GUIDANCE

ON THE WIGOS METADATA STANDARD

(WMDS)

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NOTE:

The guidance on the WIGOS Metadata Standard (WMDS) contained in this document refers to the version 1.0, approved by Congress 17 (May 2015) as part of the [*Manual on the WMO Integrated Global Observing System*](http://wis.wmo.int/WIGOS-Manual) (WMO-No. 1160) (in the further text “Manual on WIGOS”). Nevertheless, because the data model for the exchange of metadata was further developed after Cg-17, some changes to the WMDS are proposed, but not yet published. This means that some terms used in this guidance are not consistent with the terms used in the approved WMDS as shown in the following table (to be completed):

|  |  |  |  |
| --- | --- | --- | --- |
| WMDS version 1.0 | Data Model | OSCAR/Surface | This Document |
|  | Observation collection | Data series | Data series |
| Station/Platform | Observing facility | Station | Observing facility |
|  |  |  |  |

It should also be noted that the code tables contained in version 1.0 of the WMDS have been further developed and/or completed by the Inter-Commission Coordination Group on WIGOS, Task Team on WIGOS Metadata (TT-WMD) and in consultation with the wider community. Those new code tables are to be submitted to CBS Session (November 2016) for formal approval, although they are being used by OSCAR/Surface since 2 May 2016.

# INTRODUCTION

The availability of WIGOS metadata contributes to the effective utilization of WIGOS observations. These metadata are interpretation/description or observational metadata – information that enables data values to be interpreted in context and permit the effective utilization of observations from all WIGOS component observing systems by all users.

The WMO Information System (WIS) is the single coordinated global infrastructure responsible for the telecommunications and data management functions. WIS enables (i) the routine collection and dissemination service for time-critical and operation-critical data and products, (ii) Data Discovery, Access and Retrieval service, and (iii) the timely delivery service for data and products. WIGOS metadata gives insight into the conditions and methods used to make the observations which are distributed through the WIS.

WIGOS metadata describes the observed variable, the conditions under which it was observed, how it was measured or classified, and how the data has been processed, in order to provide the users with confidence that the use of the data are appropriate for their application. GCOS (Global Climate Observing System) Climate Monitoring Principle No. 3 describes the relevance of metadata as:

“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.”

Metadata can be quite static, for example, the exposure of an instrument at a fixed station, or it can change with every observation, such as the date/time of occurrence of precipitation. Metadata can even consist of observations of other (auxiliary) observed variables.

The WIGOS Metadata Standard (WMDS) specifies the metadata elements that exist and that are to be recorded and reported. It has been implemented in OSCAR/Surface (OSCAR stands for Observing Systems Capability Analysis and Review) which is the WMO's official authoritative repository of metadata, on surface-based meteorological, climatological, hydrological and other related environmental observations that are required for international exchange. OSCAR/Surface is one of the components of the WIGOS Information Resources (WIR).

Observational metadata are to be routinely submitted to, and maintained in OSCAR/Surface by WMO Members according to the provisions of the Manual on WIGOS. Metadata from a number of co-sponsored observing systems are also maintained in OSCAR/Surface. Information on space-based capabilities is provided in OSCAR/Space. OSCAR/Surface replaces and significantly extends the WMO Publication No. 9, Volume A, Observing Stations and WMO Catalogue of Radiosondes, which is now obsolete, and highlights the much wider scope of all the WIGOS component observing systems.

## Important definitions

|  |  |
| --- | --- |
| **Term** | **Description/definition** |
| Observing Network | One or more sensors, instruments or types of observation at more than one station or platform, acting together to provide a coordinated set of observations [from the [*Technical Regulations*](http://library.wmo.int/pmb_ged/wmo_49-v1-2015_en.pdf) (WMO-No. 49), Volume I – General Standards and Recommended Practices (2015 edition) PART I. The WMO Integrated Global Observing System] |
| Observing Facility | Generic term that applies to any type of meteorological, climatological or other related environmental observing set of devices identified by a unique WIGOS ID; Stations and platforms (as used in the Manual on WIGOS) are included, although, “Station” is more commonly used for a fixed facility (usually making in-situ observations), while “Platform” is more commonly used for a mobile facility (often making remote sensing observations). A single observing facility may include one or more in situ or remotely sensed observations on land, in lakes/rivers, at sea, or in space. |
| Site | Location where observations are made; Place where a station or platform is located. It defines the environment influencing the observations. |
| Observation | Evaluation of one or more variables of the physical environment [from the [*Technical Regulations*](http://library.wmo.int/pmb_ged/wmo_49-v1-2015_en.pdf) (WMO-No. 49), Volume I – General Standards and Recommended Practices (2015 edition) PART I. The WMO Integrated Global Observing System]. Note: It is the act of measuring or classifying the variable. The term is also often used to refer to the data resulting from the observation. |
| Measurand | Quantity intended to be measured [from JCGM 200:2012]. Note: generally it is a result of a measurement from an instrument. |
| Observational Metadata | WIGOS metadata describes the observed variable, the conditions under which it was observed, how it was measured, and how the data has been processed, in order to provide data users with confidence that the use of the data is appropriate for their application. |
| (Observed) Variable | Variable intended to be measured (measurand) or observed or derived, including the biogeophysical context [from the WIGOS Metadata Standard] |
| WIGOS | WMO Integrated Global Observing System |
| WIS | WMO Information System |
| Observing domain | The component of the earth system which is being observed, atmospheric (over land, sea, ice), oceanic and terrestrial. |
| Observing system | A related group of methods and facilities for making meteorological, oceanographic and other environmental observations. |

## Managing WIGOS metadata according to WMDS

## Identification of functions and responsibilities

The following functions and responsibilities have been identified:

1. Network Metadata Manager – responsible for keeping network observational metadata up-to-date, correct, quality controlled and complete.
2. Observational Metadata Manager – responsible for encoding and transmitting WIGOS Metadata (WMD), ensuring that metadata meets the WMDS.
3. Observing Facility Metadata Maintainer – responsible for recording and maintaining metadata for the observing facility.
4. Observational Metadata User – access, appropriate analysis and interpretation of observational metadata.

Note: guidance referring to this function will be developed later.

## Relation with OSCAR/Surface

The WMDS will be implemented in three phases over a five year period (2016-2020). In practice this will be done through OSCAR/Surface, which

.means that Members must transfer their WIGOS metadata, either in near-real-time or less frequently, to OSCAR/Surface for the observations they exchange internationally. Moreover, OSCAR/Surface contains a few additional metadata fields, not explicitly specified in the WMDS, e.g., population density or climate zone, amongst others. Members should include as many of the additional fields as possible in OSCAR/Surface.

## Data series and segments

A set of observations made over a period of time at a specified facility and for an observed variable is called a data series. In a data series other intrinsic measurement characteristics, such as units, observing method, spatial extent (geometry), source of observation and sampling procedures are kept unchanged. Generally, but not exclusively, these observations are made at regular intervals or continuously. A data series consists of one or more essentially uninterrupted data segments. Data segments may have minor gaps in between or may overlap. It is advisable to describe observations with as few as possible data series.

A data segment describes a sub-set of a data series that is considered to be homogeneous, in terms of (no) impact resulting from changes of the observing conditions, such as the instruments used and the environment. A new data segment should be started if one or more of the following conditions is met:

* A different instrument housing (e.g. a Stevenson screen is replaced with a radiation shield);
* The exposure of the site changes significantly (e.g. an asphalt car park has been built next to the observing site);
* A different observing program is established; or
* The sensor is relocated or repositioned within the same observing facility.

A new data segment is not required when:

* An instrument has its calibration verified by a travelling standard;
* An instrument is replaced with another instrument of the same type; and
* Routine site maintenance is performed (e.g. vegetation is trimmed, an instrument shield is cleaned).

# COLLECTING AND PRODUCING WIGOS METADATA

## General guidance

WIGOS metadata standard is an observation focused standard. However, typically observations are grouped in terms of the observing facility where one or more sensors or instruments are located.

The following metadata elements of the WMDS are mandatory for the first phase of its implementation (2016) - the references below refer to the following sub-sections:

* Observed variable (measurand) (2.1.2)
  + Variable
  + Unit
* Temporal extent (2.1.1)
* Spatial extent (2.1.2)
* Application area(s) (2.1.2)
* Programmes/network affiliation (2.1.1 & 2.1.2)
* Observing facility name (2.1.1)
* Observing facility unique identifier (2.1.1)
* Geospatial location (2.1.1)
* Observing facility status (2.1.2)
* Source of observation (2.1.2)
* Measurement/observing method (2.1.2)
* Instrument specifications (2.1.2)
* Diurnal base time (2.1.2)
* Schedule of observation (2.1.2)
* Temporal reporting period (2.1.2)
* Data policy/use constraints (2.1.2)
* Contact (nominated focal point) (2.1.3)

In OSCAR/Surface, metadata are assembled under the following five headings.

### Station (observing facility) characteristics

The metadata element that uniquely identifies the observing facility is the WIGOS identifier. This heading contains the basic information of the observing facility, such as Name, Date of establishment (Temporal extent in WMDS) and Type of observing facility, together with its Country/territory, its Coordinates (Geospatial Location in WMDS) and Time zone, as well as a description of the relevant environmental characteristics of the observing facility and its surrounds (Climate zone, Predominant surface cover, Surface roughness, Topography or bathymetry, Population in 10km / 50km). Other complementary information is listed here in Station URL, Other link and also in the Site information element which may include images (photos) of the observing facility. The official Program/network affiliations for the station are also listed here. The following fields in OSCAR/Surface are not metadata elements of the WMDS: Time zone, Climate zone, Surface roughness, Station URL and Other link, although Climate zone and Surface roughness are being considered as additional elements for the next edition of the WMDS.

2.1.1.1 Station coordinates

The method to specify station coordinates is described in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part I, Chapter 1, section “1.3.3.2 Coordinates of the station”.

### Observations / Measurements

Each observation or measurement is described succinctly in terms of the following elements, which are grouped in OSCAR/Surface under the heading “Observations / Measurements”: variable, units, analytical methods (Measurement/observing method in WMDS), Programs/network affiliations (which includes the Status of the observing facility), Application Areas, Source of observation, geometry (Spatial extent in WMDS) and Data policy/Use constraints. Under each variable and for each data series segments, that may be present, the information is structured under “schedule” and “instruments”. Under “schedule” the following metadata elements are listed: Temporal reporting interval (Temporal reporting period in WMDS), Diurnal base time and Schedule itself (Month From-To; Weekday From-To; Hour From-To); Under “Instruments” the following metadata elements are listed: Manufacturer, Model, Configuration, Serial number, QA/QC schedule, Firmware version, Use since, Use till, Coordinates (Latitude, Longitude, Elevation), Geo-positioning method, Distance from reference surface, Type of reference surface and Comments (this one is not considered a individual metadata element in the WMDS), Status, Status From, To, Maintenance periods (Description, party and date).

Some other metadata elements are included under this heading of OSCAR/Surface, which are not required for phase 1: Latency, Sampling procedures and Representativeness. Also included are the following elements which are not part of the WMDS: Near Real Time, Near Real Time URL and Last updated.

Often, multiple observations are associated with a single observing facility. Observations at an observing facility are listed in alphabetical order. A future requirement is that the Observations can be grouped according to observing domain or sub-domain.

#### 2.1.2.1 Instrument coordinates

A similar method should be followed for the coordinates of individual instruments. If the instruments are located in a single observing site, the observing facility coordinates may be used as an approximation. Where necessary, the actual instrument (sensing component) position in space is recorded following the standards recorded in Guide to Meteorological Instruments and Methods of Observation (WMO- No. 8), section “1.3.3.2 Coordinates of the station”. Additionally the height or depth of the instrument above or below its reference surface is recorded where appropriate.

### Station Contacts

The details of the station contacts are recorded. This may include functions, such as the station or network manager, data or metadata holder, or the organization responsible for the data policy.

### Bibliographic references

Where the data series or segment, or methods relating to the data series or segments, have been previously published or referenced, e.g. nationally or on the WWW, they are recorded in this section. OSCAR/Surface allows for the upload of documents.

### Documents

This section provides access to documents concerning the observing facility or the observed variables. These may include correspondence, instrument calibrations certificates, and network descriptions and so on.

## Specific guidance for different types of observing facilities

The WMDS identifies an observing facility and has a direct (one to many) relationship to the observations.

Observing facility characteristics such as a climate zone, surface cover or surface roughness (currently not in the WMDS, but implemented in OSCAR/Surface) should refer to the observing facility coordinates. For example, surface cover is generally most applicable to observations such as surface air temperature, humidity, irradiance and precipitation.

The geographic coordinates (geospatial location in the WMDS) of the observing facility should identify the reference location of that facility. The geographic coordinates of the instruments are specified separately for each instrument of the facility. The guidance for different types of observing facilities are specified in the following sections.

A change of coordinates should always reflect a physical re-location of the observing facility and/or instrument. The historical coordinate values of the observing facility location should be retained.



### Observing facilities on land

This section describes the metadata aspects related to the main types of observations made on land. It is structured in accordance to the geometry (point, profile or volume) and to the technology (in-situ or remote sensing) used for the observations.

The geographic location of the observing facility may refer to the observation which has existed for the longest period of time, or it may be the observation related to the administrative point, or to the primary application area. The coordinates should be centred over the observing instrument and the ground elevation should be the natural (undisturbed) surface of the ground.

Observing facilities on land include observations which are made at a fixed position in relation to the land surface, a mobile observation on land or those which transfer their data to a facility on land. These facilities may be close to land (such as a wharf or on a pylon grounded in the earth).

A mobile station may remain in a fixed location during a period of observations, or may be mobile during the observation.

#### Surface in-situ observations

The observations of the variables in a surface in-situ observing station, such as wind speed/direction, air temperature, relative humidity, atmospheric pressure, precipitation, present weather, cloud, etc., by the instruments/observer located at this station are described individually. Although such observations are made as in-situ observation in a station, they should represent an area surrounding the station depending on the environmental exposure conditions of the instrument.

Some instruments may measure more than one observed variable at the same time. Each observed variable should be described and the common instrument may be identified through a common serial number. Examples of such instruments include some humidity probes (report humidity and temperature), some sonic anemometers (may report wind speed, wind direction, air temperature) and “all-in-one” sensors (temperature, humidity, wind speed, wind direction and pressure).

Surface in-situ include observations which are made near the surface of the Earth, over land, such as Automatic Weather Stations (AWS) and surface manual stations. The simplest station may make only one observation (e.g. rainfall), while others may include observations of several variables, such as air temperature, humidity, wind, soil temperature, etc.

The following conditional elements of the WMDS are mandatory for fixed stations, for the first phase of the implementation of WMDS:

- Region of origin of data,

- Territory of origin of data,

- Vertical distance of sensor from a (specified) reference level such as local ground, or deck of a marine platform at the point where the sensor is located; or sea surface,

- Reference datum - for derived observations that depend on a local datum.

#### Upper-air in-situ observations

Upper-air in-situ observations primarily includes observations which are made using instrumentation attached to meteorological balloons (i.e. radiosondes), and includes balloon tracking for the calculation of winds (i.e. radar, radio-theodolite). The measurement, often referred to as a sounding, is a complete profile from the launch point to balloon burst. This relates to element 5-02, Measurement/observing method of WMDS, from code table 5-02. To ensure the timely availability, to the data users, the sounding is often split into several messages but the same metadata is included in all parts of the transmitted messages. Observations such as those made by dropsondes and using kites are also included in this category but specific guidance for these systems will be included in a later release of the metadata standard.

The majority of the metadata for these systems are incorporated within the WMO defined BUFR message and thus are reported along with the data for each sounding. It is thus very important that the Observing Facility Metadata Maintainer and the Network Metadata Manager ensure that the transmitted metadata are valid and accurate for each reported sounding. Metadata in BUFR message must be consistent with the WMDS elements and with the information that goes into OSCAR.

It is common that the launch point of the balloon has different geospatial coordinates than the observing facility and this can make a significant impact on the data users. It is important that both sets of geospatial coordinates are included in the observing facility metadata database, and that the coordinates incorporated in the BUFR messages is for the balloon launch location. Element 5-12 of WMDS, Geospatial location of instrument, is related to this, although it is a phase 2 element, while element 3-07, Geospatial location of station, refers to the main facility.

Many radiosonde systems no longer include a pressure sensor, and thus the pressure and geopotential height is derived from the Global Navigation Satellite Systems (GNSS) height. The metadata defining the source of the pressure and geopotential height measurements is mandatory and shall be included in every BUFR message. This relates to element 7-01 of WMDS, Data processing methods and algorithms, which is optional for phase 3 of implementation.

#### Weather Radar observations

Weather radars are active remote sensing observing systems to make real time and high resolution observations from a large scale area (up to a radius of 250 km). The weather radar observations have been made particularly for the detection of the precipitation, hydrometeor classification and quantitative precipitation estimation. Doppler wind speed and direction can also be reported from some weather watch radars. Radar observing facility coordinates, height of the location, tower height, frequency, polarization, scanning parameters and other characteristics of weather radar observations are metadata elements contained in the WMO Radar Database (WRD - http://wrd.mgm.gov.tr). Members should continue to collect and supply/update the metadata about their weather radars to the WRD (managed by the Turkish State Meteorological Service). The metadata regarding weather radars will be transferred from the WRD to the OSCAR/Surface by machine-to-machine procedures. Radar metadata cannot be edited manually in OSCAR/Surface.

#### Other surface-based remote sensing observations

Other surface-based remote sensing includes all observations, excluding weather radars, which are made using remote sensing instrumentation located at a fixed site. These systems are wide ranging in their methods of observation, but primarily result in a measurement profile representative of the atmosphere above the sites. Examples of systems in this category are wind profiling radars, lidars, radiometers, ground-based GNSS receivers, HF Radar.

The majority of the metadata regarding these systems are incorporated within the WMO defined BUFR message and thus are only reported along with the data for each sounding. It is thus very important that the Observing Facility Metadata Maintainer and the Network Metadata Manager ensure that the transmitted metadata are valid and accurate for each reported sounding.

These systems often use advance flagging techniques to identify measurements that do not meet the data quality criteria and it is mandatory to include this information within the metadata that is transmitted with each message. This relates to elements 8-01 to 8-05 of WMDS (Data quality) which are mandatory/conditional for phase 2.

### Observing facilities on the surface of lakes/rivers

Records of lake/river gauge height or stage and river discharge are fundamental to the management of water resources, understanding of streamflow variability in time and space, and calibration of hydrological models used in streamflow and flood forecasting. Gauge heights can be measured in various ways, such as direct observation of a staff gauge, or by automatic sensing through the use of floats, transducers, gas-bubbler manometers and acoustic methods. River flows are generally measured indirectly, through conversion of a record of stage to discharge using an empirically derived rating conversion curve. The rating curve is developed by measuring discharge at various stages checked periodically to define any change in the stage-discharge relation caused by changes in channel geometry and/or channel roughness at the gauging station.

### Observing facilities on the sea surface

Sea surface observations are taken from a variety of platforms. These include moored buoys, drifting buoys, ships and terrestrial base high-frequency radars (surface current direction and speed). Variables most commonly measured include air temperature, barometric pressure, humidity, wind direction and speed, sea surface temperature, wave height, wave period, wave direction, current speed and direction, and salinity. These observations serve similar purposes as terrestrial observations in that they are quality controlled, and ingested in numerical weather prediction models. They also are of value to local and regional forecasters as conditions off shore can be analysed and used to create short and medium term forecasts.

Ship observations typically include air temperature, barometric pressure, humidity, wind direction and speed. These are commonly measured automatically. Manual ship observations include wave height, wave period, wave direction, ceiling (cloud cover), and visibility. These observations serve the same user communities noted above.

Sea Surface observations are also being made from autonomous surface vehicles (ASVs). These are propelled by wind and/or wave action and measure air temperature, barometric pressure, humidity, wind direction, wind speed, sea surface temperature, and sea surface salinity.

Buoy positions are reported at the time of observation by the organization that operates the platform. Ship positions are also reported at the time of observation however many vessels do not report their actual identity due to economic considerations. Autonomous vehicles report their position obtained at the time of observations. The observations are reported under the ownership of the organization that is remotely controlling the vehicle(s).

### Airborne observing facilities

Airborne observations refer to a set of measurements of one or more meteorological variables along with the required metadata. These observations are made at a particular time according to a defined schedule at a location or series of locations (in three dimensional space) from an Aircraft Based Observation platform (ABO).

The ABO data is reported in the WMO BUFR template for AMDAR, 3 11 010, version 7).

In general, data is collected from three categories of ABO. Examples are:

* WMO ABO - AMDAR (Aircraft Meteorological DAta Relay) - aircraft deriving meteorological data according to WMO standards and specifications,
* ICAO ABO - ADS-C (Automatic Data Surveillance Contract) - aircraft providing data under regulations and co-operative arrangements with ICAO.
* Other ABO - Panasonic TAMDAR (Tropospheric-AMDAR) - AMDAR formatted data derived from observing platforms on commercially operated aircraft observing systems. Data availability will be dependent on NMHS arrangements with Panasonic as to whether data can be ingested to GTS.

The ABO data requires that Network Metadata Managers maintain a database of metadata relating to aircraft models and types, information on sensors and software for processing the data. There will also be a requirement for airport positional metadata with regards to initiating and terminating of profiles.

[Reference: *Guide to the Global Observing System* (WMO-No. 488), Part III, section 3.4 Aircraft Meteorological Stations]

### Observing facilities underwater

Underwater observations can be obtained in a number of ways. These include thermistor strings and devices attached to inductive cabling, expendable bathythermographs (XBTs), acoustic doppler current profiler (ADCP), ARGO floats and conductivity, temperature and depth (CTD) devices. Bottom mounted water pressure sensors are used to measure variations in the water column which indicative of a low amplitude wave (tsunami) generated by and underwater disturbance (seismic activity). A new technology, profiling gliders are unmanned underwater vehicles (UUVs) are becoming more widespread in their employment.

The variables that are observed by these devices include water temperature, water pressure, salinity, current direction and speed, fluorescence, and dissolved oxygen. All of these variables are measured at depth – as deep as the sensors or gliders are located.

The underwater observations obtained from moored buoys use the position of the buoy itself and are reported by the organization that operates the buoy. XBT’s positions are made at the point of launch and are reported by the launch vehicle (ship or aircraft). ADCPs and CTDs are usually moored at a specific location which is reported at the time of observation by the organization that is operating the device. ARGO float positions are reported at the time of observation by the organization that is operating the device. UUVs observations are reported using the position of the vehicle when it begins its subsurface excursion and are reported by the organization piloting the vehicle.

### Satellite

Satellite observations complements surface-based observations. They provide information from areas sparsely populated with conventional observations and do generally provide information on surface characteristics as well as atmospheric conditions depending on the sensor type. Vital information for satellite platforms are type of orbit (e.g. geostationary, polar orbiting) including height of the satellite and e.g. equatorial crossing times, types of instruments (active/passive, optical/microwave, imager/sounder, application areas and variables supported…) including sensor characteristics (bands measured, footprint, measurement approach like scanning versus push broom or similar, swath size if applicable, return period, etc.).

Metadata for satellite observations are collected in [OSCAR/Space](https://www.wmo-sat.info/oscar/spacecapabilities).

# EXCHANGING THE WIGOS METADATA

## Exchanging the WIGOS metadata

Note: the guidance on exchanging WIGOS metadata will be developed as soon as the XML schema is finalized

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# USING THE WIGOS METADATA

## 4.1 Using the WIGOS metadata