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Remotely Operated Multi-Parameter Stations

System Software Output Format Specification

METEOD

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Remotely Operated Multi-Parameter Stations

System Software Output Format Specification

METEOD

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Change Control Sheet

Date	Version	Author	Items
09.09.2009	1.0	Tilo Schöne	Initial Document This document replaces GITW-CST-SSP-GFZ-001 GITW-BUO-SSP-GFZ-001
05.03.2009	1.1	Tilo Schöne	Section 7 “GCO” part added. For Vaisala sensors, now all records are written to the output binary file. Section 8.1: Record_ID’s changed. Buoy and Tide gauge met are now differently identified.
17.06.2020	1.2	Cornelia Zech	Update of section 1, deletion of figure 1 (data flow from tide gauge to warning center), creation of subsection in section 5, division of section 8 in binary and ASCII form and insertion of ASCII data format in section 8.4, insertion of line “Abbreviation” in section 9 for ASCII data format

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1 INTRODUCTION AND SCOPE

In recent years, an extensive network of Remotely Operated Multi-Parameter Stations (ROMPS) has been installed in different countries and climatic zones. The stations were developed by GFZ for various applications and set up together with the corresponding partners in the particular regions. In this sense, the general station with its core functionality (querying and storing of sensor data, transmission of data to a central storage unit, providing sufficient energy for the station) is referred as ROMPS. Various sensor systems to account for different application requirements can be connected to these stations. The ROMPS can then be, e.g., a tide gauge station, a buoy or a hydrometeorological (HyMet) station.

This document provides the description of the data records from the meteorological system of the ROMPS. In the years after the first development of the data format for the German-Indonesian Tsunami Early Warning System GITEWS (tide gauge stations and buoys), the system was also used for other projects like the Global Change Observatory GCO and Advanced Remote Sensing – Ground-truth Demo and Test Facilities ACROSS (hydrometeorological stations). This resulted in a further development or adaptation of the system, so that different versions of the original data format were created. The versions differ primarily in the data representation (binary or ASCII) and the number and storage of metadata. The meteorological parameters have remained the same since the type of sensor has not changed.

All data from the sensor is requested by the ***meteod*** software program according to a pre-selected sampling rate and stored in files on the station's computer. These files will be transmitted to a central data storage using file-oriented TCP/IP services (scp, ncftp).

The scope of this document is to describe the data format and content which is available at the remote ROMPS. The data format description section is divided into subsections to account for the different format versions of the tide gauges, buoys and HyMet stations. This document is also the basis for further handling of the data, e.g. processing of data within the central data storage or warning center.

2 DEFINITIONS, ACRONYMS, ABBREVIATIONS

Abbreviation	Description
ACROSS	Advanced Remote Sensing – Ground-truth Demo and Test Facilities
GITEWS	Project: German Involvement Tsunami Early Warning System
GCO	Project: Global Change Observatory
meteod	meteo data daemon (Software module for communicating with meteo peripherals)
mgd	tide gauge daemon (Software module for communication with tide gauge peripherals)
bmd	Buoy management daemon
SW	Software
TBD	to be defined
n/a	Not available
TEWS	Tsunami Early Warning System
HyMet	Hydrometeorological
UTC	Universal Time Coordinated

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3 DATA REPRESENTATION

For Bytes, the bit numbering is from right (0) to left (7). Data is represented in TCP/IP network byte order (big endian). Most significant byte is to the left.

Bytes:

7	6	5	4	3	2	1	0

Unsigned integers:

Binary 00000001 = Decimal 1; Binary 10000001 = Decimal 129; Binary 10010001 = Decimal 145

Signed integers:

Binary 10000000 = Decimal 1; Binary 11111111 = Decimal -1; Binary 11110111 = Decimal -17

If the document refers to the acronym ASCII, the extension ISO/IEC 8859-1 is applicable.

4 DOCUMENTS

All relevant information about data structures for the design and procurement of the ROMPS and **`meteod`** software program are contained in this specification. The following documents are provided as additional information and reference. In case of incompatibilities between the document at hand and one of the following documents, this shall be brought to the attention of the customer for resolution.

The following documents are applicable documents to the Tsunami Early Warning System as a whole.

[AD1] GITW-SYS-PLN-GFZ-001, issue draft, 04-Jun-2005

GITEWS Cooperative Project Plan

[AD2] GITW-SYS-PLN-GFZ-002, issue draft, 15-Jun-2005

GITEWS Configuration Control Plan

The following documents are provided as additional interface information

AD3 GITW-BUO-SPE-GFZ-002

5 FILE NAMING CONVENTION

For historical reasons different file name conventions exist. All can be used alternatively, but each subsystem (tide gauge, buoy, hydrometeorological system) provides only one type of filenames.

In general, all files consist of a 4-letter leading identifier, intermediate information, and a filename extension. While the 4-letter leading identifier and the filename extension exist for all types of files, the intermediate information can differ. The time system of the remote site is synchronized with GPS. Therefore, all time information is based on this time scale. Exceptions are stated in the text. In the following, the different filenames are explained.

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5.1 File name type 1

Filename type one is defined as follows:

`XXXXYYYYYYYYYY.EXT` with

XXXX: 4-letter leading identifier for the station name,

YYYYYYYYYY: Unix time stamp (seconds since 01.01.1970), and

EXT: File name extension.

Typical identifiers ("XXXX") are "tg01" for a tide gauge, or "ts02" for a buoy. The count of digits for the Unix time stamp is non-fixed. ".EXT" would be typical ".met" for the meteorological system.

5.2 File name type 2

The second type is closely defined to the international standard for high-rate GPS stations and is as follows:

`XXXXWEEKDHZSCND.EXT` with

XXXX: 4-letter leading identifier for the station name,

WEEK: GPS-Week (a four digit number) counted since beginning of the year 1980,

D: GPS day of week (GPS day 0 is Sunday),

H: letter for the specific hour of the day; 'a' is hour 0, 'x' is hour 23,

Z: user-free definition, but typically 'z'

SCND: 4 digit number of seconds of the specific hour, and

EXT: file name extension, typically met for the meteorological system.

As examples, a *meteo* file for *tg01*, generated on *March 19th, 2008 11:23:20*, would be either named **tg011205922200.met** or **tg0114713kz1400.met** .

5.3 File name type 3

The third type of file name includes the type of sensor system in the file name to distinwuish between various sensor system installed at one ROMPS. It is defined as follows:

`XXXX-SSSSSS-YYYYYYYYYY.EXT` with

XXXX: 4-letter leading identifier for the station name,

SSSSSS: type of sensor system, in this case "meteod",

YYYYYYYYYY: Unix time stamp (seconds since 01.01.1970), and

EXT: File name extension.

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6 GENERAL DESCRIPTION OF *METEOD* SOFTWARE RECORD FOR TIDE GAUGES

6.1 Overview

The standard tide gauge station is equipped with meteorological sensors. The data is important for an in-depth analysis of tide gauge records as well as for the multi-hazard monitoring. In addition, the air pressure is used to correct for rapid barotropic sea level changes. The data is saved in binary form.

6.2 Data Record Definition

The **meteod** record for tide gauges consists of one section holding all values. All entries are described in Section 5.4. The data record length is 20 Bytes.

```
/meteod_record/
      time_of_measurement
      air_pressure
      air_temperature
      humidity
      wind_speed
      wind_direction
      rain_intensity
      rain_duration
      rain_accumulation
/end_meteod_record/
```

6.3 Metadata Record Definition

The **meteod** metadata record holds information taken from the meteorological system. It holds various complementary informations. After update of any of the entries the record is written to the standard output file. All entries are described in Section 8. Record length is 50 Bytes.

```
/meteod_metadata/
      station_ID
      station_Name
      time_of_metadata
      latitude_of_sensor
      longitude_of_sensor
      subsystem_state
      sensor_status
/end_meteod_metadata/
```

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7 GENERAL DESCRIPTION OF *METEOD* SOFTWARE RECORD FOR GPS BUOYS

7.1 Overview

The standard buoy is equipped with meteorological sensors. Part of the data (air pressure) is important for an in-depth analysis of the heights observed by GPS as well as for the multi-hazard monitoring. In addition, the air pressure is used to correct for rapid barotropic sea level changes (e.g., inverse barometric effects, meteotsunamis: atmospherically induced destructive ocean waves).

7.2 Data Record Definition

The meteorological record of the **meteod** consists of one section holding all values. All entries are described in Section 5.4. The data is saved in binary form and the record length is 20 Bytes.

```
/meteod_record/
      time_of_measurement
      air_pressure_1
      air_pressure_2
      air_temperature
      humidity
      wind_speed
      wind_gust
      salinity
      water_temperature
/end_meteod_record/
```

7.3 Metadata Record Definition

The **meteod** metadata record is described in Section 5.3.

8 GENERAL DESCRIPTION OF *METEOD* SOFTWARE RECORD FOR HYMET STATIONS

8.1 Overview

The concept of GITEWS was applied for other ROMPS. The **meteod** data record described here are adapted for usage of, e.g., for GCO stations. The record is designed to hold parameters measured with the Vaisala Compact Station WXT510 or WXT520. The sensor must be configured correctly. The data can be stored in binary or ASCII form. Both types are explained in the following subsections.

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8.2 Data Record Definition for binary form

The meteorological record of the meteod consists of one section holding all values. All entries are described in Section 5.4. The data record length is 38 Bytes.

```
/meteod_record/
      time_of_measurement
      air_pressure
      air_temperature
      humidity
      wind_speed
      wind_direction
      rain_intensity
      rain_duration
      rain_accumulation
      rain_peak_intensity
      hail_intensity
      hail_duration
      hail_accumulation
      hail_peak_intensity
      heating_temperature
      heating_voltage
      supply_voltage
      reference_voltage
/end_meteod_record/
```

8.3 Metadata Record Definition for binary form

The meteod metadata record is described in Section 5.3.

8.4 Header Data Record Definition for ASCII form

Each file consists of header information and the measured data. The header record consists of five lines as follows:

1. Requesting program name and version,
2. date and starting time of the measurements in this file,
3. sensor type,
4. sampling rate, and
5. End of file header line.

The date in line two is specified as GPS week (weeks since beginning of 1980) and day of week (with 0=Sunday). After this section, the data section follows with the time of the measurement. The time of measurement corresponds to the date in the header section. All values are comma-separated but are divided into several lines depending on the meteorological parameter.

Example of header lines:

```
Pgm name & version: /usr/local/bin/gitews/meteod 1.04.5
GPS date & time   : 2102-4  05:00:00
Sensor type       : WXT520
Sampling rate     :  1.0
```

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```
End of file header:
```

8.5 Data Record Definition for ASCII form

Each data section starts with the time of measurement followed by several lines of data. Each data line has an identifier to indicate the parameter type followed by an indefinite number of data values. The beginning of the data lines has the following format:

```
aRX, TT=MMMU,
```

with

a:	device address (typically 0),
RX:	measurement type,
TT:	measurement parameter,
MMM:	measurement value (number of digits not fixed, can be integer or float), and
U:	measurement unit (can be a character as listed below for each value or #).

The following identifiers exist:

Identifier	Description
0R1	Wind data measurements
0R2	Pressure, temperature and humidity measurements
0R3	Precipitation measurements
0R4	Not existing
0R5	Supervision data measurements

The order of the identifiers in the data lines can change and not all identifiers are always listed in the files.

Example of data lines:

```
05:00:31 0R2,Ta=9.5C,Ua=40.1P,Pa=746.5H
   0R1,Dn=267#,Dm=267#,Dx=267#,Sn=0.0#,Sm=0.0#,Sx=0.0#
   0R5,Th=13.6C,Vh=0.0N,Vs=13.2V,Vr=3.478V
   0R3,Rc=0.00M,Rd=0s,Ri=0.0M,Hc=0.0M,Hd=0s,Hi=0.0M
```

Users are advised to refer to the WXT5xx format specification for details about measurement units. The meteod software converts units into units described in Section 9.

9 RECORD DESCRIPTION

This record description is valid for both binary and ASCII form. While the line “Field” refers to the binary form, the line “Abbreviation” is the ASCII counterpart to it.

Field	time_of_measurement
Description	Gives the time of the measurements
Bytes	4
Data representation	unsigned integer
Unit	seconds since 1.1.1970 00:00:00
Minimum	0

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Maximum	2^32-2
Initial Value	0
Undefined Value	2^32-1
Error Code	n/a
Originating from	Bmd/local PC
Notes	no fractions of seconds In contrast to the UNIX time stamp (signed integer) an unsigned integer is used.

Field	air_pressure	
Abbreviation	Pa	
Description	air pressure measured by the meteorological station	
Bytes	2	
Data representation	signed integer	
Unit	hPa*10	
Minimum	6000	
Maximum	11000	
Error Code	32767	Invalid data
	32765	Sensor value below minimum
	32766	Sensor value above maximum
Originating from	meteod	
Notes	Air pressure is measured in 0.5hPa	

Field	air_temperature	
Abbreviation	Ta	
Description	Air temperature measured by the meteorological station	
Bytes	2	
Data representation	signed integer	
Unit	°dC	
Minimum	-520	
Maximum	600	
Error Code	32767	Invalid data
	32765	Sensor value below minimum
	32766	Sensor value above maximum
Originating from	meteod	
Notes	The original value is converted from °C to °dC.	

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Field	humidity	
Abbreviation	Ua	
Description	relative humidity measured by the meteorological station	
Bytes	2	
Data representation	signed integer	
Unit	d%RH	
Minimum	0	
Maximum	1000	
Error Code	32767	Invalid data
	32765	Sensor value below minimum
	32766	Sensor value above maximum
Originating from	meteod	
Notes	Relative humidity is measured in 0.1%RH	

Field	wind_speed	
Abbreviation	Sm	
Description	current wind speed	
Bytes	2	
Data representation	signed integer	
Unit	dm/s	
Minimum	0	
Maximum	600	
Error Code	32767	Invalid data
	32765	Sensor value below minimum
	32766	Sensor value above maximum
Originating from	meteod	
Notes	Wind speed is measured in 0,1m/s	

Field	wind_gust
Abbreviation	Sx
Description	current wind gust
Bytes	2
Data representation	signed integer
Unit	dm/s
Minimum	0
Maximum	790

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Error Code	32767	Invalid data
	32765	Sensor value below minimum
	32766	Sensor value above maximum
Originating from	meteod	
Notes	none	

Field	Not available in binary form	
Abbreviation	Sn	
Description	Wind speed minimum	
Bytes	2	
Data representation	signed integer	
Unit	m/s	
Minimum	0	
Maximum	790	
Error Code	32767	Invalid data
	32765	Sensor value below minimum
	32766	Sensor value above maximum
Originating from	meteod	
Notes	none	

Field	wind_direction	
Abbreviation	Dm	
Description	Wind direction measured versus magnetic North	
Bytes	2	
Data representation	signed integer	
Unit	degree	
Minimum	0	
Maximum	360	
Error Code	32767	Invalid data
	32765	Sensor value below minimum
	32766	Sensor value above maximum
Originating from	meteod	
Notes	North direction at the station is defined by a handheld compass	

Field	Not available in binary form
Abbreviation	Dn

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Description	Wind direction measured versus magnetic North minimum	
Bytes	2	
Data representation	signed integer	
Unit	degree	
Minimum	0	
Maximum	360	
Error Code	32767	Invalid data
	32765	Sensor value below minimum
	32766	Sensor value above maximum
Originating from	meteod	
Notes	North direction at the station is defined by a handheld compass	

Field	Not available in binary form	
Abbreviation	Dx	
Description	Wind direction measured versus magnetic North maximum	
Bytes	2	
Data representation	signed integer	
Unit	degree	
Minimum	0	
Maximum	360	
Error Code	32767	Invalid data
	32765	Sensor value below minimum
	32766	Sensor value above maximum
Originating from	meteod	
Notes	North direction at the station is defined by a handheld compass	

Field	rain_intensity	
Abbreviation	Ri	
Description	Amount of rain measured	
Bytes	2	
Data representation	signed integer	
Unit	mm/h * 10	
Minimum	0	
Maximum	200	
Error Code	32767	Invalid data
	32765	Sensor value below minimum

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	32766	Sensor value above maximum
Originating from	Meteod	
Notes	None	

Field	rain_duration	
Abbreviation	Rd	
Description	Counting each 10-second increment whenever a droplet is detected	
Bytes	2	
Data representation	signed integer	
Unit	10second	
Minimum	0	
Maximum	32000	
Error Code	32767	Invalid data
	32765	Sensor value below minimum
	32766	Sensor value above maximum
Originating from	meteod	
Notes	None	

Field	rain_accumulation	
Abbreviation	Rc	
Description	Cumulative accumulation after the last reset (automatic)	
Bytes	2	
Data representation	signed integer	
Unit	[mm]*100	
Minimum	0	
Maximum	32000	
Error Code	32767	Invalid data
	32765	Sensor value below minimum
	32766	Sensor value above maximum
Originating from	meteod	
Notes	Sensor resolution is 0.01 mm	

Field	rain_peak_intensity
Abbreviation	Rp
Description	Amount of rain measured in peak
Bytes	2

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Data representation	signed integer	
Unit	mm/h * 10	
Minimum	0	
Maximum	200	
Error Code	32767	Invalid data
	32765	Sensor value below minimum
	32766	Sensor value above maximum
Originating from	meteod	
Notes	none	

Field	hail_intensity	
Abbreviation	Hi	
Description	Amount of hail measured	
Bytes	2	
Data representation	signed integer	
Unit	hits/h or [hits/cm²/h] * 10	
Minimum	-32000	
Maximum	32000	
Error Code	32767	Invalid data
	32765	Sensor value below minimum
	32766	Sensor value above maximum
Originating from	meteod	
Notes	Positive values indicate [hits/cm²/h], while negative values indicate [hits/h]	

Field	hail_duration	
Abbreviation	Hd	
Description	Counting each 10-second increment whenever a hit is detected	
Bytes	2	
Data representation	signed integer	
Unit	10second (TBD)	
Minimum	0	
Maximum	32000	
Error Code	32767	Invalid data
	32765	Sensor value below minimum
	32766	Sensor value above maximum
Originating from	meteod	

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Notes	none

Field	hail_accumulation	
Abbreviation	Hc	
Description	Cumulative accumulation after the last reset (automatic)	
Bytes	2	
Data representation	signed integer	
Unit	[hits]*100 or [hits/cm²]*100	
Minimum	-32000	
Maximum	32000	
Error Code	32767	Invalid data
	32765	Sensor value below minimum
	32766	Sensor value above maximum
Originating from	meteod	
Notes	Positive values indicate [hits/cm²], while negative values indicate [hits]	

Field	hail_peak_intensity	
Abbreviation	Hp	
Description	Amount of hail measured in peak	
Bytes	2	
Data representation	signed integer	
Unit	hits/h*10 or [hits/cm²/h]*10	
Minimum	-32000	
Maximum	32000	
Error Code	32767	Invalid data
	32765	Sensor value below minimum
	32766	Sensor value above maximum
Originating from	meteod	
Notes	Positive values indicate [hits/cm²/h], while negative values indicate [hits/h]	

Field	salinity	
Abbreviation	Not available	
Description	Salinity of the sea water	
Bytes	2	
Data representation	signed integer	
Unit	PPT*100	

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Minimum	0	
Maximum	4000	
Error Code	32767	Invalid data
	32765	Sensor value below minimum
	32766	Sensor value above maximum
Originating from	meteod	
Notes	Measured to 0.04ppt PPT (part per thousand)	

Field	water_temperature	
Abbreviation	Not available	
Description	Temperature of the sea water	
Bytes	2	
Data representation	signed integer	
Unit	°C*100	
Minimum	-750	
Maximum	4100	
Error Code	32767	Invalid data
	32765	Sensor value below minimum
	32766	Sensor value above maximum
Originating from	meteod	
Notes	Measured to 0.05°C	

Field	heating_temperature	
Abbreviation	Th	
Description	Heating temperature of the rain sensor	
Bytes	2	
Data representation	signed integer	
Unit	°C*100	
Minimum	0	
Maximum	10000	
Error Code	32767	Invalid data
	32765	Sensor value below minimum
	32766	Sensor value above maximum
Originating from	meteod	
Notes	Measured to 0.05°C	

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Field	heating_voltage	
Abbreviation	Vh	
Description	Voltage used for the heating device	
Bytes	2	
Data representation	signed integer	
Unit	dV	
Minimum	0	
Maximum	240 (15240, see Notes)	
Error Code	32767	Invalid data
	32765	Sensor value below minimum
	32766	Sensor value above maximum
Originating from	meteod	
Notes	Measured to 0.05V	
	Value	heating option is available but have been disabled by user or the heating temperature is over the high control limit
	Value + 5000	Heating is on 50% duty cycle and heating temperature is between the high and middle control limits
	Value + 10000	Heating is on the 100% duty cycle and the heating temperature is between the low and middle control limits
	Value + 15000	Heating is on the 50% duty cycle and the heating temperature is below the low control limit

Field	supply_voltage	
Abbreviation	Vs	
Description	Supply voltage from the external source	
Bytes	2	
Data representation	signed integer	
Unit	dV	
Minimum	0	
Maximum	240	
Error Code	32767	Invalid data
	32765	Sensor value below minimum
	32766	Sensor value above maximum

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Originating from	meteod
Notes	Measured to 0.05°C

Field	reference_voltage	
Abbreviation	Vr	
Description	3.5V reference voltage	
Bytes	2	
Data representation	signed integer	
Unit	mV	
Minimum	0	
Maximum	4000	
Error Code	32767	Invalid data
	32765	Sensor value below minimum
	32766	Sensor value above maximum
Originating from	meteod	
Notes	Measured to 0.0005°C	

Field	station_ID
Abbreviation	Not available (part of header in ASCII form)
Description	Station ID
Bytes	4
Data representation	character
Unit	n/a
Minimum	n/a
Maximum	n/a
Initial Value	(blanks)
Undefined Value	n/a
Error Code	n/a
Originating from	Metadata
Notes	Typically a 4-letter code

Field	station_Name
Abbreviation	Not available
Description	Station Name
Bytes	32
Data representation	Character

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Unit	n/a
Minimum	n/a
Maximum	n/a
Initial Value	(blanks)
Undefined Value	n/a
Error Code	n/a
Originating from	metadata
Notes	typically, a country and station code

Field	time_of_metadata
Abbreviation	Not available
Description	Gives the time of the measurements
Bytes	4
Data representation	unsigned integer
Unit	seconds since 1.1.1970 00:00:00
Minimum	0
Maximum	2^32-2
Initial Value	0
Undefined Value	2^32-1
Error Code	n/a
Originating from	meteod, bmd, local PC
Notes	no fractions of seconds In contrast to the UNIX time stamp (signed integer) an unsigned integer is used.

Field	latitude_of_sensor
Abbreviation	Not available
Description	geographical latitude of the sensor
Bytes	4
Data representation	signed integer
Unit	10^6 degree (µ°)
Minimum	-90000000
Maximum	90000000
Initial Value	90000000
Undefined Value	n/a
Error Code	n/a
Originating from	metadata

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Notes	

Field	longitude_of_sensor
Abbreviation	Not available
Description	geographical longitude of the sensor
Bytes	4
Data representation	signed integer
Unit	10^6 degree (µ°)
Minimum	0
Maximum	360000000
Initial Value	0
Undefined Value	n/a
Error Code	n/a
Originating from	metadata
Notes	

Field	subsystem_state	
Abbreviation	Not available	
Description	meteo system state indicator	
Bytes	1	
Data representation	unsigned integer	
Unit	n/a	
Minimum	0	
Maximum	255	
Initial Value		
Undefined Value		
Error Code		
Originating from	bmd	
Notes	Bit 0	not defined
	Bit 1	tsunami alarm triggered
	Bit 2	not defined
	Bit 3	not defined
	Bit 4	not defined
	Bit 5	not defined
	Bit 6	not defined
	Bit 7	not defined

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	The tsunami alarm triggers are bmd-internal flags. For description see also reference [AD3]

Field	sensor_status	
Abbreviation	Not available	
Description	indicates the health status of the meteo system	
Bytes	1	
Data representation	unsigned integer	
Unit	n/a	
Minimum	0	
Maximum	200	
Initial Value	255	
Undefined Value	255	
Error Code	n/a	
Originating from	bmd	
Notes	0	Sensor works within its specs
	1	Sensor failure

9.1 File Format Description for binary forms

All data from the *meteod* is written to files. Filename convention and file storage locations are described in [AD3]. File format is a plain file, information is written binary. The meteod_record and the meteod_metadata are written sequentially to the same output file.

Each record is preceded by a unique record identifier of one-byte length. Identifiers are:

0 for meteod_metadata,

3 for meteod_record for tide gauges,

4 for meteod_record for buoys, and

5 for GCO stations.

In Issue 1.0 of this document the identifier had been defined as

2 for meteod_metadata and

1 for meteod_record.

Here, depending on the originating system, the data record has been either for tide gauges (now 3) or buoys (now 4).

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