***E-PROFILE Programme***

***MWR NetCDF Level 1 data format description***

Prepared by: **E-PROFILE MWR Data Format Task Force**

Summary: **E-PROFILE** **MWR data format description**

Action required: **For information and comment**

Distribution: **EUMETNET Members and Partners**

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| --- | --- | --- | --- |
| Reference | **Date** | **Author(s)** | **Content** |
| Version 1.0 | 31/03/2020 | MWR Data Format Task Force: Rolf Rüfenacht, Emiliano Orlandi, Bernhard Posphical, Harald Czekala, Christine Knist, Nico Cimini, Simone Bircher-Adrot, Myles Turp, Pauline Martinet, Ulrich Loehnert, Claire Merker | Initiation of draft after first meeting of MWR Data Format Task Force on 18 Mar 2020 |
| Version 1.1 | 17/07/2020 | MWR Data Format Task Force | Amendments of various members of MWR Data Format Task Force and inclusion of decisions taken during task force meeting on 17 Jun 2020 |
| Version 1.2 | 01/09/2020 | MWR Data Format Task Force | Remove L2 data format documentation - this document now only contains the L1 data format. Amendments of various members of MWR Data Format Task Force and inclusion of decisions taken during task force meeting on 25 Aug 2020 |
| Version 1.3 | 21/09/2020 | MWR Data Format Task Force | Amendments based on discussions during task force meeting on 15 Sep 2020 |
| Version 1.4 | 02/06/2021 | MWR Data Format Task Force | Inclusion of decisions taken during task force meeting on 12 Jan 2021 |
| Version 1.5 | 09/02/2022 | Rolf Rüfenacht, Bernhard Pospichal, Tobias Marke | Pre-meeting amendments for discussion on 11 Feb 2022 |
| Version 1.6 | 22/02/2022 | MWR Data fromat task force incl. new member Tobias Marke | Inclusion of decisions from meeting of 11 Feb 2022 plus work on time bounds and IR pointing |
| Version 1.7 | 16/05/2022 | Rolf Rüfenacht | Amendments from learnings during coding of mwr\_raw2l1 |
| Version 1.8 | 07/06/2022 | MWR Data Format Task Force | Amendments based on discussions during task force meeting on 03 Jun 2022 |
|  |  |  |  |
|  |  |  |  |

# Level 1: L1 - MWR TB data (1B01)

## Basics

This file provides time series of MWR brightness temperature (TB) data in variable “tb”, along with system parameters and quality flags, i.e. all necessary information so that respective raw files are not needed anymore for retrieval of L2 data products. These data correspond to data level 1B and are denoted 1B01. Data potentially coming from different elevation angles are flattened to simple time series (elevation is not a dimension) but the pointing\_flag allows to unambiguously reconstruct scans.

The file is written in NetCDF4 format using the NetCDF Climate and Forecast (CF) Metadata Conventions.

## Filename Convention

**MWR\_1B01\_N-NNNNN-N-NNNNN\_IyyyymmddHHMM.nc**

Where:

**MWR** Instruments of type microwave radiometer

**1** for level 1

**B01** is the code specifying the data type (e.g. B01 for MWR TB, B11 for IR, B21 for auxiliary meteorological data, C01 for collocated MWR TB, IR and aux met data)

**N-NNNNN-N-NNNNN** = WIGOS ID (https://wiswiki.wmo.int/tiki-index.php?page=WIGOS-Identifiers).In all WIGOS ID’s allocated after June 2016 the Issuer of the Identifier - second block from the left “NNNNN” – should correspond to the numeric ISO country code. If no WIGOS ID is available, a temporary code will be provided by the E-PROFILE network manager. E-PROFILE will help to contact the appropriate representative to get a corresponding WIGOS ID.

**I** = Instrument identifier. Should be A if there is only one instrument on the station. Additional instruments are identified with the letters B, C, D etc.

**yyyymmddHHMM** = The starting date of the observation of instant files (in case of the concatenated daily files only **yyyymmdd** is used). Time and date shall be indicated in UTC.

Please note that there is no distinction in the filename between zenith observations and boundary layer scans (the different integration times of the two observation methods go into the boundary variables).

## Global attributes

|  |  |  |
| --- | --- | --- |
| **ATTRIBUTE NAME** | **DESCRIPTION** | **Example, comments** |
| conventions | Name of the conventions followed by the dataset | “CF-1.8” |
| title | A succinct description of what is in the dataset, composed of instrument type and site name | e.g. “HATPRO G5 MWR at Lindenberg, Germany (Deutscher Wetterdienst (DWD))” |
| history | Versioning of the datasets (containing date and software version) | e.g. “20191211 raw2l1 2.1.19” |
| institution | Where the original data was produced |  |
| source | The method of production of the original data | “Ground Based Remote Sensing” |
| comment | Miscellaneous Information about the dataset or methods used to produce it |  |
| references | References that describe the data or methods used to produce it | E-PROFILE data format description document |
| site\_location | Name of measurement station | e.g. “Lindenberg, Germany” |
| instrument\_id | E-PROFILE instrument identifier | “A” if there is only one instrument on the station. Additional instruments are identified with the letters B, C, etc. |
| wigos\_station\_id | WIGOS Station identifier acording to WIGOS convention | e.g. “0-20000-0-10393”  *Note: in all WIGOS ID’s allocated after June 2016 the Issuer of the Identifier - second block from the left “NNNNN” – should correspond to the numeric ISO country code.* |
| principal\_investigator | Department responsible for the instrument | *Note: This should not include the individual name due to issues with Data Protection Act* |
| instrument\_manufacturer | Manufacturer of the instrument | e.g. RPG, Radiometrics, ATTEX, home-grown, ... |
| instrument\_model | Instrument model | e.g. for RPG: HATPRO, HUMPRO, LHATPRO, LWP, TEMPRO;  e.g. for Radiometrics: MP3000, MP2500, MP1500;  e.g. for ATTEX:  MTP-5  e.g. for home-grown: TROWARA |
| instrument\_generation | Instrument generation | e.g. for RPG HATPRO: G2, G3, G4, G5; for ATTEX MTP-5: 5H, 5HE, 5PE; for Radiometrics MP3000: MP3000, MP3000-A |
| instrument\_hw\_id | Specific to mainboard |  |
| network\_name | Name of network(s) that instrument may be part of | e.g. E-PROFILE, ACTRIS, DWD, MWRnet, ACTRIS,  *Note: Possibility to add multiple* |
| campaign\_name | Name of campaign instrument may collect data for | e.g. MOSAIC |
| dependencies | List of files the data set is depending on | *Note: for higher level products: <file name> (without date) of the depending data set or ”external” (for all data sets not archived in the database)* |
| license | Data license |  |
| instrument\_calibration\_status | Status of instrument absolute calibration | calibrated, needs calibration, diagnosed\_unfit |
| receiver1\_date\_of\_last\_absolute\_calibration | Time of last (automatic or manual) absolute calibration of receiver 1 |  |
| receiver1\_type\_of\_last\_absolute\_calibration | Type of last (automatic or manual) absolute calibration of receiver 1 | if possible, prefer one of the following formulations:  “liquid nitrogen calibration”  “sky tipping calibration”  “instrument performs no absolute calibration” |
| receiver2\_date\_of\_last\_absolute\_calibration | Time of last (automatic or manual) absolute calibration of receiver 2 | as for receiver1.  Only specify if n\_receivers>1. For n\_receivers>2 add receiver3, receiver4, receiver5 etc. to best describe your instrument |
| receiver2\_type\_of\_last\_absolute\_calibration | Type of last (automatic or manual) absolute calibration of receiver 2 | as for receiver1.  Only specify if n\_receivers>1. For n\_receivers>2 add receiver3, receiver4, receiver5 etc. to best describe your instrument |
| receiver1\_type\_of\_automatic\_calibrations | Type of automatic calibrations performed for receiver 1 | if possible, prefer one of the following formulations:  “calibration with ambient temperature target and noise diode”  “calibration with ambient temperature target and noise diode with high-frequency noise switching”  “calibration with noise diode and quasi-opaque atmosphere at low elevation”  “sky tipping calibration” |
| receiver2\_type\_of\_automatic\_calibrations | Type of automatic calibrations performed for receiver 2 | as for receiver1.  Only specify if n\_receivers>1. For n\_receivers>2 add receiver3, receiver4, receiver5 etc. to best describe your instrument |
| date\_of\_last\_covariance\_matrix | Time of last covariance update |  |
| instrument\_history | Logbook repair/replacement work performed | e.g. change of the radome |

## Dimensions

|  |  |
| --- | --- |
| **Dimension name** | **Description** |
| time |  |
| frequency | Number of microwave channels |
| receiver\_nb | Number of receivers (e.g. distinct receivers for K- and V-band) |
| bnds | 2 (number of bounds for time) |

## Variables

|  |  |  |
| --- | --- | --- |
| **Variable name** | **Long\_name** | **Attributes** |
| time | Time (UTC) of the measurement | standard\_name: time  dimension: time  units: seconds since 1970-01-01 00:00:00.000  bounds = “time\_bnds”  comment = "Time indication of samples is at end of integration-time" ; |
| time\_bnds | Start and end time (UTC) of the measurement | dimension: time, bnds  units: seconds since 1970-01-01 00:00:00.000 |
| station\_latitude | Latitude of measurement station | standard\_name : latitude  dimension: time  units : degree\_north |
| station\_longitude | Longitude of measurement station | standard\_name : longitude  dimension: time  units : degree\_east |
| station\_altitude | Altitude above mean sea level of measurement station | standard\_name: altitude  dimension: time  units: m |
| frequency | Nominal centre Frequency of microwave channels | standard\_name : radiation\_frequency  dimension: frequency  units: GHz  comment: “1) For double-sideband receivers, frequency corresponds to the local oscillator frequency whereas the radio frequency of the upper/lower sideband is frequency+/-sideband\_IF\_separation. 2) In case of known offset between the real and the nominal frequency of some channels, frequency+freq\_shift gives more accurate values.” |
| receiver\_nb | Number of the microwave receiver | dimension: receiver\_nb  comment: “Different numbers correspond to distinct receiver boards. The variable receiver indicates which frequency channels correspond to each receiver board.”  units:1  can contain numbers 1, 2, ... |
| receiver | Corresponding microwave receiver for each channel | dimension: frequency  comment: “Different numbers correspond to distinct receiver boards defined in receiver\_nb.”  units: 1  can contain numbers 1, 2, ... |
| bandwidth | Bandwidth (3 dB) of the microwave channels | dimension: frequency  Units: GHz  \_FillValue: -999.9 |
| n\_sidebands | Number of sidebands | dimension: receiver\_nb  comment: “0 corresponds to direct-detection receivers, 1 to single-sideband, 2 to double-sideband receivers. For double sideband, the frequency separation of sidebands is indicated in sideband\_IF\_separation.”  units: 1 |
| sideband\_IF\_separation | IF centre frequency as abs(RF-LO) | dimension: frequency  comment: “For double sideband channels, this is the positive and negative frequency offset of the two sidebands around the centre frequency (which is the LO frqeuency). This value is 0 if n\_sidebands = 0 or 1”  units: GHz  \_FillValue: -999.9 |
| beamwidth | Beam width (FWHM) of the microwave radiometer | dimension: frequency  units: degree  \_FillValue: -999.9 |
| freq\_shift | Frequency shift to add to frequency for better accuracy | dimension: frequency  units: GHzcomment: “For more accurate frequency values use frequency+freq\_shift”\_FillValue: -999.9  *Note: this shall not be used for improving O-B statistics but only for known real frequency offset of the reported tb with respect to the nominal frequencies* |
| **tb** | **Microwave brightness temperatures** | **standard\_name: brightness\_temperature**  **dimension: time, frequency**  **units: K**  **\_FillValue: -999.9** |
| azi | Sensor azimuth angle | standard\_name: sensor\_azimuth\_angle  dimension: time  units: degree  comment: “0=North, 90=East, 180=South, 270=West”  \_FillValue: -999.9 |
| ele | Sensor elevation angle | dimension: time  units: degree  comment: “0=horizon, 90=zenith  \_FillValue: -999.9 |
| tb\_accuracy | Total absolute calibration uncertainty of brightness temperature, one standard deviation | dimension : frequency  units: K  comment: specify here source of this variable, e.g. literature value, specified by manufacturer, result of validation effort (updated irregularily)  For RDX systems, derived from analysis performed by Tim Hewsion (Tim J. Hewison, 2006: Profiling Temperature and Humidity by Ground-based Microwave Radiometers, PhD Thesis, University of Reading.)  Derived from sensitivity analysis of LN2 calibration plus instrument noise levels (ACTRIS work), currently literature values (Maschwitz et al. for HATPRO, ? for radiometrics)  \_FillValue: -999.9 |
| tb\_cov | Error covariance matrix of brightness temperature channels | dimension: frequency, frequency  units: K\*K  target\_temp: blackbody target temperature used for the calculation of tb\_cov in Kelvin degrees. (e.g., 77.2 K for liquid nitrogen cooled blackbody, in the range 250-330 K for ambient temperature blackbody)  comment: “the covariance matrix has been determined using the xxx method from observations at a blackbody target of temperature target\_temp” where xxx specifies the standardized method used to estimate the covariance matrix  \_FillValue: -999.9 |
| quality\_flag | Quality flag | standard\_name: quality\_flag  dimension: time, frequency  units: 1 (bit variable)  flag\_masks: 1b, 2b, 4b, 8b, 16b, 32b, 64b, 128b  flag\_meanings: “missing\_tb tb\_below\_threshold tb\_above\_threshold spectral\_consistency\_above\_threshold receiver\_sanity\_failed rain\_detected sun\_in\_beam tb\_offset\_above\_threshold”  comment: 0 indicates data with good quality according to applied tests. The list of (not) applied tests is encoded in quality\_flag\_status  \_FillValue: 0b |
| quality\_flag\_status | Checks not executed in determination of quality\_flag | dimension: time, frequency  units: 1 (bit variable)  flag\_masks: 1b, 2b, 4b, 8b, 16b, 32b, 64b, 128b  flag\_meanings: “missing\_tb\_not\_checked tb\_lower\_threshold\_not\_checked tb\_upper\_threshold\_not\_checked spectral\_consistency\_not\_checked receiver\_sanity\_not\_checked rain\_not\_checked sun\_in\_beam\_not\_checked tb\_offset\_not\_checked”  \_FillValue: -128b |
| liquid\_cloud\_flag | Presence of liquid clouds in beam | dimension: time  flag\_values : 0b, 1b, 2b  flag\_meanings: “no\_liquid\_cloud liquid\_cloud\_present undefined”  \_FillValue: -128b  comment: “The way this flag was determined is encoded in liquid\_cloud\_flag\_status” |
| liquid\_cloud\_flag\_status | Method for determination of liquid\_cloud\_flag | dimension: time  flag\_values : 0b, 1b, 2b  flag\_meanings: “using\_mwr\_and\_ir using\_mwr\_only  other”  \_FillValue: -128b |
| pointing\_flag | Flag indicating a single pointing (starring) or multiple pointing (scanning) observation sequence | dimension: time  flag\_values: 0b, 1b, 2b  flag\_meanings: “single\_pointing multiple\_pointing unknown”  comment: “series of multiple-pointing observations (elevation scans) provide more information on boundary layer temperature profiles compared to single pointing observations. If available, it is advised to prefer elevation scans over starring observations for temperature profile retrievals”  \_FillValue: -128b |
| t\_amb | Ambient target temperature | dimension: time, receiver\_nb  units: K  \_FillValue: -999.9 |
| t\_rec | Receiver physical temperature | dimension: time, receiver\_nb  units: K  \_FillValue: -999.9 |
| tn | Receiver noise temperature | dimension: time, receiver\_nb  units: K  \_FillValue: -999.9 |

# Level 1: L1 - IR TB data (1B11)

## Basics

This file provides time series of infrared brightness temperature (IRT) data including system parameters, i.e. all necessary information so that respective raw files are not needed anymore for retrieval of L2 data products. These data correspond to data level 1B and are denoted 1B11.

The file is written in NetCDF4 format using the NetCDF Climate and Forecast (CF) Metadata Conventions.

## Filename Convention

**MWR\_1B11\_N-NNNNN-N-NNNNN\_IyyyymmddHHMM.nc**

Where:

**MWR** Instruments of type microwave radiometer

**1** for level 1

**B11** is the code specifying the data type (e.g. B01 for MWR TB, B11 for IR, B21 for auxiliary meteorological data, C01 for collocated MWR TB, IR and aux met data)

**N-NNNNN-N-NNNNN** = WIGOS ID (https://wiswiki.wmo.int/tiki-index.php?page=WIGOS-Identifiers).In all WIGOS ID’s allocated after June 2016 the Issuer of the Identifier - second block from the left “NNNNN” – should correspond to the numeric ISO country code. If no WIGOS ID is available, a temporary code will be provided by the E-PROFILE network manager. E-PROFILE will help to contact the appropriate representative to get a corresponding WIGOS ID.

**I** = Instrument identifier. Should be A if there is only one instrument on the station. Additional instruments are identified with the letters B, C, D etc.

**yyyymmddHHMM** = The starting date of the observation of instant files (in case of the concatenated daily files only **yyyymmdd** is used) . Time and date shall be indicated in UTC.

## Global Attributes

|  |  |  |
| --- | --- | --- |
| **ATTRIBUTE NAME** | **DESCRIPTION** | **Example, comments** |
| conventions | Name of the conventions followed by the dataset | “CF-1.8” |
| title | A succinct description of what is in the dataset, composed of instrument type and site name | e.g. “HATPRO G5 MWR at Lindenberg, Germany (Deutscher Wetterdienst (DWD))” |
| history | Versioning of the datasets (containing date and software version) | e.g. “20191211 raw2l1 2.1.19” |
| institution | Where the original data was produced |  |
| source | The method of production of the original data | “Ground Based Remote Sensing” |
| comment | Miscellaneous Information about the dataset or methods used to produce it |  |
| references | References that describe the data or methods used to produce it | E-PROFILE data format description document |
| site\_location | Name of measurement station | e.g. “Lindenberg, Germany” |
| instrument\_id | E-PROFILE instrument identifier | “A” if there is only one instrument on the station. Additional instruments are identified with the letters B, C, etc. |
| wigos\_station\_id | WIGOS Station identifier acording to WIGOS convention | e.g. “0-20000-0-10393”  *Note: in all WIGOS ID’s allocated after June 2016 the Issuer of the Identifier - second block from the left “NNNNN” – should correspond to the numeric ISO country code.* |
| principal\_investigator | Department responsible for the instrument | *Note: This should not include the individual name due to issues with Data Protection Act* |
| ir\_instrument\_manufacturer | Manufacturer of the infrared radiometer | e.g. Heitronics, Heimann |
| ir\_instrument\_model | Infrared radiometer model | e.g. KT19.85 |
| network\_name | Name of network(s) that instrument may be part of | e.g. E-PROFILE, ACTRIS, DWD, MWRnet, ACTRIS,  *Note: Possibility to add multiple* |
| campaign\_name | Name of campaign instrument may collect data for | e.g. MOSAIC |
| license | Data license | For non-commercial use only. This data is subject …. |
| instrument\_history | Logbook repair/replacement work performed | e.g. replacement of gold mirror, |
| ir\_instrument\_fabrication\_year | Fabrication year of the infrared radiometer |  |

## Dimensions

|  |  |
| --- | --- |
| **Dimension name** | **Description** |
| time |  |
| ir\_wavelength | Number of infrared channels |
| bnds | 2 (number of bounds for time) |

## Variables

|  |  |  |
| --- | --- | --- |
| **Variable name** | **Long\_name** | **Attributes** |
| time | Time (UTC) of the measurement | standard\_name: time  dimension: time  units: seconds since 1970-01-01 00:00:00.000  bounds = “time\_bnds” ;  comment = "Time indication of samples is at end of integration-time" ; |
| time\_bnds | Start and end time (UTC) of the measurement | dimension: time, bnds  units: seconds since 1970-01-01 00:00:00.000 |
| station\_latitude | Latitude of measurement station | standard\_name : latitude  dimension: time  units : degree\_north |
| station\_longitude | Longitude of measurement station | standard\_name : longitude  dimension: time  units : degree\_east |
| station\_altitude | Altitude above mean sea level of measurement station | standard\_name: altitude  dimension: time  units: m |
| ir\_wavelength | Wavelength of infrared channels | standard\_name : sensor\_band\_central\_radiation\_wavelength  dimension: ir\_wavelength  units: um |
| ir\_bandwidth | Bandwidth (3 dB) of the infrared channels | dimension: ir\_wavelength  Units: um  \_FillValue: -999.9 |
| ir\_beamwidth | Beam width (3 dB) of the of the infrared radiometer | dimension: ir\_wavelength  units: degree  \_FillValue: -999.9 |
| irt | Infrared brightness temperatures | dimension:time, ir\_wavelength  units: K  \_FillValue: -999.9 |
| ir\_azi | Infrared sensor azimuth angle | standard\_name: sensor\_azimuth\_angle  dimension: time  units: degree  comment: “0=North, 90=East, 180=South, 270=West”  \_FillValue: -999.9 |
| ir\_ele | Infrared sensor elevation angle | dimension: time  units: degree  comment: “0=horizon, 90=zenith  \_FillValue: -999.9 |
| irt\_accuracy | Total absolute calibration uncertainty of infrared brightness temperature, one standard deviation | dimension : ir\_wavelength  units: K  comment: specify here source of this variable, e.g. literature value, specified by manufacturer, result of validation effort (updated irregularly).  \_FillValue: -999.9 |

# Level 1: L1 – Auxiliary meteorological data (1B21)

## Basics

This file provides time series of auxiliary meteorological data including system parameters, i.e. all necessary information so that respective raw files are not needed anymore for retrieval of L2 data products. These data correspond to data level 1B and are denoted 1B21.

The file is written in NetCDF4 format using the NetCDF Climate and Forecast (CF) Metadata Conventions.

## Filename Convention

**MWR\_1B21\_N-NNNNN-N-NNNNN\_IyyyymmddHHMM.nc**

Where:

**MWR** Instruments of type microwave radiometer

**1** for level 1

**B21** is the code specifying the data type (e.g. B01 for MWR TB, B11 for IR, B21 for auxiliary meteorological data, C01 for collocated MWR TB, IR and aux met data)

**N-NNNNN-N-NNNNN** = WIGOS ID (https://wiswiki.wmo.int/tiki-index.php?page=WIGOS-Identifiers).In all WIGOS ID’s allocated after June 2016 the Issuer of the Identifier - second block from the left “NNNNN” – should correspond to the numeric ISO country code. If no WIGOS ID is available, a temporary code will be provided by the E-PROFILE network manager. E-PROFILE will help to contact the appropriate representative to get a corresponding WIGOS ID.

**I** = Instrument identifier. Should be A if there is only one instrument on the station. Additional instruments are identified with the letters B, C, D etc.

**yyyymmddHHMM** = The starting date of the observation of instant files (in case of the concatenated daily files only **yyyymmdd** is used) . Time and date shall be indicated in UTC.

## Global Attributes

|  |  |  |
| --- | --- | --- |
| **ATTRIBUTE NAME** | **DESCRIPTION** | **Example, comments** |
| conventions | Name of the conventions followed by the dataset | “CF-1.8” |
| title | A succinct description of what is in the dataset, composed of instrument type and site name | e.g. “HATPRO G5 MWR at Lindenberg, Germany (Deutscher Wetterdienst (DWD))” |
| history | Versioning of the datasets (containing date and software version) | e.g. “20191211 raw2l1 2.1.19” |
| institution | Where the original data was produced |  |
| source | The method of production of the original data | “Ground Based Remote Sensing” |
| comment | Miscellaneous Information about the dataset or methods used to produce it |  |
| references | References that describe the data or methods used to produce it | E-PROFILE data format description document |
| site\_location | Name of measurement station | e.g. “Lindenberg, Germany” |
| instrument\_id | E-PROFILE instrument identifier | “A” if there is only one instrument on the station. Additional instruments are identified with the letters B, C, etc. |
| wigos\_station\_id | WIGOS Station identifier acording to WIGOS convention | e.g. “0-20000-0-10393”  *Note: in all WIGOS ID’s allocated after June 2016 the Issuer of the Identifier - second block from the left “NNNNN” – should correspond to the numeric ISO country code.* |
| principal\_investigator | Department responsible for the instrument | *Note: This should not include the individual name due to issues with Data Protection Act* |
| met\_instrument\_manufacturer | Manufacturer of the weather station | e.g. Vaisala, Lufft, Reinhardt |
| met\_instrument\_model | Weather station model | e.g. WXT536, WS600, MWS3 |
| network\_name | Name of network(s) that instrument may be part of | e.g. E-PROFILE, ACTRIS, DWD, MWRnet, ACTRIS,  *Note: Possibility to add multiple* |
| campaign\_name | Name of campaign instrument may collect data for | e.g. MOSAIC |
| license | Data license |  |
| instrument\_history | Logbook repair/replacement work performed | e.g. replacement of the temperature and humidity sensor unit, |
| air\_temperature\_accuracy | Air temperature accuracy. Unit: K. |  |
| relative\_humidity\_accuracy | Relative humidity accuracy. Unit: 1. | *Note: source of this variable will be specified, e.g. literature value, specified by manufacturer, result of validation effort* |
| air\_pressure\_accuracy | Air pressure accuracy. Unit: hPa. | *Note: source of this variable will be specified, e.g. literature value, specified by manufacturer, result of validation effort* |
| rain\_rate\_accuracy | Rain rate accuracy. Unit: mm/h. | *Note: source of this variable will be specified, e.g. literature value, specified by manufacturer, result of validation effort* |
| wind\_direction\_accuracy | Wind direction accuracy. Unit: degrees. | *Note: source of this variable will be specified, e.g. literature value, specified by manufacturer, result of validation effort* |
| wind\_speed\_accuracy | Wind speed accuracy. Unit: m/s. | *Note: source of this variable will be specified, e.g. literature value, specified by manufacturer, result of validation effort* |
| met\_instrument\_fabrication\_year | Fabrication year of the weather station |  |

## Dimensions

|  |  |
| --- | --- |
| **Dimension name** | **Description** |
| time |  |
| bnds | 2 (number of bounds for time) |

## Variables

|  |  |  |
| --- | --- | --- |
| **Variable name** | **Long\_name** | **Attributes** |
| time | Time (UTC) of the measurement | standard\_name: time  dimension: time  units: seconds since 1970-01-01 00:00:00.000  bounds = “time\_bnds” ;  comment = "Time indication of samples is at end of integration-time" ; |
| time\_bnds | Start and end time (UTC) of the measurement | dimension: time, bnds  units: seconds since 1970-01-01 00:00:00.000 |
| station\_latitude | Latitude of measurement station | standard\_name : latitude  dimension: time  units : degree\_north |
| station\_longitude | Longitude of measurement station | standard\_name : longitude  dimension: time  units : degree\_east |
| station\_altitude | Altitude above mean sea level of measurement station | standard\_name: altitude  dimension: time  units: m |
| air\_temperature | Air temperature | standard\_name: air\_temperature  dimension: time  units: K  \_FillValue: -999.9 |
| relative\_humidity | Relative humidity | standard\_name: relative\_humidity  dimension: time  units: 1  \_FillValue: -999.9 |
| air\_pressure | Air pressure | standard\_name: air\_pressure  dimension: time  units: hPa  \_FillValue: -999.9 |
| rain\_rate | Precipitation amount | standard\_name: rainfall\_rate  dimension: time  units: mm/h  \_FillValue: -999.9 |
| wind\_direction | Wind direction | standard\_name: wind\_from\_direction  dimension: time  units: degree  \_FillValue: -999.9 |
| wind\_speed | Wind speed | standard\_name: wind\_speed  dimension: time  units: m/s  \_FillValue: -999.9 |
| met\_quality\_flag | Meterological data quality flag | dimension: time  units: 1 (bit variable: 0=ok, 1=problem)  flag\_masks: 1b, 2b, 4b, 8b, 16b, 32b  flag\_meanings: “low\_quality\_air\_temperature low\_quality\_relative\_humidity low\_quality\_air\_pressure low\_quality\_rain\_rate low\_quality\_wind\_direction low\_quality\_wind\_speed”  \_FillValue: 0b  *Note: should also be set to 1 if corresponding sensor not available* |
| met\_quality\_flag\_status | Meteorological data quality checks not applied | dimension: time  units: 1 (bit variable: 0=ok, 1=problem)  flag\_masks: 1b, 2b, 4b, 8b, 16b, 32b  flag\_meanings: “air\_temperature\_quality\_not\_checked relative\_humidity\_quality\_not\_checked air\_pressure\_quality\_not\_checked rain\_rate\_quality\_not\_checked wind\_direction\_quality\_not\_checked wind\_speed\_quality\_not\_checked”  \_FillValue: -128b |

# Level 1: L1 – Collocated MWR TB, IR TB and auxiliary meteorological data (1C01)

## Basics

This file provides time series of MWR brightness temperatures (TB) in variable “tb”, infrared brightness temperatures (IRT) in variable “irt”, and auxiliary meteorological data (MET) along with system parameters and quality flags, i.e. all necessary information so that respective raw files are not needed anymore for retrieval of L2 data products. For further details on its contents, please refer also to the description of 1B01, 1B11 and 1B21. In 1C01, the time series of IRT and MET data are collocated in time with the MWR brightness temperatures, i.e. all data use the time grid of TB.. The format preserves the original temporal resolution of the TB data (with differing integration times between zenith observations and boundary layer scans). These data correspond to data level 1C and are denoted 1C01.

The file is written in NetCDF4 format using the NetCDF Climate and Forecast (CF) Metadata Conventions.

## Filename Convention

**MWR\_1C01\_N-NNNNN-N-NNNNN\_IyyyymmddHHMM.nc**

Where:

**MWR** Instruments of type microwave radiometer

**1** for level 1

**C01** is the code specifying the data type (e.g. B01 for MWR TB, B11 for IR, B21 for auxiliary meteorological data, C01 for collocated MWR TB, IR and aux met data)

**N-NNNNN-N-NNNNN** = WIGOS ID (https://wiswiki.wmo.int/tiki-index.php?page=WIGOS-Identifiers).In all WIGOS ID’s allocated after June 2016 the Issuer of the Identifier - second block from the left “NNNNN” – should correspond to the numeric ISO country code. If no WIGOS ID is available, a temporary code will be provided by the E-PROFILE network manager. E-PROFILE will help to contact the appropriate representative to get a corresponding WIGOS ID.

**I** = Instrument identifier. Should be A if there is only one instrument on the station. Additional instruments are identified with the letters B, C, D etc.

**yyyymmddHHMM** = The starting date of the observation of instant files (in case of the concatenated daily files only **yyyymmdd** is used) . Time and date shall be indicated in UTC.

## Global Attributes

|  |  |  |
| --- | --- | --- |
| **ATTRIBUTE NAME** | **DESCRIPTION** | **Example, comments** |
| conventions | Name of the conventions followed by the dataset | “CF-1.8” |
| title | A succinct description of what is in the dataset, composed of instrument type and site name | e.g. “HATPRO G5 MWR at Lindenberg, Germany (Deutscher Wetterdienst (DWD))” |
| history | Versioning of the datasets (containing date and software version) | e.g. “20191211 raw2l1 2.1.19” |
| institution | Where the original data was produced |  |
| source | The method of production of the original data | “Ground Based Remote Sensing” |
| comment | Miscellaneous Information about the dataset or methods used to produce it |  |
| references | References that describe the data or methods used to produce it | E-PROFILE data format description document |
| site\_location | Name of measurement station | e.g. “Lindenberg, Germany” |
| instrument\_id | E-PROFILE instrument identifier | “A” if there is only one instrument on the station. Additional instruments are identified with the letters B, C, etc. |
| wigos\_station\_id | WIGOS Station identifier acording to WIGOS convention | e.g. “0-20000-0-10393”  *Note: in all WIGOS ID’s allocated after June 2016 the Issuer of the Identifier - second block from the left “NNNNN” – should correspond to the numeric ISO country code.* |
| principal\_investigator | Department responsible for the instrument | *Note: This should not include the individual name due to issues with Data Protection Act* |
| instrument\_manufacturer | Manufacturer of the instrument | e.g. RPG, Radiometrics, ATTEX, home-grown, ... |
| instrument\_model | Instrument model | e.g. for RPG: HATPRO, HUMPRO, LHATPRO, LWP, TEMPRO;  e.g. for Radiometrics: MP3000, MP2500, MP1500;  e.g. for ATTEX:  MTP-5  e.g. for home-grown: TROWARA |
| instrument\_generation | Instrument generation | e.g. for RPG HATPRO: G2, G3, G4, G5; for ATTEX MTP-5: 5H, 5HE, 5PE; for Radiometrics MP3000: MP3000, MP3000-A |
| instrument\_hw\_id | Specific to mainboard |  |
| network\_name | Name of network(s) that instrument may be part of | e.g. E-PROFILE, ACTRIS, DWD, MWRnet, ACTRIS,  *Note: Possibility to add multiple* |
| campaign\_name | Name of campaign instrument may collect data for | e.g. MOSAIC |
| dependencies | List of files the data set is depending on | *Note: for higher level products: <file name> (without date) of the depending data set or ”external” (for all data sets not archived in the database)* |
| license | Data license |  |
| instrument\_calibration\_status | Status of instrument absolute calibration | calibrated, needs calibration, diagnosed\_unfit |
| receiver1\_date\_of\_last\_absolute\_calibration | Time of last (automatic or manual) absolute calibration of receiver 1; |  |
| receiver1\_type\_of\_last\_absolute\_calibration | Type of last (automatic or manual) absolute calibration of receiver 1; | if possible, prefer one of the following formulations:  “liquid nitrogen calibration”  “sky tipping calibration”  “instrument performs no absolute calibration” |
| receiver2\_date\_of\_last\_absolute\_calibration | Time of last (automatic or manual) absolute calibration of receiver 2; | as for receiver1.  Only specify if n\_receivers>1. For n\_receivers>2 add receiver3, receiver4, receiver5 etc. to best describe your instrument |
| receiver2\_type\_of\_last\_absolute\_calibration | Type of last (automatic or manual) absolute calibration of receiver 2; | as for receiver1.  Only specify if n\_receivers>1. For n\_receivers>2 add receiver3, receiver4, receiver5 etc. to best describe your instrument |
| receiver1\_type\_of\_automatic\_calibrations | Type of automatic calibrations performed for receiver 1 | if possible, prefer one of the following formulations:  “calibration with ambient temperature target and noise diode”  “calibration with ambient temperature target and noise diode with high-frequency noise switching”  “calibration with noise diode and quasi-opaque atmosphere at low elevation”  “sky tipping calibration” |
| receiver2\_type\_of\_automatic\_calibrations | Type of automatic calibrations performed for receiver 2 | as for receiver1.  Only specify if n\_receivers>1. For n\_receivers>2 add receiver3, receiver4, receiver5 etc. to best describe your instrument |
| date\_of\_last\_covariance\_matrix | Time of last covariance update |  |
| type\_of\_automatic\_calibrations | Description of the type of automatic calibrations performed including information at calibration interval and respective integration time | if possible, prefer one of the following formulations:  “calibration with ambient temperature target and noise diode”  “calibration with ambient temperature target and noise diode with high-frequency noise switching”  “calibration with ambient temperature target and quasi-opaque atmosphere at low elevation”  “sky tipping calibration” |
| instrument\_history | Logbook repair/replacement work performed | e.g. change of the radome, replacement of the infrared radiometer gold mirror, replacement of the temperature and humidity sensor unit. |
| ir\_instrument\_manufacturer | Manufacturer of the infrared radiometer | e.g. Heitronics |
| ir\_instrument\_model | Infrared radiometer model | e.g. KT19.85 |
| ir\_instrument\_fabrication\_year | Fabrication year of the infrared radiometer |  |
| met\_instrument\_manufacturer | Manufacturer of the weather station | e.g. Vaisala, Lufft, Reinhardt |
| met\_instrument\_model | Weather station model | e.g. WXT536, WS600, MWS3 |
| met\_instrument\_fabrication\_year | Fabrication year of the weather station |  |
| air\_temperature\_accuracy | Air temperature accuracy. Unit: K. | *Note: source of this variable will be specified, e.g. literature value, specified by manufacturer, result of validation effort* |
| relative\_humidity\_accuracy | Relative humidity accuracy. Unit: 1. | *Note: source of this variable will be specified, e.g. literature value, specified by manufacturer, result of validation effort* |
| air\_pressure\_accuracy | Air pressure accuracy. Unit: hPa. | *Note: source of this variable will be specified, e.g. literature value, specified by manufacturer, result of validation effort* |
| rain\_rate\_accuracy | Rain rate accuracy. Unit: mm/h. | *Note: source of this variable will be specified, e.g. literature value, specified by manufacturer, result of validation effort* |
| wind\_direction\_accuracy | Wind direction accuracy. Unit: degrees. | *Note: source of this variable will be specified, e.g. literature value, specified by manufacturer, result of validation effort* |
| wind\_speed\_accuracy | Wind speed accuracy. Unit: m/s. | *Note: source of this variable will be specified, e.g. literature value, specified by manufacturer, result of validation effort* |

## Dimensions

|  |  |
| --- | --- |
| **Dimension name** | **Description** |
| time |  |
| frequency | Number of microwave channels |
| ir\_wavelength | Number of infrared channels |
| receiver\_nb | Number of receivers (e.g. distinct receivers for K- and V-band) |

## Variables

|  |  |  |
| --- | --- | --- |
| **Variable name** | **Long\_name** | **Attributes** |
| time | Time (UTC) of the measurement | standard\_name: time  dimension: time  units: seconds since 1970-01-01 00:00:00.000  bounds = “time\_bnds” ;  comment = "Time indication of samples is at end of integration-time" ; |
| time\_bnds | Start and end time (UTC) of the measurement | dimension: time, bnds  units: seconds since 1970-01-01 00:00:00.000 |
| station\_latitude | Latitude of measurement station | standard\_name : latitude  dimension: time  units : degree\_north |
| station\_longitude | Longitude of measurement station | standard\_name : longitude  dimension: time  units : degree\_east |
| station\_altitude | Altitude above mean sea level of measurement station | standard\_name: altitude  dimension: time  units: m |
| frequency | Nominal centre Frequency of microwave channels | standard\_name : radiation\_frequency  dimension: frequency  units: GHz  comment: “1) For double-sideband receivers, frequency corresponds to the local oscillator frequency whereas the radio frequency of the upper/lower sideband is frequency+/-sideband\_IF\_separation. 2) In case of known offset between the real and the nominal frequency of some channels, frequency+freq\_shift gives more accurate values.” |
| receiver\_nb | Number of the microwave receiver | dimension: receiver\_nb  comment: “Different numbers correspond to distinct receiver boards. The variable receiver indicates which frequency channels correspond to each receiver board.”  can contain numbers 1, 2, ... |
| receiver | Corresponding microwave receiver for each channel | dimension: frequency  comment: “Different numbers correspond to distinct receiver boards defined in receiver\_nb.”  can contain numbers 1, 2, ... |
| bandwidth | Bandwidth (3 dB) of the microwave channels | dimension: frequency  Units: GHz  \_FillValue: -999.9 |
| n\_sidebands | Number of sidebands | dimension: receiver\_nb  comment: “0 corresponds to direct-detection receivers, 1 to single-sideband, 2 to double-sideband receivers. For double sideband, the frequency separation of sidebands is indicated in sideband\_IF\_separation.”  units: 1 |
| sideband\_IF\_separation | IF centre frequency as abs(RF-LO) | dimension: frequency  comment: “For double sideband channels, this is the positive and negative frequency offset of the two sidebands around the centre frequency (which is the LO frqeuency). This value is 0 if n\_sidebands = 0 or 1”  units: GHz  \_FillValue: -999.9 |
| beamwidth | Beam width (FWHM) of the microwave radiometer | dimension: frequency  units: degree |
| freq\_shift | Frequency shift to add to frequency for better accuracy | dimension: frequency  units: GHz  comment: “For more accurate frequency values use frequency+freq\_shift”  \_FillValue: -999.9  *Note: this shall not be used for improving O-B statistics but only for known real frequency offset of the reported tb with respect to the nominal frequencies* |
| **tb** | **Microwave brightness temperatures** | **standard\_name: brightness\_temperature**  **dimension:time, frequency**  **units: K**  **\_FillValue: -999.9** |
| azi | Microwave sensor azimuth angle | standard\_name: sensor\_azimuth\_angle  dimension: time  units: degree  comment: “0=North, 90=East, 180=South, 270=West”  \_FillValue: -999.9 |
| ele | Microwave sensor elevation angle | dimension: time  units: degree  comment: “0=horizon, 90=zenith  \_FillValue: -999.9 |
| tb\_accuracy | Total absolute calibration uncertainty of brightness temperature, one standard deviation | dimension : frequency  units: K  comment: specify here source of this variable, e.g. literature value, specified by manufacturer, result of validation effort (updated irregularily)  For RDX systems, derived from analysis performed by Tim Hewsion (Tim J. Hewison, 2006: Profiling Temperature and Humidity by Ground-based Microwave Radiometers, PhD Thesis, University of Reading.)  Derived from sensitivity analysis of LN2 calibration plus instrument noise levels (ACTRIS work), currently literature values (Maschwitz et al. for HATPRO, ? for radiometrics)  \_FillValue: -999.9 |
| tb\_cov | Error covariance matrix of microwave brightness temperature channels | dimension: frequency, frequency)  units: K\*K  target\_temp: blackbody target temperature used for the calculation of tb\_cov in Kelvin degrees. (e.g., 77.2 K for liquid nitrogen cooled blackbody, in the range 250-330 K for ambient temperature blackbody)  comment: “the covariance matrix has been determined using the xxx method from observations at a blackbody target of temperature target\_temp” where xxx specifies the standardized method used to estimate the covariance matrix  \_FillValue: -999.9 |
| quality\_flag | Quality\_flag | standard\_name: quality\_flag  dimension: time, frequency  units: 1 (bit variable)  flag\_masks: 1b, 2b, 4b, 8b, 16b, 32b, 64b, 128b  flag\_meanings:  “missing\_tb tb\_below\_threshold tb\_above\_threshold spectral\_consistency\_above\_threshold receiver\_sanity\_failed rain\_detected sun\_in\_beam tb\_offset\_above\_threshold”  comment: 0 indicates data with good quality according to applied tests. The list of (not) applied tests is encoded in quality\_flag\_status  \_FillValue: 0b |
| quality\_flag\_status | Checks not executed in determination of quality\_flag | Dimension: time, frequency  units: 1 (bit variable)  flag\_masks: 1b, 2b, 4b, 8b, 16b, 32b, 64b, 128b  flag\_meanings:  “missing\_tb\_not\_checked tb\_lower\_threshold\_not\_checked tb\_upper\_threshold\_not\_checked spectral\_consistency\_not\_checked receiver\_sanity\_not\_checked rain\_not\_checked sun\_in\_beam\_not\_checked tb\_offset\_not\_checked”  \_FillValue: -128b |
| liquid\_cloud\_flag | Presence of liquid clouds in beam | dimension: time  flag\_values : 0b, 1b, 2b  flag\_meanings: “no\_liquid\_cloud liquid\_cloud\_present undefined”  \_FillValue: -128b  comment: “The way this flag was determined is encoded in liquid\_cloud\_flag\_status” |
| liquid\_cloud\_flag\_status | Method for determination of liquid\_cloud\_flag | dimension: time  flag\_values : 0b, 1b, 2b  flag\_meanings: “using\_mwr\_and\_ir using\_mwr\_only  other”  \_FillValue: -128b |
| pointing\_flag | Flag indicating a single pointing (starring) or multiple pointing (scanning) observation sequence | dimension: time  flag\_values: 0b, 1b, 2b  flag\_meanings: “single\_pointing multiple\_pointing unknown”  comment: “series of multiple-pointing observations (elevation scans) provide more information on boundary layer temperature profiles compared to single pointing observations. If available, it is advised to prefer elevation scans over starring observations for temperature profile retrievals”  \_FillValue: -128b |
| t\_amb | Ambient target temperature | dimension: time, receiver\_nb  units: K  \_FillValue: -999.9 |
| t\_rec | Receiver physical temperature | dimension: time, receiver\_nb  units: K  \_FillValue: -999.9 |
| tn | Receiver noise temperature | dimension: time, receiver\_nb  units: K  \_FillValue: -999.9 |
| ir\_wavelength | Wavelength of infrared channels | dimension: ir\_wavelength  units: um |
| ir\_bandwidth | Bandwidth (3 dB) of the infrared channels | dimension: ir\_wavelength  Units: um  \_FillValue: -999.9 |
| ir\_beamwidth | Beam width (3 dB) of the of the infrared radiometer | dimension: ir\_wavelength  units: degree  \_FillValue: -999.9 |
| irt | Infrared brightness temperatures | dimension: time, ir\_wavelength  units: K  \_FillValue: -999.9 |
| ir\_azi | Infrared sensor azimuth angle | dimension: time  units: degree  comment: “0=North, 90=East, 180=South, 270=West”  \_FillValue: -999.9 |
| ir\_ele | Infrared sensor elevation angle | dimension: time  units: degree  comment: “0=horizon, 90=zenith  \_FillValue: -999.9 |
| air\_temperature | Air temperature | standard\_name: air\_temperature  dimension: time  units: K  \_FillValue: -999.9 |
| relative\_humidity | Relative humidity | standard\_name: relative\_humidity  dimension: time  units: 1  \_FillValue: -999.9 |
| air\_pressure | Air pressure | standard\_name: air\_pressure  dimension: time  units: hPa  \_FillValue: -999.9 |
| rain\_rate | Precipitation amount | standard\_name: rainfall\_rate  dimension: time  units: mm/h  \_FillValue: -999.9 |
| wind\_direction | Wind direction | standard\_name: wind\_from\_direction  dimension: time  units: degree  \_FillValue: -999.9 |
| wind\_speed | Wind speed | standard\_name: wind\_speed  dimension: time  units: m/s  \_FillValue: -999.9 |
| met\_quality\_flag | Meterological data quality flag | dimension: time  units: 1 (bit variable: 0=ok, 1=problem)  flag\_masks: 1b, 2b, 4b, 8b, 16b, 32b  flag\_meanings: “low\_quality\_air\_temperature low\_quality\_relative\_humidity low\_quality\_air\_pressure low\_quality\_rain\_rate low\_quality\_wind\_direction low\_quality\_wind\_speed”  \_FillValue: 0b  *Note: should also be set to 1 if corresponding sensor not available* |
| met\_quality\_flag\_status | Meteorological data quality checks not applied | dimension: time  units: 1 (bit variable: 0=ok, 1=problem)  flag\_masks: 1b, 2b, 4b, 8b, 16b, 32b  flag\_meanings: “air\_temperature\_quality\_not\_checked relative\_humidity\_quality\_not\_checked air\_pressure\_quality\_not\_checked rain\_rate\_quality\_not\_checked wind\_direction\_quality\_not\_checked wind\_speed\_quality\_not\_checked”  \_FillValue: -128b |