station/platform to which the instrument(s) belong(s);

(e)   Ownership and data policy restrictions;

(f)   Contact.

An instrument output may contribute to observations of one or more variables. For example:

(a)   A four-wire humidity probe can produce temperature and humidity, as well as dewpoint;

(b)   A sonic anemometer reports wind speed and wind direction and can report air temperature;

(c)   A spectrometer can report absorption due to many different chemical species.

An instrument typically will be associated with the categories:

(a)   Instruments and methods of observation;

(b)   Sampling (e.g. 10 Hz samples of air temperature);

(c)   Data processing and reporting (e.g. ceilometer reporting of 10-minute statistics of cloud height following processing through a sky condition algorithm).

An observed variable may be influenced or characterized by the environment, for example:

(a)   Wind speed (observed variable) on top of a hill (environment);

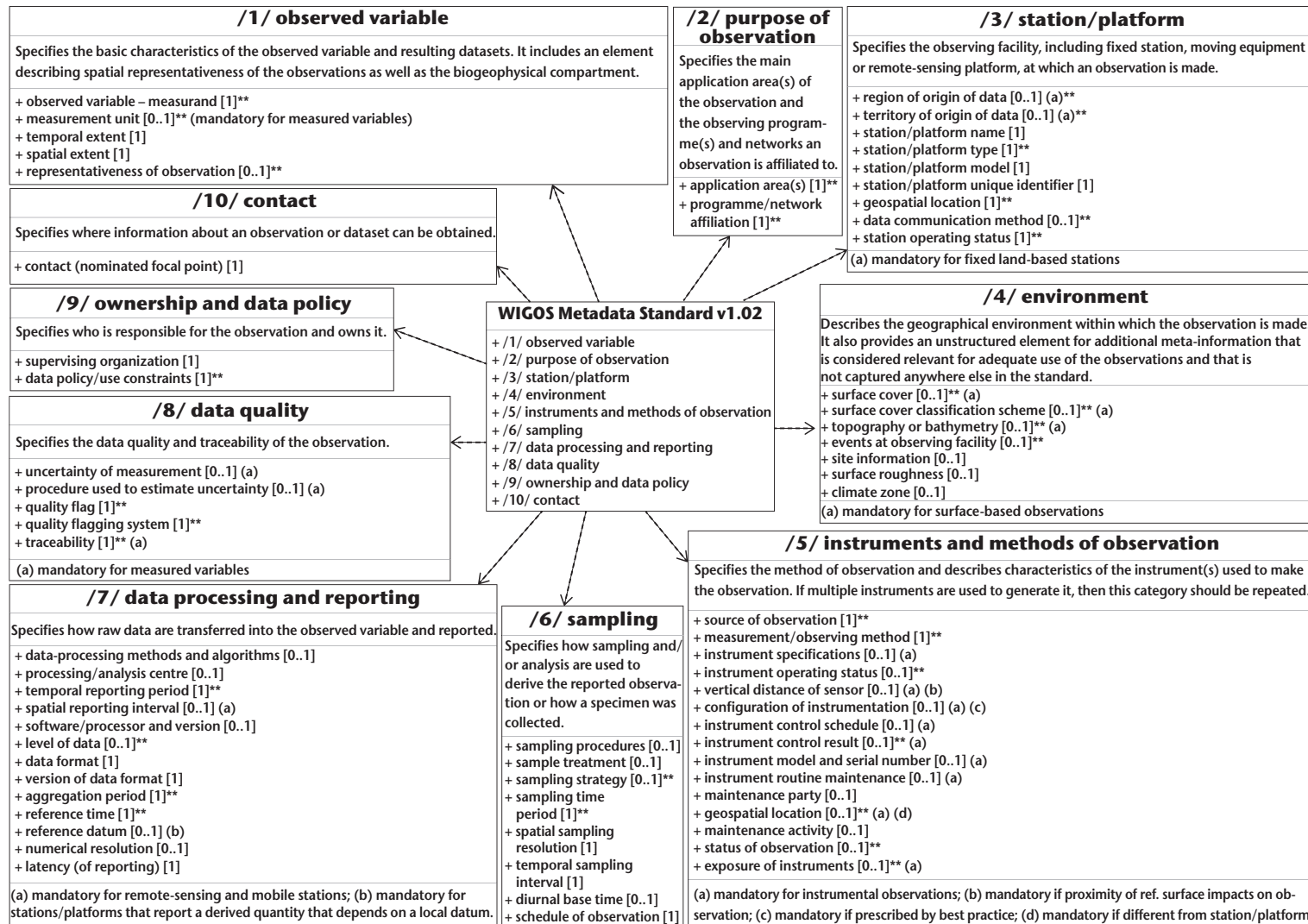(b)   River yield (observed variable) characterized by the upstream catchment and land use.

/1/ observed variable

Specifies the basic characteristics of the observed variable and resulting datasets. It includes an element describing spatial representativeness of the observations as well as the biogeophysical compartment.

+ observed variable – measurand [1]**
+ measurement unit [0..1]** (mandatory for measured variables)
+ temporal extent [1]
+ spatial extent [1]
+ representativeness of observation [0..1]**

/2/ purpose of observation

Specifies the main application area(s) of the observation and the observing programme(s) and networks an observation is affiliated to.

+ application area(s) [1]**
+ programme/network affiliation [1]**

/3/ station/platform

Specifies the observing facility, including fixed station, moving equipment or remote-sensing platform, at which an observation is made.

+ region of origin of data [0..1] (a)**
+ territory of origin of data [0..1] (a)**
+ station/platform name [1]
+ station/platform type [1]**
+ station/platform model [1]
+ station/platform unique identifier [1]
+ geospatial location [1]**
+ data communication method [0..1]**
+ station operating status [1]**

(a) mandatory for fixed land-based stations

/10/ contact

Specifies where information about an observation or dataset can be obtained.

+ contact (nominated focal point) [1]

/9/ ownership and data policy

Specifies who is responsible for the observation and owns it.

+ supervising organization [1]
+ data policy/use constraints [1]**

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+ /1/ observed variable
+ /2/ purpose of observation
+ /3/ station/platform
+ /4/ environment
+ /5/ instruments and methods of observation
+ /6/ sampling
+ /7/ data processing and reporting
+ /8/ data quality
+ /9/ ownership and data policy
+ /10/ contact

/4/ environment

Describes the geographical environment within which the observation is made. It also provides an unstructured element for additional meta-information that is considered relevant for adequate use of the observations and that is not captured anywhere else in the standard.

+ surface cover [0..1]** (a)
+ surface cover classification scheme [0..1]** (a)
+ topography or bathymetry [0..1]** (a)
+ events at observing facility [0..1]**
+ site information [0..1]
+ surface roughness [0..1]
+ climate zone [0..1]

(a) mandatory for surface-based observations

/8/ data quality

Specifies the data quality and traceability of the observation.

+ uncertainty of measurement [0..1] (a)
+ procedure used to estimate uncertainty [0..1] (a)
+ quality flag [1]**
+ quality flagging system [1]**
+ traceability [1]** (a)

(a) mandatory for measured variables

/7/ data processing and reporting

Specifies how raw data are transferred into the observed variable and reported.

+ data-processing methods and algorithms [0..1]
+ processing/analysis centre [0..1]
+ temporal reporting period [1]**
+ spatial reporting interval [0..1] (a)
+ software/processor and version [0..1]
+ level of data [0..1]**
+ data format [1]
+ version of data format [1]
+ aggregation period [1]**
+ reference time [1]**
+ reference datum [0..1] (b)
+ numerical resolution [0..1]
+ latency (of reporting) [1]

(a) mandatory for remote-sensing and mobile stations; (b) mandatory for stations/platforms that report a derived quantity that depends on a local datum.

/6/ sampling

Specifies how sampling and/or analysis are used to derive the reported observation or how a specimen was collected.

+ sampling procedures [0..1]
+ sample treatment [0..1]
+ sampling strategy [0..1]**
+ sampling time period [1]**
+ spatial sampling resolution [1]
+ temporal sampling interval [1]
+ diurnal base time [0..1]
+ schedule of observation [1]

/5/ instruments and methods of observation

Specifies the method of observation and describes characteristics of the instrument(s) used to make the observation. If multiple instruments are used to generate it, then this category should be repeated.

+ source of observation [1]**
+ measurement/observing method [1]**
+ instrument specifications [0..1] (a)
+ instrument operating status [0..1]**
+ vertical distance of sensor [0..1] (a) (b)
+ configuration of instrumentation [0..1] (a) (c)
+ instrument control schedule [0..1] (a)
+ instrument control result [0..1]** (a)
+ instrument model and serial number [0..1] (a)
+ instrument routine maintenance [0..1] (a)
+ maintenance party [0..1]
+ geospatial location [0..1]** (a) (d)
+ maintenance activity [0..1]
+ status of observation [0..1]**
+ exposure of instruments [0..1]** (a)

(a) mandatory for instrumental observations; (b) mandatory if proximity of ref. surface impacts on observation; (c) mandatory if prescribed by best practice; (d) mandatory if different from station/platform

Figure 1. Unified Modeling Language (UML) diagram specifying the WIGOS Metadata Standard (** = code tables expected; [0..1] = optional or conditional elements. Conditional elements become mandatory if a given condition is met. Conditions are referenced in parentheses. Optional elements may be declared mandatory as part of profiling the standard for specific application areas; [1] = mandatory elements. These elements must be reported. In some cases, if no value is available, a nilReason can be reported, which indicates that the metadata are either unknown, not applicable or not available.)

Table 2. Names and definition of elements

Each element is classified as mandatory (M), conditional (C) or optional (O). An asterisk (*) signifies that the element is required for the WMO Rolling Review of Requirements process. A hash sign (#) means that it is acceptable to record a mandatory element with a value of nilReason (which indicates that the metadata are either unknown, not applicable, or not available) in any circumstances or otherwise according to stated specifications (see nilReason specifications in Chapter 7).

Category	ID	Name	Definition	MCO	Phase
1. Observed variable	1-01	Observed variable – measurand	Variable intended to be measured, observed or derived, including the biogeophysical context	M*	I
	1-02	Measurement unit	Real scalar quantity, defined and adopted by convention, with which any other quantity of the same kind can be compared to express the ratio of the two quantities as a number (JCGM, 2012; reference no. 1.9)	C*	I
	1-03	Temporal extent	Time period covered by a series of observations inclusive of the specified date/time indications (measurement history)	M*	I
	1-04	Spatial extent	Typical spatial georeferenced volume covered by the observations	M*	I
	1-05	Representativeness	Spatial extent of the region around the observation of which it is representative	O	II
2. Purpose of observation	2-01	Application area(s)	Context within, or intended application(s) for which the observation is primarily made or which has/have the most stringent requirements	M*	I
	2-02	Programme/network affiliation	The global, regional or national programme(s)/network(s) that the station/platform is associated with	M	I
3. Station/ platform	3-01	Region of origin of data	WMO Region	C*	I
	3-02	Territory of origin of data	Country or territory name of the location of the observation	C*	I
	3-03	Station/platform name	Official name of the station/platform	M	I
	3-04	Station/platform type	A categorization of the type of observing facility at which an observation is made	M*	II
	3-05	Station/platform model	The model of the observing equipment used at the station/platform	M*#	III
	3-06	Station/platform unique identifier	A unique and consistent identifier for an observing facility (station/platform), which may be used as an external point of reference	M*	I
	3-07	Geospatial location	Position in space defining the location of the observing station/platform at the time of observation	M*	I
	3-08	Data communication method	Data communication method between the station/platform and some central facility	O	II
	3-09	Station operating status	Declared reporting status of the station	M	I

Category	ID	Name	Definition	MCO	Phase
4. Environment	4-01	Surface cover	The observed (bio)physical cover on the Earth's surface in the vicinity of the observation	C#	III
	4-02	Surface cover classification scheme	Name and reference or link to document describing the classification scheme	C#	III
	4-03	Topography or bathymetry	The shape or configuration of a geographical feature, represented on a map by contour lines	C#	III
	4-04	Events at observing facility	Description of human action or natural event at the facility or in the vicinity that may influence the observation	O	II
	4-05	Site information	Non-formalized information about the location and surroundings at which an observation is made and that may influence it	O	II
	4-06	Surface roughness	Terrain classification in terms of aerodynamic roughness length	O	III
	4-07	Climate zone	The Köppen climate classification of the region where the observing facility is located. The Köppen-Geiger climate classification scheme divides climates into five main groups (A, B, C, D, E), each having several types and subtypes	O	III
5. Instruments and methods of observation	5-01	Source of observation	The source of the dataset described by the metadata	M	I
	5-02	Measurement/observing method	The method of measurement/observation used	M#	I
	5-03	Instrument specifications	Intrinsic capability of the measurement/observing method to measure the designated element, including range, stability, precision, etc.	C*#	I
	5-04	Instrument operating status	The status of an instrument with respect to its operation	O	III
	5-05	Vertical distance of sensor	Vertical distance of the sensor from a (specified) reference level, such as local ground, deck of a marine platform at the point where the sensor is located, or sea surface	C*	I
	5-06	Configuration of instrumentation	Description of any shielding or configuration/setup of the instrumentation or auxiliary equipment needed to make the observation or to reduce the impact of extraneous influences on the observation	C#	III
	5-07	Instrument control schedule	Description of schedule for calibrations or verification of instrument	C	III
	5-08	Instrument control result	The result of an instrument control check, including date, time, location, standard type and period of validity	C#	III
	5-09	Instrument model and serial number	Details of manufacturer, model number, serial number and firmware version if applicable	C#	III
	5-10	Instrument routine maintenance	A description of maintenance that is routinely performed on an instrument	C#	III
	5-11	Maintenance party	Identifier of the organization or individual who performed the maintenance activity	O	II
	5-12	Geospatial location	Geospatial location of instrument/sensor	C*#	II
	5-13	Maintenance activity	Description of maintenance performed on instrument	O	III
	5-14	Status of observation	Official status of observation	O	III
	5-15	Exposure of instruments	The degree to which an instrument is affected by external influences and reflects the value of the observed variable	C#	II

Category	ID	Name	Definition	MCO	Phase
6. Sampling	6-01	Sampling procedures	Procedures involved in obtaining a sample	O	III
	6-02	Sample treatment	Chemical or physical treatment of sample prior to analysis	O	III
	6-03	Sampling strategy	The strategy used to generate the observed variable	O*	I
	6-04	Sampling time period	The period of time over which a measurement is taken	M#	III
	6-05	Spatial sampling resolution	Spatial resolution refers to the size of the smallest observable object. The intrinsic resolution of an imaging system is determined primarily by the instantaneous field of view of the sensor, which is a measure of the ground area viewed by a single detector element in a given instance in time	M#	II
	6-06	Temporal sampling interval	Time period between the beginning of consecutive sampling periods	M#	III
	6-07	Diurnal base time	Time to which diurnal statistics are referenced	C#	I
	6-08	Schedule of observation	Schedule of observation	M#	I
7. Data processing and reporting	7-01	Data-processing methods and algorithms	A description of the processing used to generate the observation and list of algorithms utilized to derive the resultant value	O	III
	7-02	Processing/analysis centre	Centre at which the observation is processed	O	II
	7-03	Temporal reporting period	Time period over which the observed variable is reported	M*	I
	7-04	Spatial reporting interval	Spatial interval at which the observed variable is reported	C*	I
	7-05	Software/processor and version	Name and version of the software or processor utilized to derive the element value	O	III
	7-06	Level of data	Level of data processing	O	II
	7-07	Data format	Description of the format in which the observed variable is being provided	M	III
	7-08	Version of data format	Version of the data format in which the observed variable is being provided	M	III
	7-09	Aggregation period	Time period over which individual samples/observations are aggregated	M	II
	7-10	Reference time	Time base to which date and time stamps refer	M	II
	7-11	Reference datum	Reference datum used to convert observed quantity to reported quantity	C	I
	7-12	Numerical resolution	Measure of the detail in which a numerical quantity is expressed	O	III
	7-13	Latency (of reporting)	The typical time between completion of the observation or collection of the datum and when the datum is reported	M	III

Category	ID	Name	Definition	MCO	Phase
8. Data quality	8-01	Uncertainty of measurement	Non-negative parameter, associated with the result of a measurement, that characterizes the dispersion of the values that could reasonably be attributed to the observation/measurand	C*#	II
	8-02	Procedure used to estimate uncertainty	A reference or link pointing to a document describing the procedures/algorithms used to derive the uncertainty statement	C*#	II
	8-03	Quality flag	An ordered list of qualifiers indicating the result of a quality control process applied to the observation	M#	II
	8-04	Quality flagging system	Reference to the system used to flag the quality of the observation	M#	II
	8-05	Traceability	Statement defining traceability to a standard, including sequence of measurement standards and calibrations that is used to relate a measurement result to a reference (JCGM, 2012; reference number 2.42)	C*#	II
9. Ownership and data policy	9-01	Supervising organization	Name of organization who owns the observation	M	II
	9-02	Data policy/use constraints	Details relating to the use and limitations surrounding data imposed by the supervising organization	M*	I
10. Contact	10-01	Contact (nominated focal point)	Principal contact (nominated focal point) for resource	M	I

CHAPTER 3. A NOTE ON SPACE AND TIME

It is important to understand that WIGOS metadata are intended to describe an individual observation or a dataset, that is, one or several observations, including where, when, how and even why the observations were made. As a consequence, references to space and time are made in several places throughout the standard.

Figure 2 illustrates the concepts and terms used to describe the temporal aspects of an observation or dataset, including sampling strategy, analysis, data processing and reporting.

The concepts and terms used to describe spatial aspects (i.e. geospatial location) of observations are even more complex (see Figure 3). For example, for ground-based in situ observations, the spatial extent of the observation coincides with the geospatial location of the sensor, which in most cases will be time-invariant and is normally close to the geospatial location of the station/platform where the observation was made. For a satellite-based lidar system, the situation is quite different. Depending on the granularity of metadata desired, the spatial extent of the individual observation may be an individual pixel in space, the straight line probed during an individual laser pulse, or perhaps an entire swath. In any case, the spatial extent of the observation will not coincide with the location of the sensor. The WIGOS Metadata Standard therefore needs to take into account such elements as:

(a) The spatial extent of the observed variable (e.g. atmospheric column above a Dobson spectrophotometer) (see 1-04);

(b) The geospatial location of the station/platform (e.g. radar transmitter/receiver or aircraft position/route) (see 3-07);

(c) The geospatial location of the instrument (e.g. the anemometer is adjacent to a runway) (see 5-05 and 5-12);

(d) The spatial representativeness of the observation (see 1-05).
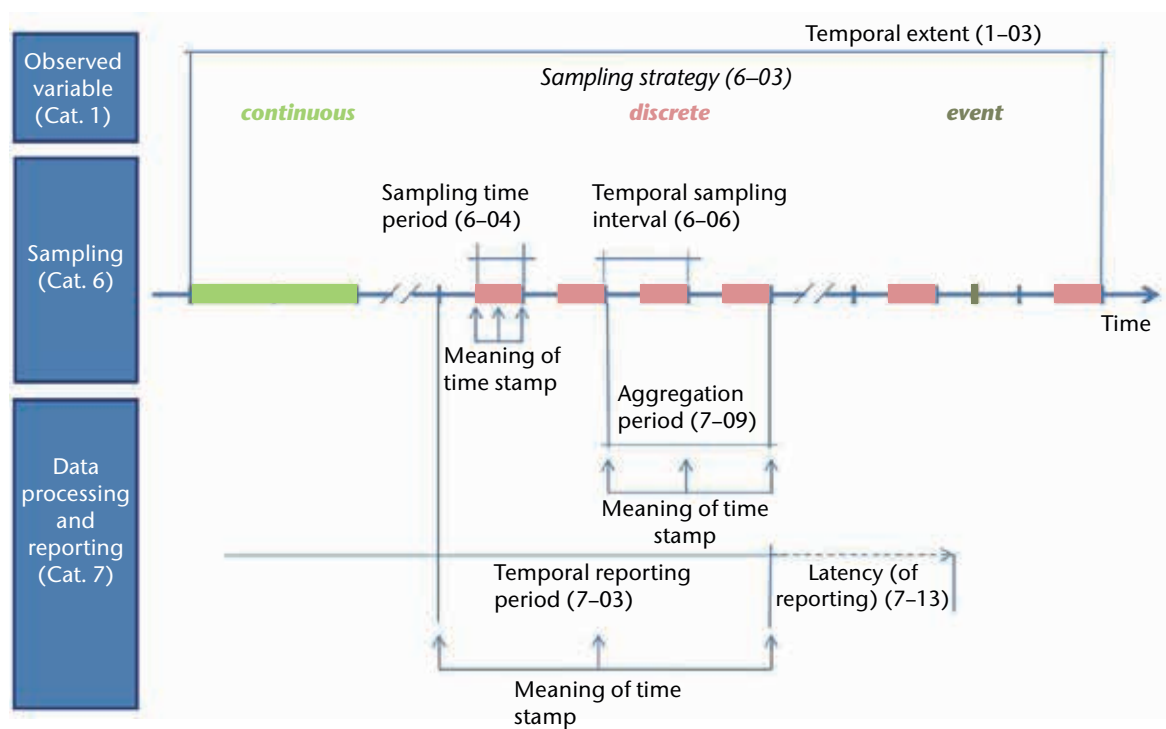
Figure 2. Graphical representation of temporal elements referenced in WIGOS metadata categories
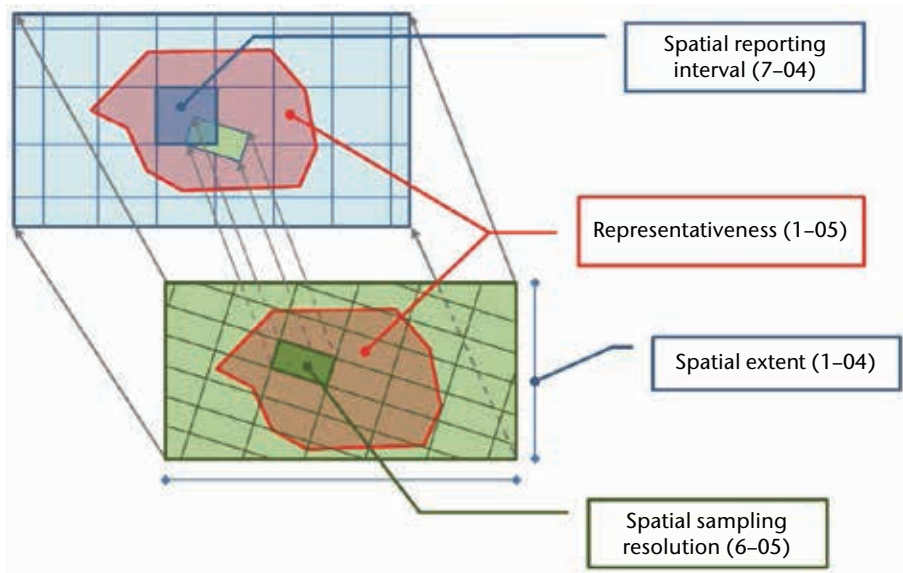
Figure 3. Graphical representation of spatial elements referenced in WIGOS metadata categories

All these are expressed in terms of geospatial location, specifying either a zero-dimensional geographic extent (a point), a one-dimensional geographic extent (a line, either straight or curved), a two-dimensional geographic extent (a plane or other surface), or a three-dimensional geographic extent (a volume).

A station/platform can be:

(a)   Collocated with the observed quantity as for in situ surface observing stations (e.g. an automatic weather station);

(b)   Collocated with the instrument but remote to the observed quantity (e.g. radar);

(c)   Remote from where the instrument may transmit data to the station (e.g. airport surface station where instruments are located across the airport, or a balloon atmosphere profiling station);

(d)   In motion and travelling through the observed medium (e.g. Aircraft Meteorological Data Relay (AMDAR) equipped aircraft);

(e)   In motion and remote to the observed medium (e.g. satellite platform).

An instrument can be:

(a)   Collocated with the observed variable (e.g. surface-temperature sensor);

(b)   Remote to the observed variable (e.g. radar transmitter/receiver);

(c)   In motion but located in the observed medium (e.g. radiosonde);

(d)   In motion and remote from the observed quantity (e.g. satellite-based radiometer);

(e)   Located within a standardized enclosure (e.g. a temperature sensor within a Stevenson screen).

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CHAPTER 4. REPORTING OBLIGATIONS FOR WIGOS METADATA

In accordance with the International Organization for Standardization (ISO), the metadata elements are classified as either mandatory (M), conditional (C) or optional (O).

Mandatory metadata elements shall always be made available. The content of the corresponding fields shall never be empty: either the metadata value, or in specified cases the reason for no-value, shall be made available.

Most of the elements in this standard are considered **mandatory** in view of enabling adequate future use of observations in all WMO application areas. Metadata providers are expected to report mandatory metadata elements, and a formal validation of a metadata record will fail if mandatory elements are not reported. In some cases, if Members cannot provide a mandatory element, the reason for that shall be reported as not applicable, unknown or not available. The motivation for this is that knowledge of the reason why a mandatory metadata element is not available provides more information than not reporting a mandatory element at all. In Table 2 and in the tables of Chapter 7, these cases are indicated with a hash sign (#).

Conditional metadata elements shall be made available when the specified condition or conditions are met, in which case the content of the corresponding fields shall never be empty: either the metadata value or (for elements marked with a hash sign) the reason for no-value, shall be made available. For example, the element "Spatial reporting interval" is classified as conditional because it only applies to remote-sensing observations and mobile platforms. Therefore, the elements in this category should be considered mandatory for remote-sensing and mobile observing systems but not so for surface land stations, for instance.

Optional metadata elements should also be made available. They provide useful information that can help to better understand an observation. In this version of the standard, very few elements are considered optional. Optional elements are likely to be important for a particular community but less so for others.

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CHAPTER 5. TECHNICAL IMPLEMENTATION AND USE OF THE STANDARD

This document is a semantic standard that specifies the elements that exist and that can be recorded and reported. It does not specify how the information shall be encoded or exchanged. However, the following are likely scenarios and important aspects that may help the reader appreciate what lies ahead.

(a)   The most likely implementation will be in Extensible Markup Language (XML), in line with the specifications for WIS metadata and common interoperability standards. Regardless of the final implementation, the full metadata record describing a dataset can be envisioned as a tree with the categories as branches and the individual elements as leaves on these branches. Some branches may occur more than once, for example, a dataset may have been generated using more than one instrument at once, in which case two branches for the instrument category may be required.

(b)   Not all of the elements specified in this document need to be updated at the same frequency. Some elements, such as position of a land-based station, are more or less time-invariant, while others, such as a specific sensor, may change regularly every year. Still other elements, such as environment, may change gradually or rarely but perhaps abruptly. Finally, elements restricting the application of an observation, for example, the forecasting of road conditions, may have to be transmitted with every observation. The implementation of the WIGOS metadata needs to be able to deal with this.

(c)   Not all applications of observations require the full suite of metadata as specified in this standard at any given time. The amount of metadata needed to make adequate use of an observation, for example, for the purpose of issuing a heavy precipitation warning, is much less than for the adequate use of even the same observation for a climatological analysis. On the other hand, the metadata needed for near-real-time applications may also need to be provided in near real time. This is important to realize, as it makes the task of providing WIGOS metadata much more tractable. The implementation of WIGOS metadata needs to be able to cope with vastly different update intervals and with incremental submission of additional metadata to allow the creation of metadata records that are as complete as possible.

(d)   Users will want to obtain and filter datasets according to certain criteria/properties as described within each WIGOS metadata record. This functionality requires either a central repository for WIGOS metadata or full interoperability of the archives collecting WIGOS metadata.

How, then, can these requirements be met? In the case where observations are clearly only used for some near-real-time application and there is evidently no long-term use or re-analysis application to be expected, a profile of the WIGOS Metadata Standard may be specified that declares a specific subset of metadata elements as mandatory. This is depicted schematically in Figure 4.

Importantly, all WIGOS metadata elements (or groups of elements) will have to be time stamped with the time of validity and associated to a unique identifier for a dataset during transmission and for archiving. The specification of time stamps should also include a statement on the use of daylight savings time. Using this approach, increments of a "full" WIGOS metadata record can be transmitted anytime changes occur and updates are deemed necessary. At the archive, the increments can be added to the existing metadata record for that dataset, establishing the full history of a particular observation with time.
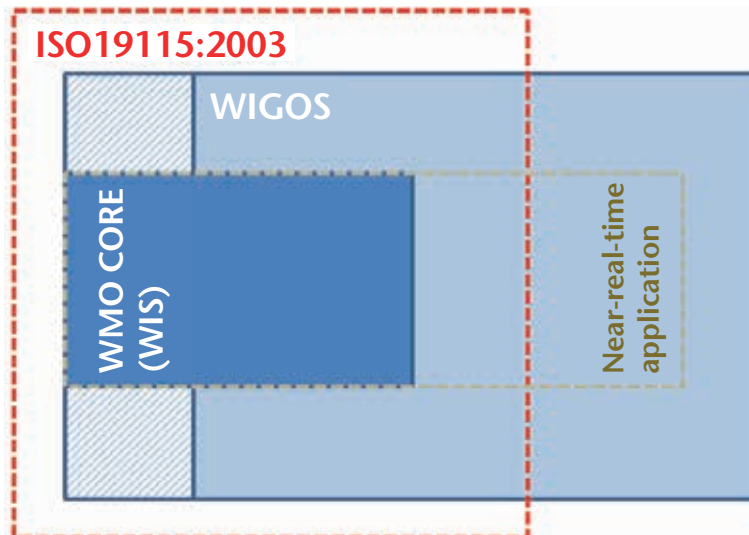
Figure 4. Schematic of the relationship of WIS and WIGOS metadata and the scope of the ISO 19115 standard (ISO, 2003). The WMO Core is a profile of ISO 19115. WIGOS metadata exceed the scope of the ISO 19115 standard. A possible profile (subset) of WIGOS metadata elements for some specific near-real-time application is also shown.

CHAPTER 6. ADOPTION THROUGH A PHASED APPROACH

Making available WIGOS metadata will generate substantial benefits for Members, but developing the capacity to make available these metadata also requires a substantial effort on the part of (meta)data providers. To help Members comply with obligations, guidance material will be developed and provided.

Moreover, obligations will be enforced in phases in order to allow Members sufficient time to develop the capacity to comply. Balancing the effort required to generate and make available the metadata elements, and the need to have this information to make adequate use of observations, implementation will proceed through three phases as shown in Table 3. Importantly, elements required by the end of Phase I are either listed as mandatory elements in *Weather Reporting* (WMO-No. 9), Volume A, or are of critical importance for the Observing Systems Capability Analysis and Review (OSCAR) tool of the WIGOS Information Resource, and are considered of benefit for all application areas. Phase II adds elements recognized to be more challenging for Members, but the knowledge of which is still of rather immediate need for the adequate use of observations, in particular for assessing the quality of observations. Phase III adds the remaining elements specified in this version of the standard.

Elements emerging as being important for specific application areas or observing programmes will be added to the standard as it evolves.

Table 3. List of elements specified in the WIGOS Metadata Standard, and implementation phases for Members

Category	Phase I	Phase II	Phase III
	2016	*2017–2018*	*2019–2020*
1. Observed variable	**1-01 Observed variable – measurand (M)**	1-05 Representativeness (O)	
	1-02 Measurement unit (C)		
	1-03 Temporal extent (M)		
	1-04 Spatial extent (M)		
2. Purpose of observation	**2-01 Application area(s) (M)**		
	2-02 Programme/ network affiliation (M)		
3. Station/ platform	*3-01 Region of origin of data (C)*	**3-04 Station/platform type (M)**	**3-05 Station/platform model (M)**
	3-02 Territory of origin of data (C)	3-08 Data communication method (O)	
	3-03 Station/platform name (M)		
	3-06 Station/platform unique identifier (M)		
	3-07 Geospatial location (M)		
	3-09 Station operating status (M)		

Category	Phase I	Phase II	Phase III
	2016	2017–2018	2019–2020
4. Environment		4-04 Events at observing facility (O)	4-01 Surface cover (C)
		4-05 Site information (O)	4-02 Surface cover classification scheme (C)
			4-03 Topography or bathymetry (C)
			4-06 Surface roughness (O)
			4-07 Climate zone (O)
5. Instruments and methods of observation	**5-01 Source of observation (M)**	5-11 Maintenance party (O)	5-04 Instrument operating status (O)
	5-02 Measurement/ observing method (M)	5-12 Geospatial location (C)	5-06 Configuration of instrumentation (C)
	5-03 Instrument specifications (C)	5-15 Exposure of instruments (C)	5-07 Instrument control schedule (C)
	5-05 Vertical distance of sensor (C)		5-08 Instrument control result (C)
			5-09 Instrument model and serial number (C)
			5-10 Instrument routine maintenance (C)
			5-13 Maintenance activity (O)
			5-14 Status of observation (O)
6. Sampling	6-03 Sampling strategy (O)	**6-05 Spatial sampling resolution (M)**	6-01 Sampling procedures (O)
	6-07 Diurnal base time (C)		6-02 Sample treatment (O)
	6-08 Schedule of observation (M)		**6-04 Sampling time period (M)**
			6-06 Temporal sampling interval (M)
7. Data processing and reporting	**7-03 Temporal reporting period (M)**	7-02 Processing/analysis centre (O)	7-01 Data-processing methods and algorithms (O)
	7-04 Spatial reporting interval (C)	7-06 Level of data (O)	7-05 Software/processor and version (O)
	7-11 Reference datum (C)	**7-09 Aggregation period (M)**	**7-07 Data format (M)**
		7-10 Reference time (M)	**7-08 Version of data format (M)**
			7-12 Numerical resolution (O)
			7-13 Latency (of reporting) (M)
8. Data quality		8-01 Uncertainty of measurement (C)	
		8-02 Procedure used to estimate uncertainty (C)	
		8-03 Quality flag (M)	
		8-04 Quality flagging system (M)	
		8-05 Traceability (C)	

Category	Phase I	Phase II	Phase III
	2016	2017–2018	2019–2020
9. Ownership and data policy	**9-02 Data policy/use constraints (M)**	**9-01 Supervising organization (M)**	
10. Contact	**10-01 Contact (nominated focal point) (M)**		

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CHAPTER 7. DETAILED SPECIFICATION OF WIGOS METADATA ELEMENTS

Each element is classified as mandatory (M), conditional (C) or optional (O). An asterisk (*) signifies that the element is required for the WMO Rolling Review of Requirements process. A hash sign (#) means that it is acceptable to record a mandatory element with a value of nilReason (which indicates that the metadata are either unknown, not applicable or not available) in any circumstances or otherwise according to stated specifications.

CATEGORY 1: OBSERVED VARIABLE

Specifies the basic characteristics of the observed variable and the resulting datasets. It includes an element describing the spatial representativeness of the observation as well as the biogeophysical compartment the observation describes.

ID	Name	Definition	Note or example	Code table	MCO
1-01	Observed variable – measurand	Variable intended to be measured, observed or derived, including the biogeophysical context	*(ISO 19156:2011) NOTE 1*: In conventional measurement theory the term "measurement" is used. However, a distinction between measurement and category-observation has been adopted in more recent work, so the term "observation" is used for the general concept. "Measurement" may be reserved for cases where the result is a numeric quantity. *NOTE 2*: The biogeophysical context is expressed in terms of domain, subdomain/matrix, and layer, and variables are organized hierarchically using these dimensions. Relevant domains, matrices and layers include atmosphere, aerosol, lake, river, ocean, soil, cloud water, aerosol particulate phase, land surface, troposphere, upper troposphere/lower stratosphere, space, etc. *EXAMPLES*: (a) In hydrology, this would typically be stage or discharge; (b) Present weather; (c) Air temperature near the surface; (d) CO_2 mixing ratio in the atmosphere.	1-01	M* (Phase I)

ID	Name	Definition	Note or example	Code table	MCO
1-02	Measurement unit	Real scalar quantity, defined and adopted by convention, with which any other quantity of the same kind can be compared to express the ratio of the two quantities as a number (JCGM, 2012; reference no. 1.9)	NOTE 1: Measurement units are designated by conventionally assigned names and symbols. (JCGM, 2012; reference no. 1.9) NOTE 2: Measurement units of quantities of the same quantity dimension may be designated by the same name and symbol even when the quantities are not of the same kind. For example, joule per kelvin and J/K are respectively the name and symbol of both a measurement unit of heat capacity and a measurement unit of entropy, which are generally not considered to be quantities of the same kind. However, in some cases special measurement unit names are restricted to be used with quantities of a specific kind only. For example, the measurement unit 'second to the power minus one' (1/s) is called hertz (Hz) when used for frequencies and becquerel (Bq) when used for activities of radionuclides. (JCGM, 2012; reference no. 1.9) NOTE 3: Measurement units of quantities of dimension one are numbers. In some cases these measurement units are given special names, e.g. radian, steradian, and decibel, or are expressed by quotients such as millimole per mole equal to 10^{-3} and microgram per kilogram equal to 10^{-9}. (JCGM, 2012; reference no. 1.9) NOTE 4: For a given quantity, the short term "unit" is often combined with the quantity name, such as "mass unit" or "unit of mass". (JCGM, 2012; reference no. 1.9) EXAMPLE: In hydrology, this would typically be m for stage or m^3/s for discharge.	1-02	C* (Phase I)
1-03	Temporal extent	Time period covered by a series of observations inclusive of the specified date/time indications (measurement history)	NOTE 1: The temporal extent is defined based on the beginning and end dates of observations. NOTE 2: If the data are still being added to, omit the end date (but specify a beginning date). NOTE 3: If there are gaps in the data collection (e.g. 1950–1955, then collection resumes 1960–present), then the first date recorded should be the earliest date and the last the most recent, ignoring the gap. EXAMPLES: (a) Surface temperature at the station Säntis has been observed since 1 September 1882; (b) The CO_2 record at Mauna Loa extends from 1958 to today; (c) Continuous, one-hourly aggregates are available from the World Data Centre for Greenhouse Gases for the period 1 January 1974 to 31 December 2011.		M* (Phase I)

ID	Name	Definition	Note or example	Code table	MCO
1-04	Spatial extent	Typical spatial georeferenced volume covered by the observations	*NOTE 1*: The spatial extent of an observed quantity can be a zero-, one-, two- or three-dimensional feature and will be expressed in terms of a series of geospatial locations describing a geometric shape. In the case of space-based observations, the spatial coverage should be stated in terms of global (e.g. for low Earth orbits, characteristics like swath width and repeat cycle), disk (for geostationary Earth orbits), vertical (for soundings), etc. *NOTE 2*: A zero-dimensional geospatial location of an observation implies either an in situ (point) observation or, by convention, a column-averaged quantity above the specified geospatial location in nadir. One-dimensional geospatial location of an observation implies a distribution/profile of a quantity along a trajectory (e.g. a straight line from the ground up with a given zenith angle). A two-dimensional geospatial location of an observation implies an area or hypersurface (e.g. a radar image or a satellite pixel of a property near the surface). A three-dimensional geospatial location of an observation implies a volume-averaged quantity (e.g. a radar pixel in 3D-space). *EXAMPLES*: (a) Air temperature at a surface observing site: Sydney Airport, New South Wales, Australia: lat. 33.9465°N, lon. 151.1731°E, alt. 6.0 m above mean sea level (amsl); (b) The projected area or volume of the cone around a particular weather radar with a maximum range of 370 km (radar reflectivity) and 150 km (Doppler); to be expressed as a geometric shape; (c) Three-dimensional grid of radar pixels; (d) For infrared and visible imagery by meteorological satellite (sun-synchronous): global; (e) For nadir sounding: atmospheric column above ocean; (f) The NASA Aura satellite (705 km altitude) has a 16-day (233 orbit) repeat cycle; (g) River discharge by gauge: size and geometric shape of a river catchment.	Free text, which could be comple-mented by one or more URLs	M* (Phase I)

ID	Name	Definition	Note or example	Code table	MCO
1-05	Representativeness	Spatial extent of the region around the observation of which it is representative	NOTE: The representativeness of an observation is the degree to which it describes the value of the variable needed for a specific purpose. Therefore, it is not a fixed quality of any observation, but results from joint appraisal of instrumentation, measurement interval and exposure against the requirements of some particular application (WMO-No. 8; see WMO, 2014a). Representativeness of an observed value describes the concept that the result of an observation made at a given geospatial location would be compatible with the result of other observations of the same quantity at other geospatial locations. In statistics, the term describes the notion that a sample of a population allows an adequate description of the whole population. "Assessing representativeness can only be accomplished in the context of the question the data [or observations] are supposed to address. In the simplest terms, if the data [or observations] can answer the question, it is representative" (Ramsey and Hewitt, 2005). The representativeness of an environmental observation depends on the spatio-temporal dynamics of the observed quantity (Henne et al., 2010). Representativeness of an observation can sometimes be specified quantitatively, in most cases qualitatively, based on experience or heuristic arguments.	1-05	O (Phase II)

Condition:

{1-02} Mandatory for variables that are measured, as opposed to classified

CATEGORY 2: PURPOSE OF OBSERVATION

Specifies the main application area(s) of the observation and the observing programme(s) and networks the observation is affiliated to.

ID	Name	Definition	Note or example	Code table	MCO
2-01	Application area(s)	Context within, or intended application(s) for which the observation is primarily made or which has/have the most stringent requirements	*NOTE*: Many observations serve more than one purpose, meeting the requirements of various applications areas. In such cases, the application area for which the station or platform was originally established should be listed first.	2-01	M* (Phase I)
2-02	Programme/ network affiliation	The global, regional or national programme(s)/ network(s) that the station/platform is associated with	*EXAMPLES (ensure that full names are referenced in code table)*: (a) GCOS Upper-air Network (GUAN); (b) Aircraft Meteorological Data Relay (AMDAR); (c) Global Atmosphere Watch (GAW); (d) Regional Basic Synoptic Network (RBSN); (e) WMO Hydrological Observing System (WHOS).	2-02	M (Phase I)

CATEGORY 3: STATION/PLATFORM

Specifies the observing facility, including fixed station, moving equipment or remote-sensing platform, at which the observation is made.

ID	Name	Definition	Note or example	Code table	MCO
3-01	Region of origin of data	WMO Region	*NOTE*: WMO divides Member countries into six regional associations responsible for the coordination of meteorological, hydrological and related activities within their respective Regions.	3-01	C* (Phase I)
3-02	Territory of origin of data	Country or territory name of the location of the observation	*EXAMPLE*: Australia	3-02	C* (Phase I)
3-03	Station/ platform name	Official name of the station/ platform	*EXAMPLES*: (a) Mauna Loa (b) South Pole		M (Phase I)

ID	Name	Definition	Note or example	Code table	MCO
3-04	Station/ platform type	A categorization of the type of observing facility at which an observation is made	*NOTE*: See code table according to INSPIRE, 2013 (SpecialisedEMFTypeValue, p. 33).	3-04	M* (Phase II)
3-05	Station/ platform model	The model of the observing equipment used at the station/platform	*EXAMPLES*: (a) Landsat-8 is a satellite platform/station model; (b) Almos automatic weather station is a land station model; (c) Airbus A340-600 is an aircraft model.		M*# (Phase III)
3-06	Station/ platform unique identifier	A unique and consistent identifier for an observing facility (station/platform), which may be used as an external point of reference	*NOTE*: A globally unique identifier assigned by WMO for a station. Where a station has multiple identifiers, there must be a way of recording that they are synonyms. This is to be defined according to WMO guidelines. *EXAMPLE*: Ship: Call sign		M* (Phase I)
3-07	Geospatial location	Position in space defining the location of the observing station/platform at the time of observation	*NOTE 1*: Required for fixed stations and stations following a pre-determined trajectory (e.g. satellites) *NOTE 2*: The elevation of a fixed terrestrial station is defined as the height above sea level of the ground on which the station stands ("Hha" in *Weather Reporting* (WMO-No. 9), Volume A). *NOTE 3*: The geospatial location can be a zero-, one-, two-, or three-dimensional feature. *NOTE 4*: Geographical coordinates can be specified in decimal degrees. Latitudes are specified with reference to the Equator, with positive sign for latitudes north of the Equator, and negative sign for latitudes south of the Equator. Longitudes are specified with reference to the Greenwich meridian, with positive sign for longitudes east of Greenwich, and negative sign for meridians west of Greenwich. Elevation is a signed number specified in some distance measure (e.g. metres) relative to a reference elevation, with positive sign in the direction away from the Earth centre. *NOTE 5*: The latitudinal and longitudinal positions of a station referred to in the World Geodetic System 1984 (WGS-84) Earth Geodetic Model 1996 (EGM96) must be recorded to a resolution of at least 0.001 decimal degrees (see the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part I, Chapter 1, 1.3.3.2).	11-01 11-02	M* (Phase I)

ID	Name	Definition	Note or example	Code table	MCO
			NOTE 6: This element comprises three entities: the coordinates (lat/long/alt), the geopositioning method (code table 11-01) which produced the coordinates, as well as the geospatial reference system (code table 11-02) used. *EXAMPLES*: (a) The station Jungfraujoch is located at 46.54749°N, 7.98509°E (3 580.00 m amsl). The reference system is WGS-84; (b) Voluntary Observing Ship route: WMO Regional Association V, sub-area 6 (R56); (c) (Geostationary satellite) Meteosat-8 (MSG-1), 3.6°E; (d) (Sun-synchronous satellite) NOAA-19, height 870 km, local solar time 1339; (e) Weather Watch Radar: Warruwi, Northern Territory, Australia – 11.6485°N, 133.3800°E, height 19.1 m amsl; (f) River discharge gauge: Warrego River at Cunnamulla weir, 28.1000°S, 145.6833°E, height 180 m amsl.		
3-08	Data communication method	Data communication method between the station/platform and some central facility	*EXAMPLES*: (a) Inmarsat-C (b) Argos (c) Cellular (d) Globalstar (e) Geostationary Meteorological Satellite (GMS), (data collection platforms) (f) Iridium (g) Orbcomm (h) Very small aperture terminal (VSAT) (i) Landline telephone (j) Mail	3-08	O (Phase II)
3-09	Station operating status	Declared reporting status of the station	*NOTE*: Refer to the code table.	3-09	M (Phase I)

Conditions:

{3-01, 3-02} Mandatory for fixed land-based stations, optional for mobile stations

CATEGORY 4: ENVIRONMENT

Describes the geographical environment within which the observation is made. It also provides an unstructured element for additional meta-information that is considered relevant for adequate use of the observations and that is not captured anywhere else in this standard.

ID	Name	Definition	Note or example	Code table	MCO
4-01	Surface cover	The observed (bio)physical cover on the Earth's surface in the vicinity of the observation	NOTE 1: To be applied to three different geographic scales of the vicinity of the observation, namely, horizontal radii of < 100 m, 100 m to 3 km, and 3 km to 100 km. NOTE 2: Surface cover or land cover is distinct from land use despite the two terms often being used interchangeably. Land use is a description of how people utilize the land and socioeconomic activity – urban and agricultural land uses are two of the most commonly known land use classes. At any one point or place, there may be multiple and alternate land uses, the specification of which may have a political dimension. (Wikipedia, 2013) NOTE 3: There are various classification methods for land cover. The Moderate-resolution Imaging Spectroradiometer (MODIS) product MCD12Q1 provides five different classifications on 500 m resolution grid (see LP DAAC, 2017). These include the IGBP (International Geosphere–Biosphere Programme), UMD (University of Maryland), LAI/fPAR (leaf area index/fraction of absorbed photosynthetically active radiation), NPP (Net Primary Production) and PFT (Plant Functional Type) classifications. NOTE 4: An alternative approach is the Land Cover Classification System (LCCS) (Di Gregorio, 2005) adopted by the Food and Agriculture Organization of the United Nations. Translation of other systems to LCCS has been explored by Herold et al., 2009. Eight major surface cover types are identified during the first, dichotomous classification phase. These are refined in a subsequent so-called modular-hierarchical phase, in which surface cover classes are created by the combination of sets of pre-defined classifiers. These classifiers are tailored to each of the eight major surface cover types. This process can be supported by software or manually using a field log sheet (http:// commons.wikimedia.org/wiki/File:LCCS_field_protokoll.png).	4-01	C# (Phase III)
4-02	Surface cover classification scheme	Name and reference or link to document describing the classification scheme	EXAMPLES: IGBP, UMD, LAI/fPAR, NPP, PFT, or LCCS (recommended implementation as a Uniform Resource Identifier (URI) pointing to the code table)	4-02	C# (Phase III)

ID	Name	Definition	Note or example	Code table	MCO
4-03	Topography or bathymetry	The shape or configuration of a geographical feature, represented on a map by contour lines	*NOTE 1*: Topography shall be formally expressed with the four elements: local topography, relative elevation, topographic context, and altitude/depth. *NOTE 2*: The term "altitude" is used for elevations above mean sea level. The term "depth" is used for elevations below mean sea level. *EXAMPLES (can be converted into entries of the code table)*: (a) A ridge at low relative elevation within valleys of middle altitude; (b) A depression within plains of very low depth.	4-03	C# (Phase III)
4-04	Events at observing facility	Description of human action or natural event at the facility or in the vicinity that may influence the observation	*NOTE 1*: This information may be frequently changing (for example, ocean debris impacting buoys). *NOTE 2*: The start and end time/date of the event should be included.	4-04, free text or a URL	O (Phase II)
4-05	Site information	Non-formalized information about the location and surroundings at which an observation is made and that may influence it	*NOTE*: In hydrology, this entails a description and dating of activities occurring in the basin that can affect the observed discharge, such as construction of a regulation structure upstream of the gauging location that significantly affects the hydrological regime, inter-basin diversion of water into or from the basin upstream of the gauging location, significant change in consumptive use, surface cover, or land use. *EXAMPLES*: Maps, plans, photographs, descriptions and other unique site information that is difficult to express in words or that cannot easily be quantified	Free text and/or URL(s)	O (Phase II)
4-06	Surface roughness	Terrain classification in terms of aerodynamic roughness length	*NOTE*: The terrain classification (Davenport and Wieringa) as mentioned in the *Guide to Meteorological Instruments and Methods of Observation*, Part I, annex to Chapter 5	4-06	O (Phase III)
4-07	Climate zone	The Köppen climate classification of the region where the observing facility is located	*NOTE*: The Köppen-Geiger climate classification scheme divides climates into five main groups (A, B, C, D, E), each having several types and subtypes.	4-07	O (Phase III)

Condition:

{4-01, 4-02, 4-03} Mandatory for surface-based observations

NilReason specifications:

{4-01, 4-02, 4-03} For hydrologic observations, specifying a nilReason value is acceptable

CATEGORY 5: INSTRUMENTS AND METHODS OF OBSERVATION

Specifies the method of observation and describes characteristics of the instrument(s) used to make the observation. If multiple instruments are used to generate the observation, then this category should be repeated.

ID	Name	Definition	Note or example	Code table	MCO
5-01	Source of observation	The source of the dataset described by the metadata	*NOTE*: Refer to the code table.	5-01	M (Phase I)
5-02	Measurement/ observing method	The method of measurement/ observation used	*EXAMPLES*: (a) Temperature can be determined using different principles: liquid in glass, mechanical, electrical resistance, thermistor, thermocouple. Likewise, humidity is determined in AMDAR as a mass mixing ratio. (b) Several chemical variables can be determined using infrared absorption spectroscopy. (c) In hydrology, stage would be observed using a staff gauge, electric tape, pressure transducer, gas bubbler, or acoustics. (d) Examples of satellite observation principles: Cross-nadir scanning infrared sounder, microwave imaging/sounding radiometer, or conical scanning. (e) Visual observation of weather, cloud type.	5-02	M# (Phase I)
5-03	Instrument specifications	Intrinsic capability of the measurement/observing method to measure the designated element, including range, stability, precision, etc.	*NOTE 1*: The metadata record can be "not available". *NOTE 2*: Includes the upper limit of operational range and the lower limit of operational range. For space-based observations, the channels and their frequencies should be included. *EXAMPLES*: (a) Barometer measurement range 800–1 100 hPa (i.e. unsuitable for some mountain ranges, Mt Everest ~ 300 hPa); (b) Maximum distance a human observer can observe given the topography.	A URL is acceptable in case of space-based observa-tions	C*# (Phase I)
5-04	Instrument operating status	The status of an instrument with respect to its operation	*NOTE*: To be recorded by data providers for each individual observation	5-04	O (Phase III)

ID	Name	Definition	Note or example	Code table	MCO
5-05	Vertical distance of sensor	Vertical distance of the sensor from a (specified) reference level, such as local ground, deck of a marine platform at the point where the sensor is located, or sea surface	*NOTE 1*: The reference surface (generally a surface which will strongly influence the observation) must be specified. *NOTE 2*: Away from centre of Earth, use positive values. Negative values indicate position below reference surface. *EXAMPLES*: (a) Air temperature: height of the temperature sensor is 1.50 m above ground surface (station level); (b) Surface wind: 10.0 m above ground surface (station level); (c) Soil temperature: 0.50 m below soil surface; (d) Ship: visual observation height: 22.0 m amsl; (e) Weather Watch Radar: Warruwi, Australia, 24.30 m above ground surface; (f) Transmissometer: 2.55 m above runway surface; (g) Depth of buoy relative to lowest astronomical tide; (h) Pressure sensor: vertical distance above mean sea level.		C* (Phase I)
5-06	Configuration of instrumentation	Description of any shielding or configuration/setup of the instrumentation or auxiliary equipment needed to make the observation or to reduce the impact of extraneous influences on the observation	*NOTE*: A URL could be provided in case of space-based observations. *EXAMPLES (for surface-based observations)*: (a) Shelter, temperature control (b) Internal volume: (m^3) (c) Aspirated: (natural/forced/na) (d) Aspiration rate: (m^3s^{-1}) (e) Shielding from: (radiation/precipitation/wind)		C# (Phase III)
5-07	Instrument control schedule	Description of schedule for calibrations or verification of instrument	*NOTE*: For space-based observations, this applies only to major changes; for very frequent changes to parameters, a specific link to the external source should be provided. *EXAMPLE*: Every year in first week of February		C (Phase III)

ID	Name	Definition	Note or example	Code table	MCO
5-08	Instrument control result	The result of an instrument control check, including date, time, location, standard type and period of validity	*NOTE 1*: For the result of the control check, code table 5-08 is to be used. *NOTE 2*: Record even if "not available". *NOTE 3*: Information should contain at least the following elements: (a) Standard type (international, primary, secondary, reference, working, transfer, travelling, collective) (b) Standard name (free text) (c) Standard reference (serial number or equivalent) (d) Within verification limit (Y/N) *NOTE 4*: Can be implemented with a URI pointing to a document containing this information. *NOTE 5*: For space-based observations, this applies only to major changes; for very frequent changes to parameters, a specific link to the external source should be provided. *EXAMPLE*: 02.07.2014 1530 UTC, travelling standard, \<name>, \<S/N>, field calibration, result: in calibration, validity: 4 years	5-08	C# (Phase III)
5-09	Instrument model and serial number	Details of manufacturer, model number, serial number and firmware version if applicable	*NOTE 1*: Record "not available". *NOTE 2*: Use the following formats: (a) Instrument manufacturer (free text) (b) Instrument model (free text) (c) Instrument serial number (free text) (d) Firmware version (free text) *EXAMPLE*: Vaisala PTB330B G2120006		C# (Phase III)
5-10	Instrument routine maintenance	A description of maintenance that is routinely performed on an instrument	*EXAMPLE*: Daily cleaning of a radiation sensor		C# (Phase III)
5-11	Maintenance party	Identifier of the organization or individual who performed the maintenance activity			O (Phase II)

ID	Name	Definition	Note or example	Code table	MCO
5-12	Geospatial location	Geospatial location of instrument/sensor	*NOTE 1*: Geographic location of instrument, such as airfield anemometer or transmissometer. *NOTE 2*: This element comprises three entities: the coordinates (lat/long/alt), the geopositioning method (code table 11-01) which produced the coordinates, as well as the geospatial reference system (code table 11-02) used. *EXAMPLES*: (a) Melbourne airport, Australia (east anemometer) – 37.6602°N, 144.8443°E, 122.00 m amsl; (b) Relative position of wind sensor aboard ship; (c) 30 km upstream of river mouth.	11-01 11-02	C*# (Phase II)
5-13	Maintenance activity	Description of maintenance performed on instrument	*NOTE*: A log of actual maintenance activity, both planned and corrective		O (Phase III)
5-14	Status of observation	Official status of observation	*NOTE*: A binary flag	5-14	O (Phase III)
5-15	Exposure of instruments	The degree to which an instrument is affected by external influences and reflects the value of the observed variable	*NOTE*: The exposure of an instrument results from joint appraisal of the environment, measurement interval and exposure against the requirements of some particular application. Expressed in terms of the code table.	5-15	C# (Phase II)

Conditions:

{5-03, 5-07, 5-08, 5-09, 5-10, 5-15} Mandatory for instrumental observations

{5-05} Mandatory for instrumental observations and if proximity of reference surface impacts on observation

{5-06} Mandatory for instrumental observations and if prescribed by best practice

{5-12} Mandatory for instrumental observations and if different from station/platform

NilReason specifications:

{5-06, 5-10, 5-12, 5-15} A nilReason = "not applicable" is acceptable for space-based observations

CATEGORY 6: SAMPLING

Specifies how sampling and/or analysis are used to derive the reported observation or how a specimen is collected.

ID	Name	Definition	Note or example	Code table	MCO
6-01	Sampling procedures	Procedures involved in obtaining a sample	*EXAMPLES*: (a) Temperature measurements are made using an XYZ thermometer and reported results are an average of 10 measurements made in a given hour. (b) Aerosols may be sampled with an inlet with size-cutoff at 2.5 μm and be deposited on a teflon filter. (c) Manual reading of a liquid-in-glass thermometer every three hours. (d) As an exception, an observer may observe the state of the sky from home rather than at the station during night. (e) Rainfall is accumulated during the whole weekend and distributed evenly over these two days.	A URL in case of space-based observa-tions	O (Phase III)
6-02	Sample treatment	Chemical or physical treatment of sample prior to analysis	*EXAMPLES*: Homogenization, milling, mixing, drying, sieving, heating, melting, freezing, evaporation		O (Phase III)
6-03	Sampling strategy	The strategy used to generate the observed variable	*EXAMPLES*: (a) Continuous: global radiation, atmospheric pressure, or continuous ozone monitoring with an ultraviolet monitor; (b) Discrete: gas chromatographic analysis of carbon monoxide, radar rainfall; (c) Event: grab water samples, flask sampling of air.	6-03 or a URL for space-based observa-tions	O* (Phase I)
6-04	Sampling time period	The period of time over which a measurement is taken	*NOTE*: Includes the sampling time period, plus the meaning of time stamp (11–03)	11-03	M# (Phase III)
6-05	Spatial sampling resolution	Spatial resolution refers to the size of the smallest observable object. The intrinsic resolution of an imaging system is determined primarily by the instantaneous field of view of the sensor, which is a measure of the ground area viewed by a single detector element in a given instance in time.	*NOTE*: A representative value (L × L × L), where "L" is a length, is expected, according to the dimension (1-D, 2-D or 3-D), but free text is allowed for the characteristics to be explained. *EXAMPLES*: (a) The sample is a point in space or a very small volume resembling a point, e.g. a temperature sampled by a thermocouple element: no size to be reported; (b) The sample is a line, either straight (e.g. a line of sight of a differential optical absorption spectroscopy instrument) or curved (e.g. the humidity sampled by an aircraft in flight): the length of the line is to be reported; (c) The sample is an area, either rectangular or of any other shape, e.g. the reach of a radar image: the "length x length" of the area is to be reported; (d) The sample is a volume, e.g. a water sample or a well-mixed volume of air sampled by flask: the "length x length x length" of the volume is to be reported.		M# (Phase II)

ID	Name	Definition	Note or example	Code table	MCO
6-06	Temporal sampling interval	Time period between the beginning of consecutive sampling periods	*EXAMPLES*: (a) Surface winds sampled every 0.25 seconds (frequency 4 Hz) (WMO-No. 8; see WMO, 2014*a*); (b) Surface winds measured once per hour; (c) Barometric pressure measured once every 6 minutes; (d) Water column height measured every 15 seconds; (e) Water temperature measured once per hour. For each example, time stamp indicates "end of period".		M# (Phase III)
6-07	Diurnal base time	Time to which diurnal statistics are referenced	*EXAMPLES*: (a) Rainfall observation is accumulated for 24 hours up until 0700Z, the diurnal base time here is 0700Z. (b) Daily temperature maxima refer to the period beginning at 0600 local time, the diurnal base time here is 1200Z (GMT-6).		C# (Phase I)
6-08	Schedule of observation	Schedule of observation	*EXAMPLES*: (a) AMDAR profiling observations are available from Zurich airport, Switzerland, between 0600 and 1200 local time; (b) Radiosondes are collected at a particular station from January to August on weekdays at 0000Z and 1200Z.	Free text	M# (Phase I)

Condition:

{6-07} Mandatory for observations collected during 24-hour period(s)

NilReason specifications:

{6-05, 6-06, 6-07, 6-08} A nilReason = "not applicable" is acceptable for space-based observations

CATEGORY 7: DATA PROCESSING AND REPORTING

Specifies how raw data are transferred into the observed variables and reported to the users.

ID	Name	Definition	Note or example	Code table	MCO
7-01	Data-processing methods and algorithms	A description of the processing used to generate the observation and list of algorithms utilized to derive the resultant value	*NOTE*: In hydrology, this would be the equation(s) defining the rating curve and any shifts or corrections applied to the data or the curve. *EXAMPLE*: Radiation correction and calculation of geopotential height for upper-air soundings	Free text or a URL	O (Phase III)
7-02	Processing/ analysis centre	Centre at which the observation is processed.	*EXAMPLES*: (a) Chemical analysis centre (b) AMDAR processing centre (c) National Hydrological Service office		O (Phase II)
7-03	Temporal reporting period	Time period over which the observed variable is reported	*NOTE*: Includes the temporal reporting interval, plus the meaning of time stamp *EXAMPLES*: (a) Hourly (b) Daily (c) Monthly (d) Seasonal (e) Event-based (f) 80-second interval during the day In each case, the meaning, that is, the beginning, middle or end of the period, is indicated.	11-03	M* (Phase I)
7-04	Spatial reporting interval	Spatial interval at which the observed variable is reported	*NOTE*: For most remote-sensing observations, this will be redundant with element 6-05. *EXAMPLES*: (a) An observation from a satellite may be reported with a spatial resolution of 10 km x 20 km; (b) An aircraft may sample every 1 km along its trajectory (see 6-05), but may report at a spatial interval of 10 km.		C* (Phase I)
7-05	Software/ processor and version	Name and version of the software or processor utilized to derive the element value	*EXAMPLES*: (a) Avionics version (b) Retrieval algorithm version (c) Meteorological, Climatological and Hydrological (MCH) Database Management System version 25.10.2013		O (Phase III)
7-06	Level of data	Level of data processing	*NOTE*: Pre- or post-processing	7-06	O (Phase II)

ID	Name	Definition	Note or example	Code table	MCO
7-07	Data format[1]	Description of the format in which the observed variable is being provided	EXAMPLES: (a) American Standard Code for Information Interchange (ASCII) (b) BUFR (c) NASA Ames (d) Hierarchical Data Format (HDF) (e) XML (f) AMDAR (g) Comma-separated (CSV) (h) Tab-separated (.txt) (i) MCH (for interchange)	7-07	M (Phase III)
7-08	Version of data format[1]	Version of the data format in which the observed variable is being provided	EXAMPLES: (a) FM 12–XIV Ext. SYNOP (b) FM 42-XI Ext. AMDAR (c) FM 94-XIV BUFR Version 20.0.0 (d) Radar: ODIM_H5		M (Phase III)
7-09	Aggregation period	Time period over which individual samples/ observations are aggregated	NOTE: Includes the aggregation interval, plus the meaning of time stamp EXAMPLES: (a) Five-minute mean, meaning of time stamp is "middle of period"; (b) Daily maximum, meaning of time stamp is "end of period"; (c) Event-based, meaning of time stamp is "beginning of period".	11-03	M (Phase II)
7-10	Reference time	Time base to which date and time stamps refer	NOTE: The reference time must not be confused with the time zone (which is part of the representation of the time stamp), but indicates what the source of the time stamp is, i.e. to which reference time the time stamps of the observation are aligned. EXAMPLES: (a) National Institute of Standards and Technology (NIST) time server (b) Network Time Protocol (NTP) pool project	7-10	M (Phase II)

ID	Name	Definition	Note or example	Code table	MCO
7-11	Reference datum	Reference datum used to convert observed quantity to reported quantity	*NOTE 1*: Atmospheric pressure can be reported as (i) field elevation pressure (QFE), where the reference datum is the elevation corresponding to the official elevation of the aerodrome; or (ii) atmospheric pressure at nautical height (QNH), where the reference datum is mean sea level and the pressure altitude relationship of the International Civil Aviation Organization standard atmosphere is used. Where observed atmospheric pressure cannot be reduced to mean sea level, a station should, by regional agreement, report either the geopotential of an agreed "constant pressure level" or the pressure reduced to an agreed datum for the station. The level chosen for the station should be reported in this field. (See the *Guide to Meteorological Instruments and Methods of Observation*, Part I, Chapter 3, 3.11.1.) *NOTE 2*: Hydrology may report a gauge zero which is the gauge height of zero flow.		C (Phase I)
7-12	Numerical resolution	Measure of the detail in which a numerical quantity is expressed	*NOTE 1*: Numerical resolution can be expressed as the smallest possible difference between two numbers. It can also be expressed as the number of significant figures of a number, which are those digits that carry meaning contributing to its resolution. *EXAMPLE*: If a measurement resolution to four decimal places (0.0001) is given as 12.23 then it might be understood that only two decimal places of resolution are available. Stating the result as 12.2300 makes clear that it is precise to four decimal places (in this case, six significant figures). *NOTE 2*: The notion of measurement resolution is related, but must not be confounded, with the uncertainty of an observation. *EXAMPLES*: (a) An anemometer may measure wind speed with a measurement resolution of 0.1 ms^{-1} with a 1 Hz scan rate. Observations may be aggregated to 1-minute values and may be rounded and reported with a (reduced) measurement resolution of 1 ms^{-1}; (b) A barometer may be capable of measuring atmospheric pressure with a readout resolution of 1 hPa and an uncertainty of 5 hPa ($k = 2$). The data can be reported to the nearest hPa; however, the measurement resolution should be stated as 5 hPa or 3 significant digits; (c) An ocean thermometer measures temperature to 0.0001 °C; (d) Seawater salinity measured to 0.001 salinity units (derived from conductivity measurements with a resolution of 0.01 Sm^{-1}).		O (Phase III)

ID	Name	Definition	Note or example	Code table	MCO
7-13	Latency (of reporting)	The typical time between completion of the observation or collection of the datum and when the datum is reported	*EXAMPLES*: (a) For satellite data, the observation (e.g. a complete image) can take 20 minutes to generate. Hence the latency would be the time between the completion of the image collection and when it is available. Typically this can be 2–3 minutes. Some satellite products, such as sea-surface temperature, can take about 10 minutes of processing until it is available; (b) A radar volumetric scan can take 6–10 minutes (in Australia), so the latency would be the time between the completion of the scan and when the data are locally available. In Australia, this varies between a few seconds to several minutes depending on delays in data communications; (c) Data from automatic weather stations may have a latency of 1–20 seconds (or considerably more in some places) between the completion of the observation and arrival of the data at a central archive.		M (Phase III)

[1] Provided as part of the WIS metadata records

Conditions:

{7-04} Mandatory for remote-sensing observations and mobile platforms in general

{7-11} Mandatory for stations/platforms that report a derived observation value that depends on a local datum

CATEGORY 8: DATA QUALITY

Specifies the data quality and traceability of the observation.

ID	Name	Definition	Note or example	Code table	MCO
8-01	Uncertainty of measurement	Non-negative parameter, associated with the result of a measurement, that characterizes the dispersion of the values that could reasonably be attributed to the observation/measurand	*NOTE 1*: In principle, an uncertainty statement needs to be reported for each observation, as it can change from observation to observation. If the uncertainty of observations remains virtually constant over time, it is sufficient to report the uncertainty at the beginning of the period and then again when substantial changes in the uncertainty occur. The actual uncertainty statements should be reported with the observations. *NOTE 2*: Complex observations, such as gridded satellite imagery, may contain large error covariance matrices that are not useful for the purpose of this standard. Such information must be kept with the data, and it is sufficient to report an aggregate (e.g. mean or median) uncertainty in the metadata. *NOTE 3*: Uncertainty may be expressed, for example, as a standard deviation (or a given multiple of it), or the half-width of an interval having a stated level of confidence. *NOTE 4*: Uncertainty of measurement comprises, in general, many components. Some of these components may be evaluated from the statistical distribution of the results of series of measurements and can be characterized by experimental standard deviations. The other components, which also can be characterized by standard deviations, are evaluated from assumed probability distributions based on experience or other information. *NOTE 5*: It is understood that the result of the measurement is the best estimate of the value of the measurand, and that all components of uncertainty, including those arising from systematic effects, such as components associated with corrections and reference standards, contribute to the dispersion. *EXAMPLE*: A thermometer reading may yield a value of 13.7 °C. A quality assessment of that observation may indicate that it has an expanded uncertainty of +/− 0.3 °C ($k = 2$), where $k = 2$ is a coverage factor corresponding approximately to a confidence interval of 95%.		C*# (Phase II)
8-02	Procedure used to estimate uncertainty	A reference or link pointing to a document describing the procedures/algorithms used to derive the uncertainty statement	*NOTE*: Uncertainty is a well-defined term, and guidance material exists to assist in the assessment of the uncertainty of observations and formulation of adequate uncertainty statements. The authoritative source is the *Evaluation of Measurement Data – Guide to the Expression of Uncertainty in Measurement* (JCGM, 2008).	8-02	C*# (Phase II)

ID	Name	Definition	Note or example	Code table	MCO
8-03	Quality flag	An ordered list of qualifiers indicating the result of a quality control process applied to the observation	*NOTE 1:* The BUFR code table series 0 33 contains data quality flags/definitions (WMO-No. 306; see WMO, 2015*a*). *NOTE 2:* To be recorded by data providers for each individual observation	8-03	M# (Phase II)
8-04	Quality flagging system	Reference to the system used to flag the quality of the observation	*NOTE 1:* At present, there is no single, globally accepted flagging system. The reference to the flagging system should either be a URL to a document explaining the meaning of the quality flag, or a link to a code table where this information can be found. *NOTE 2:* The use of the BUFR quality codes listed above is recommended.	8-04	M# (Phase II)
8-05	Traceability	Statement defining traceability to a standard, including sequence of measurement standards and calibrations that is used to relate a measurement result to a reference (JCGM, 2012; reference no. 2.42)	*NOTE 1:* A metrological traceability chain is defined through a calibration hierarchy. (JCGM, 2012; reference no. 2.42) *NOTE 2:* A metrological traceability chain is used to establish metrological traceability of a measurement result. (JCGM, 2012; reference no. 2.42) *NOTE 3:* A comparison between two measurement standards may be viewed as a calibration if the comparison is used to check and, if necessary, correct the quantity value and measurement uncertainty attributed to one of the measurement standards. (JCGM, 2012; reference no. 2.42) *NOTE 4:* For the statement on traceability, code table 8-05 is to be used.	8-05	C*# (Phase II)

Conditions:

{8-01, 8-02, 8-05} Mandatory for variables that are measured, as opposed to classified

CATEGORY 9: OWNERSHIP AND DATA POLICY

Specifies who is responsible for the observation and owns it.

ID	Name	Definition	Note or example	Code table	MCO
9-01	Supervising organization	Name of organization who owns the observation	*EXAMPLES*: For satellite operators: European Organization for the Exploitation of Meteorological Satellites (EUMETSAT), European Space Agency (ESA), National Oceanic and Atmospheric Administration (NOAA), National Aeronautics and Space Administration (NASA), China Meteorological Administration (CMA), RapidEye, Indian Space Research Organisation (ISRO)		M (Phase II)
9-02	Data policy/use constraints	Details relating to the use and limitations surrounding data imposed by the supervising organization	*NOTE*: Only one single use constraint with a value taken from WMO_DataLicenseCode is allowed to ensure unambiguity (WMO-No. 1060, p. 50; see WMO, 2015*b*)	9-02	M* (Phase I)

CATEGORY 10: CONTACT

Specifies where information about an observation or dataset can be obtained.

ID	Name	Definition	Note or example	Code table	MCO
10-01	Contact (nominated focal point)	Principal contact (nominated focal point) for resource	*NOTE*: The focal point should be able to provide data users with information regarding individual observing platforms and their observations. *EXAMPLES*: Programme or network manager – for example, a EUMETNET AMDAR technical coordinator has responsibility for data quality of several airlines' fleets, and has information on aircraft type/software/known errors.		M (Phase I)

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