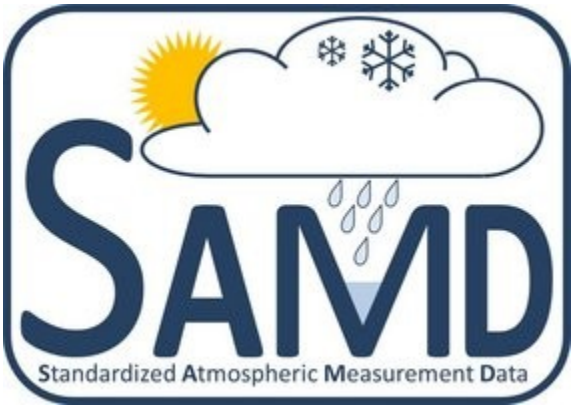


# The SAMD Product Standard (Standardized Atmospheric Measurement Data)

## Version 2.0

Annika Jahnke-Bornemann
University of Hamburg

February 8, 2022

The SAMD *light* data-product description-document includes the conventions for file names, variables and NetCDF-files. The standardized XML-file convention is included as well as all necessary abbreviations for institutes, instruments, variables, etc.

This document is successor and replaces SAMD Product Standard Version 1.2 (DOI:10.5281/zenodo.1741364), that was written by Andrea Lammert, Verena Grützun, and Erasmia Stamnas in November 2018. Passages that were cited from the original document are in black. Omitted parts are marked with [...]. Changes to formatting or corrections to spelling were not marked. Thanks again to all the people who contributed to the original document!

## SAMD contact

Dr. Annika Jahnke-Bornemann
ICDC, CEN, University of Hamburg
Grindelberg 5
D-20144 Hamburg
https://www.cen.uni-hamburg.de/icdc

## Version history

[...]

**SAMD Product Standard**

| Document Version | Date | Responsible | Changes |
|---|---|---|---|
| 1.0 | 2016-09-30 | Andrea Lammert, Erasmia Stamnas | Document rewritten |
| 1.1 | 2018-02-28 | Andrea Lammert | new super-sites, new instruments, completion of information about checksum and file pass |
| 1.2 | 2018-11-29 | Andrea Lammert | new campaigns |
| 2.0 | 2022-01-28 | Annika Jahnke-Bornemann | Document rewritten, SAMD light |

# Content

# 1 Introduction

## 1.1 General Information

“SAMD” is a repository for Standardized Atmospheric Measurement Data [1]. The SAMD standard [2] was introduced in 2018. After the end of the project “HD(CP)² - High definition clouds and precipitation for advancing climate prediction" funded by “Forschung für Nachhaltigkeit” (FONA), BMBF, it turned out that the guidelines were too inflexible and not practicable in some areas. Since then, the project has also been moved from the Cologne data center to the Integrated Climate Data Center (ICDC) [3] at the CEN of the University of Hamburg. During this move, many technical aspects have changed. There are also no more Observation Expert Users. After a long phase in which the SAMD project was offered unchanged in terms of content, it can now be expanded with new data. Due to all these points, a revised SAMD Light standard is required instead of the original SAMD standard, which is presented in this document.

The files provided for the SAMD database have to be in Unidata’s NetCDF format [4], version 4 or higher. The files have to obey the standards defined in this document, contain a standardized minimum of meta-data in the NetCDF header defined below, and have a unique Metadata file in XML format as described below. [...]

In general we want to provide daily files for the products. For some cases it is more practicable to provide files with a different increment, e.g. for satellite overpasses or scans. We do allow for well justified exceptions [...].

With regard to the representation of the products in the NetCDF-files we follow the principles given in the NetCDF Climate and Forecast (CF) Metadata Conventions version 1.6 (CF-Standard1) as far as possible. This especially means that our definition of the coordinate arrays and data arrays bases on this standard. For many variables, an attribute <standard_name>, a name and applicable units are defined there, as well as representations of coordinate systems. However, since it was developed for model data, it doesn’t cover the wide range of observational data. This especially means that we cannot provide the standardized name and attribute <standard_name> for all variables covered by this document but defined some variable names for SAMD (see Section 6).

Generally, one quantity per file is mandated, which may have ancillary variables like the quantity’s error or quality flags. For some instruments however, it is more meaningful to combine several variables (e.g. brightness temperatures for microwave radiometers). We allow for combining variables, but variable groups that are not described in this document can cause technical problems and must therefore be discussed with ICDC. [...]

## 1.2 History

[…] The SAMD archive has been developed as part of the project ”High definition Clouds and Precipitation for advancing Climate Prediction”, short HD(CP)², that was funded by the German Federal Ministry of Education and Research. HD(CP)² was a German research initiative to improve the understanding of cloud and precipitation processes, and their implication for climate prediction. [...] For this purpose, a model was developed as part of the project that was able to carry out very high-resolution simulations (hindcasts) with horizontal grid spacing of 100 m. [...]

The second key aspect of HD(CP)² was to use, organize and improve ground, in-situ and satellite based observations of cloud and precipitation events with very high resolution. The third pillar of HD(CP)² was to understand, synthesize and combine the results from modeling and observations in order to validate, modify and improve existing climate models. [...]

In the first years of the project, the observation data were only used within the HD(CP)² project. In 2018 the data was made available to all researchers in a standardized format via the SAMD archive.

# 2 The SAMD data archive

## 2.1 Long-term measurements

The long term observations of the different super-sites are one of the key elements of the SAMD data archive. At the moment, there is not really a common definition of the term ”meteorological super-site”, it depends on the project and the instrument focus. As an example: For the super-site RAO (Richard-Assmann-Observatory Lindenberg), the so-called ”Lindenberg column”, the German Weather Service defines the current objectives and research activities, among other, as the ”three-dimensional/four-dimensional long-term climate monitoring of the atmosphere (4D Lindenberg column), including the analysis of long term trends” [...].

For the SAMD archive a super-site means an observatory for long term measurements, including as minimum equipment: a cloud radar, a microwave radiometer and a lidar system [...]. Each additional instrument, like a meteorological tower, surface meteorology station, radio soundings, and/or radiation measurements, of course is a surplus profit. [...]

In addition to the local measurements at the super-sites, the archive includes so-called “full-domain” observations. In SAMD the "Full domain" means both the observations of networks of ground based instruments, like radar, ceilometer, and GPS, as well as satellite observations from different instrument, like MODIS on TERRA and AQUA and SEVIRI on MSG (MeteoSat second generation). Currently, the archive includes data sets of different satellite based instruments, like MODIS on satellites AQUA and TERRA, and SEVIRI on the MeteoSat second generation (MSG) satellites. Partly the satellite data is (in part freely) available via other data centers. The data in the SAMD archive are provided in the SAMD data format, with the focus on the regions of interest.

Second part of the full-domain observations are the data of ground based instrument networks. Currently, the archive provides data of:

- the C-band Radar network of the German Weather Service (RADOLAN), with 5 min temporal and 1x1 km2 horizontal resolution,
- the Ceilometer network, and
- the GNSS (Global Navigation Satellite System) network.

[…] See Version 1.2 of this document [2] for example figures.

## 2.2 Short-term measurements

In contrast to the long-term observations, measurement campaigns and Intensive Observation Periods (IOP’s) yield atmospheric data for a short time period and just at a special location, but with a high density of instruments. As part of HD(CP)², the HD(CP)² Observation Prototype Experiment (HOPE) took place in April and May 2013 at and around the super-site JOYCE in Jülich. ”HOPE was designed

to provide a critical model evaluation at the scale of the model simulations and further to provide information on sub-grid variability and micro-physical properties that are subject to parametrizations even at high-resolution simulations.” Therefore the focus was ”on the onset of clouds (activation) and precipitation (auto conversion) in the convective atmospheric boundary layer. By capturing the 3D cloud distribution the measurement can support the investigation of cloud-overlap and 3D radiative effects. In the absence of boundary layer clouds, the remote sensing instrument system was ideally suited to retrieve aerosol and cirrus cloud properties.” [...]

A second campaign, HOPE-Melpitz, took place in September 2013 in Melpitz, nearby Leipzig. This field experiment concentrated on the closure of the joint ground-based remote sensing techniques with the in-situ observations from ACTOS, the helicopter-based Aerosol and Cloud micro-physics and Turbulence Observation System. In addition, measurements of a large number of devices for the chemical and micro-physical characterization of the surface-near aerosol were performed that provide additional boundary conditions for the planned coupling of the mobile super-site LACROS and the ACTOS measurements.

Beneath the data of ”big” measurement campaigns, the archive includes the possibility of so called IOP’s, Intensive Observation Periods. IOP’s could be located at super-sites or in the middle of nowhere, important is just the intensive observation of one or more instruments for a given time interval. […]

The field campaign FESSTVaL (Field Experiment on sub-mesoscale spatio-temporal variability in Lindenberg) took place from May-August 2021 in the surroundings of the Meteorological Observatory Lindenberg – Richard-Aßmann-Observatory of the German Meteorological Service (DWD). The FESSTVaL campaigns were included into the SAMD archive in 2022. FESSTVaL was funded by the Deutscher Wetterdienst within the Hans-Ertel Centre for Weather Research.

The project aimed at an improved understanding of the initiation and interaction of cold pools and wind gusts in the summertime convective boundary layer. Unique to this campaign was the high-density near-surface measurement network made of approx. 100 ground-level stations including 19 automatic weather stations as well as a dense soil moisture measurement network. An X-band radar and several energy balance stations were also used. In cooperation with external partners at KIT and DLR, nine Doppler lidar systems for measurements of the wind profile and turbulence variables up to an altitude of several kilometers were tested in a coordinated manner. Moreover, thermodynamic properties and precipitation were measured using two mobile profilers and measurement flights with unmanned and remote-controlled aircraft were carried out by the University of Tübingen and DLR. In this way, further vertical information was obtained to verify the ground-based remote sensing systems. As a supplement to these measurements, the project investigated the gain of a citizen science measurement network.

Data sets from the main campaign FESSTVaL (2021) were included. In 2020, local field experiments took place under the abbreviation FESST@home and selected data sets from this pre-campaign were included, as well as selected data sets from the test campaign in summer 2019 near Lindenberg.

# 3 SAMD Data policy

The SAMD Data Policy has to be accepted by data providers and data users. The current version can be read as a PDF-document, see [5]. This policy holds for all data that is provided by the SAMD archive. For data sets from the FESSTVaL campaign, the FESSTVaL data policy [6] applies as well.

1. **Creative Commons License:** All data in the SAMD archive are licensed under a Creative Commons License CC-BY-NC-SA (https://creativecommons.org/licenses/by-nc-sa/4.0/legalcode ) as far as those conditions are not in any way modified by the following conditions or by any conditions specific to data (especially Cloudnet data, see 7.).
2. **Used freely for non-commercial only:** Data from the SAMD archive may be used freely for research only (non-commercial).
3. **Audit:** All downloads from the SAMD archive are auditable. Information will be used for statistical analyses, such as download statistics.
4. **Publications:** Articles, papers, or written scientific works of any form, based in whole or in part on data supplied by the SAMD archive, will contain a reference including the title, author, and PID number of each used data set, as given in the meta data file(s).
5. **Share alike:** Any person extracting data from this server will accept responsibility for informing all data users of these conditions.
6. **Liability / Warranty:** The data are delivered to the user without a warranty of any kind. The user is aware that the data were generated in keeping with the current state of science and technology.
7. **Data originating from other data bases:** Here, the data policy of the source data base (e.g. CloudNet Data in the frame of ACTRIS) […] applies in addition which is stored in the meta data of the data set. Please make sure that you use these data in agreement with the corresponding conditions of use.

# 4 The SAMD Data Portal at ICDC

All checked and uploaded data are available at the SAMD Data Portal that is located at the Integrated Climate Data Center (ICDC) of the University of Hamburg [7]. Currently, all available data is stored at ICDC's servers:

https://www.cen.uni-hamburg.de/icdc/research/samd.html

[…] The Portal provides, beneath information about the file naming and conventions, the meta data of the different data set and the possibility to browse the archive for specific data […] using the website: Menu-Categories are "Long Term Observations", subdivided into Local and Full Domain Observations, and "Short Term Observations", subdivided into different campaigns. Shown are all data sets of the given category, sorted alphabetically. […]

Alternative you could search directly the data archive catalog to find all data sets of specific instruments, variables and years. It gives you the chance to "root" through the archive, if you are a bit familiar with measurement instruments. […]

Beneath the standardized compact information for each data set, based on the Metadata-Files, the Data Portal provides the specific link to both, the complete metadata and the data set itself. […] The SAMD archive at ICDC is open without login. Still the user has to follow the rules of the SAMD data policy (see Section 3).


*Fig. 1: The Homepage of the SAMD Archive at ICDC.*

# 5 Naming conventions

## 5.1 The file naming

Files shall be named according to the following naming convention:

**<kkk>_<sss>_<instnn>_<lll>_<var>_<vnn>_YYYYMMDDhhmmss.nc**

where:

- *kkk* is the kind of measurement type: Super-site, full domain or campaign data,
- *sss* super-site or owner institute of the instrument or distributor of data,
- *instnn* instrument or synergy product, retrieval algorithm plus numbering, starting with ”*00*”
- *lll* level of data processing, starting with “*l1”*
- *var* variable name for level 2 and higher (for level 1 data, which may contain more than one variable use ”*any*”),
- *vnn* version of data set, starting with “*v00*”), and
- *YYYYMMDD* the start of the data file as *YYYY*=year, *MM*=month, *DD*=day,
- *hhmmss* is hour, minutes, seconds in UTC.

**Example1:** *sups_joy_ceilo00_l1_any_v00_20130101000000.nc*

which is the name for a data set of the super-site (”*sups*”) JOYCE (”*joy*”), from the instrument Ceilometer (”*ceilo00*”), level 1 (”*l1*”, means raw data), including several variables (”*any*”), 1st version of the data set (”*v00*”) for January 1, 2013 0:00:00.

**Example2:** *hdfd_igmk_gnssnet00_l2_prw_v00_20130101000000.nc*

which stands for a HD(CP)² full domain data set (”*hdfd*”) of the IGM, University of Cologne (”*igmk*”), measured by the ceilometers network (”*gnssnet00*”), processing level 2 (”*l2*”), is the path of integrated water vapor ("*prw*"), version 1 (”*v00*”) for January 1, 2013 0:00:00.

The sorting into the database depends on the information given in the file names and should follow these rules. […] The file names have to be unique, and defined by the information you provide for the Metadata-Files (Section 8). In the following, the different possible entries for the fields are listed.

### 5.1.1 The Measurement type (<kkk>)

In general the data sets are distinguished between “Long-term” and “Campaign” data, and the “Long-term” data in “Local” and “Full-domain” observation (see table 3 on next site).

**Table 3: List of abbreviations for the measurement type <kkk>**

| Kind of Measurement type | Abbreviation | SAMD Standard |
|---|---|---|
| Super site | sups | 1.2 |
| HD(CP)² full domain observations | hdfd | 1.2 |
| HOPE campaign | hope | 1.2 |
| HOPE Melpitz campaign | hopem | 1.2 |
| IOP (Intensive observation period) + location | iopxxx | 1.2 |
| TRIPEX (TRIple-frequency and Polarimetric radar Experiment for improving pro-<br>cess observation of winter precipitation) | tripex | 1.2 |
| HALO (High Altitude and LOng range) research aircraft | halo | 1.2 |
| FESSTVaL (Field Experiment on sub-mesoscale spatio-temporal variability in Lindenberg) campaign | fval | 2.0 |

### 5.1.2 The Super-sites (<sss>, part 1)

“Super-site” means here an atmospheric measurement site, which is able to yield long-term observations and has as minimum instrumentation a lidar, a microwave radiometer, and a cloud radar (plus basic meteorological measurements, like 2 m temperature and humidity, air pressure, precipitation).

**Table 4: List of abbreviations for the super-sites <sss>**

| Super-sites | Abbreviation |
|---|---|
| BCO - Barbados Cloud Observatory | bco |
| CESAR - Cabauw Experimental Site for Atmospheric Research | ces |
| JOYCE - Jülich ObservatorY for Cloud Evaluation | joy |
| KITCube - Mobile facility of the Karlsruhe Institute for Technology | kic |
| LACROS - Leipzig Aerosol and Cloud Remote Observations System | lac |
| LMU - Ludwig-Maximilians-Universität München | lmu |
| RAO - Richard Assman Observatory Lindenberg | rao |
| UFS - Environmental Research Station Schneefernerhaus | ufs |

### 5.1.3 The Institutions (<sss>, part 2)

**Table 5: List of abbreviations for the Institutes <sss>**

| Owner Institute | Abbreviation |
|---|---|
| Deutscher Wetterdienst | dwd |
| German Aerospace Center/Deutsches Zentrum für Luft und Raumfahrt | dlr |
| Institute of Energy and Climate, Research Center Juelich | fzj |
| Institute of Geophysics and Meteorology, University of Cologne | igmk, uzk |
| Institute for Meteorology and Climate Research, Karlsruhe Institute of Technology | kit |
| Institute for Meteorology, University of Leipzig | lim |
| Institute for Physics and Meteorology, University of Hohenheim | ipm |
| Institute for Space Sciences or Institute for Meteorology, Free University Berlin | fub |
| Leibniz Institute for Tropospheric Research, Leipzig | trop |
| Max-Planck-Institute for Meteorology, Hamburg | mpi |
| Meteorological Institute, University of Bonn | miub |
| Meteorological Institute, University of Hamburg | uhh |
| Meteorological Institute at the Ludwig-Maximilans-University Munich | lmu |
| Richard Assmann Observatory, Lindenberg | rao |
| Royal Netherlands Meteorological Institute | knmi |
| University of Basilicata - Potenza | unibas |
| Wageningen University and Research | wur |

**Table 6: List of abbreviations for HALO campaign data <sss>**

| HALO campaign | Abbreviation |
|---|---|
| NARVAL North | narn |
| NARVAL South | nars |
| NARVAL 2 | nar2 |

### 5.1.4 The Instruments (<instnn>)

If your institute has more than one instrument of the same type, the number (nn) behind the instrument tag is used to distinguish the instruments. E.g., if you have two ceilometers, the <inst>-tags would be ceilo00 and ceilo01. If only one instrument is present the number is 00 per default.

If your instrument has a specific name/acronym it is commonly known under and you would like to name your files accordingly, please contact ICDC, so we can eventually include it.

**Table 7: List of abbreviations for Instruments for Local observations <instnn>**

| Instrument or synergy/retrieval | Abbreviation |
|---|---|
| ACTOS (Airborne Cloud Turbulence Observation System) | actos |
| Ceilometer | ceilo |
| Cloud radar | cr |
| Cloud camera | ccam |
| DIAL (Differential Absorption lidar) | dial |
| Disdrometer | dm |
| Doppler lidar | dlid |
| scanning with varying elevation and azimuth (custom) | dlidCUST |
| measured vectors from where wind profiles can be estimated | dlidDBS |
| scanning with varying elevation (range height indicator) | dlidRHI |
| scanning with varying azimuth | dlidVAD |
| zenith only | dlidST |
| GNSS (Global Navigation Satellite System) | gnss |
| Infrared thermometer | irt |
| scanning | irtS |
| Infrared spectrometer | irs |
| Meteorological data (near surface) | mets |
| Meteorological tower data | mett |
| Micro Rain Radar | mrr |
| Microwave radiometer | mwr |
| boundary layer scan new | mwrBL |
| Pyranometer | pyr |
| Pyranometer network | pyrnet |
| Pyrgeometer | pyrg |

| Instrument or synergy/retrieval | Abbreviation |
|---|---|
| Radar wind profiler | rwp |
| Radiation data (surface energy balance system) | sebs |
| Radio sounding | sonde |
| Raman lidar | rlid |
| Sodar | sodar |
| UV lidar new | uvlid |
| Weather Radar, S-Band | wrs |
| Weather Radar, X-Band | wrx |
| **Predefined instrument combinations** | |
| Cloudnet (MWR + CR + lidar) | cln |
| DIAL + Raman lidar + Doppler lidar | drdl |
| MWR + CR + xxx | ipr |
| MWR + CR + IPT | ipt |
| Raman lidar + MWR | rlmwr |
| Triple frequency Cloud Radar | tricr |

**Table 8: List of abbreviations for Instruments for Full-domain observations <instnn>**

| Instrument or synergy/retrieval (on satellite) | Abbreviation |
|---|---|
| AATSR/MERIS synergy | aatrs |
| AMSU-B/MHS on METOP/NOAA series | amsu |
| CALIOP on CALIPSO | caliop |
| Ceilometer network | cmnet |
| CPR on CloudSat | cpr |
| DWD C-Band Doppler radar network | drnet |
| GNSS network | gnssnet |
| MERIS on ENVISAT | meris |
| MODIS on TERRA and AQUA | modis |
| MSG Radar composite | msg |
| SEVIRI on MeteoSat | seviri |
| **Predefined instrument combinations** | |
| Ceilometer Network + Seviri | cmnetsev |
| CALIOP + CPR | calcpr |

### 5.1.5 The Level (<lll>)

Several versions/stages of processing at one data level may be indicated with the version tag <vnn> (see below). In some exceptional cases, where it is reasonable to provide more than one level in your data, put the highest level into the file name (see e.g. CloudSat data). Level 0 data (raw data) are normally not of interest for the SAMD archive.

**Table 9: Level description <lll>**

| Level | Abbreviation |
|---|---|
| Level 0: Raw data as produced by the instrument | l0 |
| Level 1: Raw, processed data in standardized form. Processing may include quality controls or calibration factors. | l1 |
| Level 2: Quality-tested data. Value-added products, means quantities which are derived from the instrument data and not directly measured (e.g. wind vector from Doppler lidar system). | l2 |
| Level 3: Quality-tested data which combine different instruments (without model data). | l3 |
| Level 4: Quality-tested data, re-gridded to a regular grid and/or synergy with model data | l4 |

Several versions/stages of processing at one data level may be indicated with the version tag <vnn> contained in the file name. The first version has the tag v00. For each subsequent version of a data set the tag will be increased by 1. For example, if you time- or space average your level 1 data, or if you reprocess your level 2 data with an improved processing routine, the version tag will be increased by one for the resulting data set.

The <var>-tag in the file name corresponds to the output variable name of the quantity (see Section 5.2). Level 1 data files may contain more than one variable. In this case, please use ”any” for the tag. Note that the ”any”-tag should only be used for level 1 data. For all other levels one variable or product per data set is aimed at.

### 5.1.6 The version numbering (<vnn>)

The first version of you data set gets the version number ”v00”. Please note that each change in your data like

- a new processing, a fixed bug in the processing, a new position of the instrument, a significant new instrument software, and so on,

implicates a new data set with a new file name and a new version number. Changes must be declared in the NetCDF header as a global attribute "History" (see Sec. 6.1).

## 5.2 The variable naming

The naming of variables should follow the current version of the CF Conventions [8]. In the following, output variables/products are defined. Given is the CF standard name if it is existent, the output variable name, which is identical with the <*var*>-tag for the file name, and the canonical unit for the variable. Note that there are some level 1 variables, that should not appear in the file name, in the table they are marked accordingly. If no standard_name is defined, the long_name attribute becomes mandatory for the description of the variable in the NetCDF file (see Section 6). In that case, the *standard_name* attribute should be left out completely. For some variables *long_name* have already been suggested as common *long_name* within the project. […] The list of variables is very long, this is why you please find the complete alphabetical list of all SAMD variable naming in Appendix C.

**Table 10a: Example for Variable description <var>**

| Variable description | CF-Standard_name / not CF: suggested long_name | Abbreviation / filename <var> | Unit | in CF: YES or NO |
|---|---|---|---|---|
| Absolute humidity | mass_concentration_of_water_vapor_in_air | hua | g m-3 | y |
| Aerosol Angström exponent | angstrom_exponent_of_ambient_aerosol_in_air | aae | 1 | y |
| *... and so on, see Appendix C* | | | | |

For some combinations of instruments and variables (e.g. wind components) it makes sense to allow an exception of the rule of just one variable per file for higher level data. For those cases the files should be named with a variable group instead of ”any” or one variable.

**Table 11: Conventions for variable groups**

| Variable group | Comments | Filename <var> |
|---|---|---|
| Aerosol classification | for Cloudnet; file includes additionally model data | aclass |
| Target classification | for Cloudnet; file includes additionally model data | class |
| Wind | file includes wind components, direction, etc. | wind |
| Cloud | Cloud related variables (e.g. for cmnetsev: zcb+zgct) | cloud |

# 6 NetCDF conventions

[…] In the following the minimum meta-data, which have to be provided in each NetCDF file [4] as so called ”Global Attribute” are described. Also, the technical structure of the coordinate system and variables is described in this chapter, which is widely identical with the structures found in the CF Standard 1.6 [8]. […]

## 6.1 Global Attributes

The global attributes apply for the whole NetCDF file rather than any particular variable. The SAMD standard defines some standardized global attributes, given in Table 12. Please note that the order as well as the spelling of the global attributes is binding, including upper/lower case, and the usage of underscores instead of spaces in the attributes name. All attributes have to be filled, except ”*Comments*” (in the case of no content, please fill in ”none”). The attribute “*History*” is important for the versioning of the data sets. In the first version of a data set, information about used programs and routines can be filled in. […] For each new version (please see Sec. 5.1.6) append in the “History” attribute the information about the reasons and keep all previous information.

**Table 12: Global Attributes contained in the NetCDF-file header**

| Attribute | Content and Explanation | Comments, Examples |
|---|---|---|
| Title | Short Title including Instrument and content of data set. | The title will be used as a description of the data set in the web portal of the archive. So, please choose the title carefully. e .g.“S-Band Doppler Radar Rain Rates Barbados” |
| Institution | Owner Institution or distributor of data set. | e.g. "Data owned by Max Plank Institute for Meteorology, provided to HD(CP)² by Meteorological Institute, University of Bonn" |
| Contact_person | <Name>, <email> | e.g. "Annika Jahnke-Bornemann, annika.bornemann@uni-hamburg.de" |
| Source | Instrument(s) (and its software version, if important for interpretation of the data) | e.g. "Barbados S-Band Doppler Radar, Original Data by Max Planck Institute for Meteorology, put into netCDF format by Meteorological Institute, University of Bonn" |
| History | First version: How is the data set processed? Programs or routines with version number; For higher version numbers: Differences to the last version of the data set. | e.g. "Scan elevation 0 degree. Rain rate converted from radar reflectivity factor using Marshall-Palmer ZR relationship ..." |
| Dependencies | just in case of higher level products: <file name> (without date) of the depending data set or ”external” (for all data sets not archived in the DB) | e.g. "external" |

| Attribute | Content and Explanation | Comments, Examples |
|---|---|---|
| Conventions | State applicable CF version | e.g. "CF-1.6 where applicable" |
| Processing_date | <YYYY-MM-DD, hh:mm:ss > (time the file was produced) | e.g. "2018-02-15T02:25:13" |
| Author | <name>, <email> | e.g. "Annika Jahnke-Bornemann, annika.bornemann@uni-hamburg.de" |
| Comments | Miscellaneous Information about your dataset, otherwise none | e.g. "The time resolution might not be the same for all netCDF files" |
| License | State the applicable license. | e.g. “For non-commercial use only. This data is subject to the SAMD data policy to be found at http://doi.org/10.25592/uhhfdm.9824 and in the SAMD Observation Data Product standard v2.0.” |

As another example, global attributes of the data file *sups_joy_ceilo00_l1_any_20130422000000.nc*, so for the Ceilometer data, level 1, at super-site JOYCE for 22 April 2013, are, as given in NetCDF header:

*// global attributes:*

*:Title = ”Jenoptik CHM15k ceilometer data” ;*

*:Institution = ”Research Center of Jülich, Institute for Energy and Climate (IEK-8)” ;*

*:Contact_person = ”Ulrich Loehnert (Loehnert@meteo.uni-koeln.de)” ;*

*:Source = ”Jenoptik CHM15k ceilometer: ID CHM120109, serlom TUB120017, software version 12.03.1 2.13 0.559” ;*

*:History = ”Data processed with readin_jenoptik_ceilodata_hdcp2_0.1.0 and write_jenoptik_ceilonc_hdcp2_earlysoftware_0.1.0 by University of Cologne” ;*

*:Dependencies = ”external” ;*

*:Conventions = ”CF-1.6 where applicable” ;*

*:Processing_date = ”2014-03-14 15:03:06 (CET)” ;*

*:Author = ”Anne Hirsikko (anne.hirsikko@fmi.fi)” ;*

*:Comments = ”none” ;*

*:License = ”For non-commercial use only. This data is subject to the HD(CP)² data policy to be found at www.hdcp2.eu and in the HD(CP)² Observation Data Product standard.”*

## 6.2 Instrument meta-data for ground based instruments

For each instrument the following information has to be included into the file. In the case of just one instrument the information has to be stored as variables without dimension, otherwise, the variables are stored as one dimensional fields, length equal number of instruments (e.g. ground based lidar network).

- longitude of instrument position in degree_east (float)
- latitude of instrument position in degree_north (float)
- height of instrument above ground (float)
- altitude of instrument above above mean sea level in meter (float)

For example, the instrument meta-data for rain radar on Geomatikum's roof in Hamburg (as given in NetCDF header) is given as :

*variables:*

*float lat ;*

*lat:standard_name = "latitude" ;*

*lat:comments = " Latidude of instrument location" ;*

*lat:units = "degrees_north" ;*

*lat = 53.569 ;*

*float lon ;*

*lat:standard_name = "longitude" ;*

*lat:comments = " Longitude of instrument location" ;*

*lat:units = "degrees_east" ;*

*lon = 9.974 ;*

*float zsl ;*

*lat:standard_name = "altitude" ;*

*lat:comments = " Altitude of instrument above mean sea level" ;*

*lat:units = "m" ;*

*zsl = 124.8 ;*

## 6.3 Dimensions

A variable may have any number of dimensions and the dimensions must all have different names. The dimensions of the variable define the axes of the quantity it contains. Dimensions other than those of space and time may be included. Especially the dimensions for the variables time, height, range, lon, and lat should be named like the variable itself.

## 6.4 Coordinate system

The structures of coordinates and variables have to follow the CF Standard 1.6 or higher. We only provide some example coordinates here, a variety of example coordinate systems can be found in the CF Standard and for a detailed description we refer to its documentation at the CF convention website [8]. The dimensions, as far as present, should appear in the following order: time, then height, then latitude, then longitude (or time, height, range if applicable):

time [, height or range] [, lon] [, lat]

Please see the example for variables below for details, or have a look into the CF convention [8]. Please note that time is in any case the first dimension.

### 6.4.1 Time

Time has to be given as seconds (minutes, hours, days) since 1 January 1970, 00:00:00, given as UTC (e.g., *”minutes since 1970-01-01 00:00:00*”). As usual, time has to be stored with as much precision as necessary, not more. For a measurement with 10 seconds resolution it doesn’t make sense to give the time as a double variable with several decimal places. A boundary array is mandatory for the time to have a unique description of the date's time averaging. The boundary array has one dimension more than your time array. For *time(i)* you have *time_bnds(i,0)* and *time_bnds(i,1)* containing the start and end of the averaging interval, respectively. Please note, the time boundary variable corresponds to cell boundaries in CF standard 1.6. Thus, in the NetCDF file time has the following structure:

*dimensions:*

*time = 12345; (”UNLIMITED” as possible)*

*nv = 2 ; (Number of boundaries, in this case start and end of time interval => 2)*

*variables:*

*double time (time) ;*

*time:standard_name = ”time” ;*

*time:units = ”seconds since 1970-01-01 00:00:00” ; (in UTC)*

*time:bounds = ”time_bnds” ;*

*double time_bnds (time,nv)*

In case of swath-based satellite data please define the first pixel time as variable *base_time* without *time_bnds* and give the difference of each pixel to *base_time* as variable *dtime*:

*dimensions:*

*time = 12345; (”UNLIMITED” as possible)*

*variables:*

*double base_time ;*

*base_time:long_name = ”reference time” ;*

*base_time:units = ”seconds since 1970-01-01 00:00:00”; (in UTC)*

*base_time:description = ”earliest time stamp of data field for both day and night”;*

*float (or double) dtime (time) ;*

*dtime:long_name = ”difference time” ;*

*dtime:units = ”s” ;*

*dtime:description = ”actual relative time of each pixel corresponding to the reference time (see variable base_time): dtime=pixel_time-reference_time” ;*

**Important:** For level 3 and higher level data sets, time has to be a continuous variable with equidistant steps for the whole day (24 hours). […] So, for a temporal resolution of one hour, your data set must include 24 time steps per file and gaps in the measurement variable must be filled with the defined fill value. This is an important step towards the ”easy-to-use” approach, e.g. for the validation of model data.

### 6.4.2 Geographical Grid

The following coordinates might vary, depending on the instrument. The given examples show the most common ones. A boundary array for spatial coordinates is not requested, but recommended to provide if possible. This will specify the spatial resolution of the data and facilitate the comparison with model data. Longitudes and latitudes have to be adjusted to the instrument, bounds may be skipped!

*dimensions:*

*lon=360; // **to be adjusted to the instrument!***

*lat=180; // **to be adjusted to the instrument!***

*nv = 2;*

*variables:*

*float lon (lon);*

*lon:standard_name = ”longitude”;*

*lon:units = ”degrees_east”;*

*lon:bounds = ”lon_bnds” // **may be skipped, if not:***

*float lon_bounds (lon,nv)*

*float lat (lat);*

*lat:standard_name = ”latitude”;*

*lat:units = ”degrees_north”;*

*lat:bounds = ”lat_bnds”; // **may be skipped, if not:***

*float lat_bounds (lat,nv);*

*float zsl (lat,lon);*

*zsl:standard_name = ”altitude” ;*

*zsl:long_name = ”altitude above mean sea level” ;*

*zsl:units = ”m” ;*

## 6.5 Variables

Variables must have a name, dimension, and the CF standard name (if standard name is existent, if not, please leave out the attribute completely), units, and a fill value. If no CF standard name is present, the *long_name* attribute is mandatory to describe the variable. […] We strongly suggest that common *long_name* attributes for the same variables are used. Flags may be added to the variables using the attributes ”*flag_values*”, ”*flag_meanings*”, ”*flag_masks*” and marked as ”*ancillary_variables*” attribute to the variable itself, as described in the CF-standard [8]. “Air temperature” is used here as an example of a variable:

*dimensions:*

*time = ”UNLIMITED”;*

*height=100*

*lat = 360;*

*lon = 360;*

*variables:*

*double ta (time,height,lat,lon); // **Note dimensions order***

*ta:standard_name = ”air_temperature”;*

*ta:long_name = ”height resolved air temperature”;*

*ta:_FillValue=-999.d ;*

*ta:units = ”K”;*

*ta:ancillary_variables = ”ta_flag” ;*

*byte ta_flag (time,height,lat,lon)*

*ta_flag:standard_name = ”air_temperature status_flag” ;*

*ta_flag:flag_values = 0b,1b,2b ;*

*ta_flag:flag_meanings = ”no_measurement good_quality bad_quality” ;*

Note the dimension’s order [time, height, lat, lon], given for “ta” in the example, which is how it should appear. Variable’s names are listed in Section 5.2. […] We strongly suggest using the canonical units given above. […]

# 7 Metadata conventions

Well documented data should enable other researchers to understand, use and reuse the data correctly. For this reason, every data set which is published by the SAMD archive must be associated with metadata in an appropriate form. We designed about 30 metadata descriptive elements to define our own standard, among others SAMD has adapted some well-established attributes from the data file's NetCDF header.

The SAMD metadata files are encoded in the eXtensible Markup Language (XML).

## 7.1 The SAMD metadata web interface

All data sets get a separated metadata file with detailed information about measurement and instruments. […] The needed information can be provided to ICDC: Each data provider has to answer several questions in a specifically designed web form that will be sent to ICDC. The form contains lists of selectable items as well as fields that allow free text. As an example, a selection of SAMD approved variables (see 5.2) can be picked from a list. At the end of the questionnaire ICDC will transform the filled-in information into a valid XML document and provide it with a digital signature (hash key). The data provider can get a copy of the sent metadata via email.

**Table 13: SAMD Metadata standard Part 1: XML elements**

| XML element | Sub-element | Definition |
|---|---|---|
| project | | Project under which the data were obtained. |
| region | | Measurement region (used for the generation of the PID of the data set) |
| dsName | | Name of data set (5 parts). |
| fileAverageSize | size [unit], status | Average size of the data set files in MB, uncompressed. |
| datatype | | Daily data file or exceptions (16-day, event). |
| provenance | | Data provenance (description of the origin and purpose) |
| contactPersons | list number, institution, forename, surname, code, phone, email | Contact data of person responsible for data, person in permanent position if possible. |
| keywordLists | list number, experimentType, measurementType, mainGroup, variableGroup | Keywords describing the data according to the SAMD classification tree (see Section 7.3). |
| temporalExtent | startDate, endDate | Day the measurement started respectively ended, or if the measurement is continuous, ongoing. |

| XML element | Sub-element | Definition |
|---|---|---|
| resolution | temporal [unit], horizontal [unit], vertical [unit] | Data resolution |
| location | | Short description of measurement location and type of measuring instrument (single, group or network). In prose text, no acronyms please. In addition it may be used to give information about flight paths, orbits, etc. |
| productDescription | | Short description of the data product. |
| limitations | | Limits of measurement, environmental conditions under which the data were acquired (optional). |
| references | list number, referenceType, publicationDate, author, title, abstract, publish | Specify references with form, date, author, title, abstract, and publishing media (optional). |
| instruments | list number, source, instrumentLocation:<br>- latitude [unit],<br>- longitude [unit],<br>- altitude [unit],<br>- height [unit],<br>instrument-Specification | Name and type of instrument, Attributes characterizing the measuring facilities:<br>- declaration of instrument used for the measurement,<br>- relative position or location.<br>Additional information for measuring facility or instrument, e.g. wavelengths of lidar, frequency of radar, etc. (optional) |

[…] The meta-information should be present in the NetCDF header of the data (global attributes and variable information), and will be extracted and added to the metadata file.

**Table 14: SAMD Metadata standard Part 2: XML elements extacted from NetCDF header**

| XML element | sub-element | Definition | NetCDF header |
|---|---|---|---|
| subtitle | | Additional title, short headline. | Title |
| dsAuthor | forename, surname, email | Person who processed the data. Name and email-address of person primarily responsible for making the resource. | Author |
| institution | | Instrument institution or distributor of data. | Institution |
| conventions | | Based on the climate and forecast metadata conventions (current CF-1.6). | Conventions |

| XML element | sub-element | Definition | NetCDF header |
|---|---|---|---|
| dependencies | | Name of the parent data set, for dependent data sets archived in SAMD, otherwise ’external’. | Dependencies |
| versionHistory | | Description of data processing, software used, what has changed compared to previous versions, etc. | History |
| license | | SAMD data policy (potential additional agreements). | License |
| comments | | Other useful information about the data, information describing aspects of the primary data. | Comments |
| dimensions | time, height, nv | Dimensions of data contained in the NetCDF file, see chapter 6.4 | dimensions |
| variables | name, dimension, standard_name, long_name, units | Variables contained in the NetCDF file. | variables |

The SAMD metadata scheme provides mandatory, optional and automatically generated attributes. The final metadata file contains all elements listed in table 14. Please note that the metadata element spelling you find in the table is binding, including uppercase and lowercase. […]

Also note that a significant change in data processing, a fixed bug, a new position of the instrument and so on, implies a new data set version with a new metadata file. You have to go through the process of creating new metadata and NetCDF header again and the version number of your data set must then increase by 1. […] The final XML file includes all information and elements from Tables 13 and 14 and some standardized elements inserted by ICDC (see table 15, Appendix B). Please find the complete metadata attributes in Appendix B.

## 7.2 Persistent Identity (PID)

Regarding sustainability one important part of the metadata is the Persistent Identity (PID) […] . The PID allows the unique identification of each single data set. Therefore the PID consists of the following information: The first group includes the institution, which assigns the PID. The second group characterizes the data type and the measurement region, whereas the last group includes the main part of the data set name.

An example for the PID is:

**de.hamburg.icdc/amd.de.sups/joy.cr00.l1.beta**

with

- **de.hamburg.icdc**: the Integrated Climate Data Center (*icdc*) of the University of Hamburg (*hamburg*), Germany (*de*) as the PID assigning institution,
- **amd.de.sups**: Atmospheric Measurement Data (*amd*) in Germany (*de*) at a super-site (*sups*), and
- **joy.cr00.l1.beta**: abbreviation of the super-site JOYCE (*joy*), the instrument Cloud radar (*cr*), the level (*l1*), and the variable name (*beta*).

## 7.3 Keywords

As part of the meta data web interface, data providers are able to choose between different keywords to characterize and sort their data set and make it as easy as possible to find the data in the archive. […]

The keyword based search function that was originally implemented can not be provided in the SAMD light version of the archive. Still keywords can be added to the meta data.

# 8 Compliance check and data upload

Before you can provide your data to the databases you have to provide one example data file with a complete metadata information which describes your data set […] . The example data file and the XML-file will undergo a compliance check […] against the standards. Once the files pass the checks you can start providing the files to ICDC. After a successful upload your data will be available via the SAMD Data Portal hosted at the Integrated Climate Data Centre of the University of Hamburg.

Thus the steps for data upload are:

1. Please read this product standard and the ”Data approval – Step-by-Step” (See Appendix A) carefully!
2. Contact ICDC via email.
3. Provide a test file of your data (netCDF file) and meta data (web form).
4. Wait for results of checking, correct your files according to the results.
5. Once the files have passed the quality checks, you may provide your data to ICDC. […]

# A. Data approval – Step-by-Step

1. **Do a quality check of your data.** No scientific checking will be done at ICDC.
2. **Check your netCDF file with ncdump and ncview, and then with the CF-Convention Compliance Checker.** Use online NetCDF checker, which you can find at http://pumatest.nerc.ac.uk/cgi-bin/cf-checker.pl If that's ok, proceed:
3. Contact ICDC at University of Hamburg and you will get the link to provide the meta data and a test file of your data set.
4. Fill in a web form to create a web-xml file for one data set at ICDC. Provide the test file. We perform some more checks for compliance with the SAMD Standard and give feedback before you can start uploading your data sets. Correct your data and continue with the corrected netCDF file (same name, unless the name had to be corrected).
5. Contact ICDC to get information for the file exchange.

[…]

# B. SAMD Metadata

Table 15: Overview of all SAMD Metadata attributes. * = Mandatory element

| No | XML element | Sub-element | Definition | By whom? |
|---|---|---|---|---|
| | | **General** | | |
| 1 | PID* | (region) | Persistent identifier | ICDC |
| 2 | language* | | Metadata describing language: english (en) | ICDC |
| 3 | samd* | | Data Product Standard Version | ICDC |
| 4 | project* | | Project under which the data were obtained | Provider |
| | | **Data set - global** | | |
| 5 | dsName* | | Name of data set (6 parts) | ICDC |
| 6 | dsVersion* | | Version of data file | Provider |
| 7 | dsTitle* | | Short title of dataset including instrument/variable name | Provider |
| 8 | subtitle | | Additional title, short headline | Provider |
| 9 | dsAuthor* | forename<br>surname<br>email | Person who processed the data. Name and email-address of person primarily responsible for making the resource. | Provider |
| 10 | institution* | | Instrument institution or distributor of data | Provider |
| 11 | conventions* | | Based on the climate and forecast metadata conventions (current CF-1.6) | Provider |
| 12 | dependencies* | | Name of the parent data set, for dependent data sets archived in SAMD, otherwise ’external’ | Provider |
| 13 | versionHistory | | Description of data processing, software used,<br>what has changed compared to previous versions, etc | Provider |
| 14 | fileFormat* | | Specified format of data (e.g. NetCDF 3 or 4) | ICDC |
| 15 | fileAverageSize | size [unit]<br>status | Average size of the dataset files in MB, uncompressed | ICDC |
| 16 | datatype* | | Daily data file or exceptions (16-day, event) | ICDC |
| 17 | level* | | Data processing level, with the lowest level of<br>data being designated as 0 (raw data) | Provider |

| No | XML element | Sub-element | Definition | By whom? |
|---|---|---|---|---|
| 18 | license* | | SAMD data policy (potential additional agreements) | Provider |
| 19 | provenance | | Data provenance (description of the origin and purpose) | Provider |
| 20 | contactPersons* | list number [unlimited], forename, surname, code, phone, email | Contact data of person responsible for data, person in permanent position if possible | Provider |
| 21 | keywordLists | list number [unlimited], experimentType, measurementType, mainGroup, variableGroup | Keywords describing the data | Provider |
| 22 | temporalExtent* | StartDate, endDate | Day the measurement started respectively ended, or if the measurement is continuous, ongoing | Provider |
| 23 | resolution | temporal [unit], horizontal [unit], vertical [unit] | Data resolution | Provider |
| 24 | location | | Short description of measurement location and type of measuring instrument (single, group or network). In prose text, no acronyms. In addition may be used to give information about flight paths, orbits, etc. | Provider |
| 25 | productDescription | | Short description of the data product | Provider |
| 26 | limitations | | Limits of measurement, environmental conditions under which the data were acquired | Provider |
| 27 | comments | | Other useful information about the data, information describing aspects of the primary data | Provider |
| 28 | references | list number [unlimited], referenceType, | Specify references with form, date, author, title, abstract, and publishing media. | Provider |

| No | XML element | Sub-element | Definition | By whom? |
|---|---|---|---|---|
| | | publicationDate,<br>author,<br>title,<br>abstract,<br>publish | | |
| **Datatype - specific** | | | | |
| 29 | instruments* | list number [unlimited]*,<br>source,<br>instrumentLocation:<br>- latitude [unit]*,<br>- longitude [unit]*,<br>- altitude [unit]*,<br>- height [unit]*,<br>instrumentSpecification | Attributes characterizing the measuring facilities:<br>- declaration of instrument used for the measurement,<br>- relative position or location.<br>Additional information for measuring facility/instrument, e.g. wavelengths of lidar, frequency of radar, etc. | Provider |
| 30 | dimensions* | time, height, nv | Coordinates contained in NetCDF file, see chapter 6.3 | ICDC |
| 31 | variables* | name, dimension, standard_name, long_name, units | Variables contained in NetCDF file, see chapter 6.5 | ICDC |

# C. Variable description

[…]

Table 10: Variable description <var>

| Variable description | CF-Standard_name / not CF: suggested long_name | Abbreviation / filename <var> | Unit | in CF: YES or NO |
|---|---|---|---|---|
| Absolute humidity | mass_concentration_of_water_vapor_in_air | hua | g m-3 | y |
| Aerosol Angström exponent | angstrom_exponent_of_ambient_aerosol_in_air | aae | 1 | y |
| Aerosol layer heights | aerosol_layer_eight | zal | m | n |
| Aerosol number concentration | number_concentration_of_ambient_aerosol_in_air | conccn | m-3 | y |
| Aerosol optical thickness | atmosphere_optical_thickness_due_to_ambient_aerosol | aot | 1 | y |
| Aerosol particle extinction coefficient | volume_extinction_coefficient_in_air_due_to_ambient_aerosol | apec | m -1 | y |
| Altitude above mean sea level | altitude | zsl | m | y |
| Atmospheric boundary layer height | atmosphere_boundary_layer_thickness | zmla | m | y |
| Atmospheric boundary layer height derived from aerosol profile | mixing_layer_height_from_aerosol_profile | zmlaa | m | n |
| Atmospheric boundary layer height derived from wind profile | mixing_layer_height_from_vertical_wind_profile | zmlaw | m | n |
| Attenuated backscatter coefficient | volume_attenuated_backwards_scattering_function_in_air | beta | m-1 sr-1 | y |
| Backscatter intensity | backscatter_intensity | intensity | 1 | n |
| Brightness temperature | brightness_temperature | tb | K | y |
| Buoyancy | buoyancy | buoy | N | n |
| CAPE | specific_convective_available_potential_energy | cape | J kg-1 | y |
| CIN | atmosphere_convective_inhibition | cin | J kg-1 | y |
| Cloud base altitude | cloud_base_altitude | zcb | m | y |
| Cloud base pressure | air_pressure_at_cloud_base | pcb | Pa | y |
| Cloud base temperature | cloud_base_temperature | tcb | K | n |
| Cloud fraction (total) | cloud_area_fraction | clt | 1 | y |
| Cloud ice content (height resolved) | mass_fraction_of_cloud_ice_in_air | cli | 1 | y |
| Cloud liquid water content (height resolved) | mass_concentration_of_cloud_liquid_water_in_air | cllw | kg m-3 | y |
| Cloud mask | cloud_mask | clm | 1 | n |
| Cloud optical thickness | atmosphere_optical_thickness_due_to_cloud | otc | 1 | y |

| Variable description | CF-Standard_name / not CF: suggested long_name | Abbreviation / filename <var> | Unit | in CF: YES or NO |
|---|---|---|---|---|
| Cloud optical thickness due to ice water | atmosphere optical thickness due to ice water | otcli | 1 | y |
| Cloud optical thickness due to liquid water | atmosphere_optical_thickness_due_to_cloud_ice_water | otcli | 1 | n |
| Cloud optical thickness due to liquid water | atmosphere_optical_thickness_due_to_cloud_liquid_water | otclw | 1 | n |
| Cloud thickness (liquid clouds) | thickness_of_liquid_water_cloud | cth | m | y |
| Cloud top altitude (geometric height above geoid) | cloud_top_altitude | zgct | m | y |
| Cloud top height (distance above surface) | height_at_cloud_top | zth | m | y |
| Cloud top pressure | air_pressure_at_cloud_top | pct | Pa | y |
| Cloud top temperature | air_temperature_at_cloud_top | tct | K | y |
| Cloud water content (height resolved) | mass_fraction_of_cloud_liquid_water_in_air | clw | 1 | y |
| Convective precipitation | convective_precipitation_amount | prcon | kg m-2 | y |
| Doppler velocity | doppler_velocity | dv | m s-1 | n |
| Drizzle liquid water (height resolved) | mass_concentration_of_drizzle_in_air | drlw | kg m-3 | y |
| Drop number concentration | drop_number_concentration | dnc | m-3 mm-1 | n |
| Effective radius of cloud ice particles | effective_radius_of_cloud_ice_particles | reffcli | m | n |
| Effective radius of cloud liquid water particles | effective_radius_of_cloud_liquid_water_particle | reffclw | m | y |
| Frequency band of sensor | sensor_band_central_radiation_frequency | freq_sb | s-1 | y |
| Frozen phase water content (height resolved) | mass_concentration_of_frozen_water_in_air | iwc | kg m-3 | n |
| Geopotential height | geopotential_height | zg | m | y |
| Height | height | Height or zag | m | y |
| Humidity mixing ratio | humidity_mixing_ratio | humr | 1 | y |
| Ice crystal number concentration | number_concentration_of_ice_crystals_in_air | dnccli | m-3 | y |
| Latent heat flux | surface_upward_latent_heat_flux | hfls | W m-2 | y |
| Latitude | latitude | lat | degree_north | y |
| Liquid water content (height resolved; cloud + rain) | mass_concentration_of_liquid_water_in_air | lwc | kg m-3 | y |
| Longitude | longitude | lon | degree_east | Y |
| LW broadband downwelling radiation (surface) | surface_downwelling_longwave_flux_in_air | rlds | W m-2 | y |

| Variable description | CF-Standard_name / not CF: suggested long_name | Abbreviation / filename <var> | Unit | in CF: YES or NO |
|---|---|---|---|---|
| LW broadband upwelling radiation (surface) | surface_upwelling_longwave_flux_in_air | rlus | W m-2 | y |
| Normalized Difference Vegetation Index | normalized_difference_vegetation_index | ndvi | 1 | y |
| Normalized range corrected signal (lidar) | normalized_range_corrected_signal, Alias: range_corrected_backscatter_signal | beta_raw | 1 | n |
| Nyquist frequency | nyquist frequency | nqf | s-1 | n |
| Nyquist velocity | nyquist velocity | nqv | m s-1 | n |
| Particle backscatter coefficient | particle_backscatter_coefficient | pbc | m-1 sr-1 | n |
| Particle depolarization ratio | particle_depolarization_ratio | pdr | 1 | n |
| Particle extinction coefficient | particle_extinction_coefficient | pec | m-1 | n |
| Particle lidar ratio | particle_lidar_ratio | plr | sr | n |
| Path integrated attenuation | path_integrated_attenuation | pia | dBZ | n |
| Path of integrated cloud liquid water | atmosphere_mass_content_of_cloud_liquid_water | clwvi | kg m-2 | y |
| Path of integrated ice water | atmosphere_mass_content_of_cloud_ice | ciwvi | kg m-2 | y |
| Path of integrated water vapor | atmosphere_mass_content_of_water_vapor | prw | kg m-2 | y |
| Precipitation | precipitation_amount | precip | kg m-2 | y |
| Pressure | air_pressure | pa | Pa | y |
| Radar co-polar correlation function | radar_co-polar_correlation_function | rhohv | 1 | n |
| Radar differential reflectivity | radar_differential_reflectivity | zdr | dBZ | n |
| Radar integrated differential phase | radar_integrated_differential_phase | phidp | deg | n |
| Radar linear depolarization ratio | radar_linear_depolarization_ratio | ldr | dB | n |
| Radar reflectivity factor | equivalent_reflectivity_factor | dbz | dBZ | y |
| Radar specific differential phase | radar_specific_differential_phase | kdp | deg km-1 | n |
| Radar spectral width | radar_spectral_width | sw | m s-1 | n |
| Radar spectral skewness | radar_spectral_skewness | rsk | 1 | n |
| Radial velocity or fall velocity | radial_velocity_of_scatterers_away_from_instrument | rv | m s-1 | y |
| Rain rate | rainfall_rate | rr | m s-1 | y |
| Range | distance_from_sensor_to_center_of_each_range_gates_along_the_line_of_sight | range | m | n |
| Range corrected backscatter signal | range_corrected_backscatter_signal, Alias: normalized_range_corrected_signal | beta_raw | 1 | n |
| Reflected solar spectral radiance | downwelling_radiance_per_unit_wavelength_in_air , Alias: downwelling_spectral_radiance_in _air | rssr | W m-2 | y |

| Variable description | CF-Standard_name / not CF: suggested long_name | Abbreviation / filename <var> | Unit | in CF: YES or NO |
|---|---|---|---|---|
| Relative humidity | relative_humidity | hur | 1 | y |
| Sea surface temperature | sea_surface_temperature | sst | K | y |
| Sensible heat flux | surface_upward_sensible_heat_flux | hfss | W m-2 | y |
| Sensor azimuth angle | sensor_azimuth_angle | azi | degree | y |
| Sensor azimuth angle velocity | sensor azimuth angle velocity | aziv | degree s-1 | n |
| Sensor elevation angle | sensor elevation angle | ele | degree | n |
| Sensor elevation angle velocity | sensor elevation angle velocity | elev | degree s-1 | n |
| Soil heat flux (downward) | downward_heat_flux_in_soil | hfsoil | W m-2 | y |
| Solar radiation flux (atmosphere) | downwelling_shortwave_flux_in_ air | rsd | W m-2 | y |
| Specific humidity | specific_humidity | hus | kg kg-1 | y |
| Station number | station number | stat | 1 | n |
| Surface albedo | surface_albedo | surfalb | 1 | y |
| Surface longwave emissivity | surface_longwave_emissivity | sle | 1 | y |
| Surface temperature | surface_temperature | ts | K | y |
| SW broadband downwelling radiation (surface) | surface_downwelling_shortwave_flux_in_air | rsds | W m-2 | y |
| SW broadband upwelling radiation (surface) | surface_upwelling_shortwave_flux_in_air | rsus | W m-2 | y |
| Temperature | air_temperature | ta | K | y |
| Time | time | time | seconds since 1970-01-01 00:00:00 | y |
| Total downwelling radiation | total_downwelling_radiation | rtd | W m-2 | n |
| Total upwelling radiation | total upwelling radiation | rtu | W m-2 | n |
| Vertical velocity | upward_air_velocity | wl | m s-1 | y |
| Visibility | visibility_in_air | vis | m | y |
| Volume depolarization ratio | volume depolarisation ratio | vdr | 1 | n |
| Volume extinction coefficient | volume extinction coefficient | vec | 1 | n |
| Wavelength of radiation | radiation_wavelength | wl | m | y |
| Wind direction | wind_from_direction | wdir | degree | y |
| Wind speed | wind_speed | wspeed | m s-1 | y |
| Wind speed maximum (gust) | wind_speed_of_gust | wspeed_max | m s-1 | y |
| Zenith angle of beam direction | zenith_angle | zenith | degrees | y |

[...]

## References

1: re3data.org, SAMD, re3data.org - Registry of Research Data Repositories, editing status 2021-07-14. http://doi.org/10.17616/R3D944
2: Lammert, Andrea, Grützun, Verena, Stamnas, Erasmia., The SAMD Product Standard (Standardized Atmospheric Measurement Data). . Zenodo, 2018. https://doi.org/10.5281/zenodo.1741364
2: ICDC, Integrated Climate Data Center, re3data.org, DOI:10.17616/R39S3N, 2021-11-16. https://www.cen.uni-hamburg.de/icdc
3: NetCDF, doi:10.5065/D6H70CW6 , UCAR/Unidata, 2019. https://doi.org/10.5065/D6H70CW6
5: Annika Jahnke-Bornemann, Andrea Lammert, Felix Ament, SAMD: Data Policy for Data USERS (Version 1). FDM/UHH, 2022. http://doi.org/10.25592/uhhfdm.9824
6: Sarah, Wiesner, Data Policy for FESSTVaL campaign data. FDM/UHH, 2022, February 2. http://doi.org/10.25592/uhhfdm.9891
6: ICDC, SAMD Archive at ICDC, 2018, https://www.cen.uni-hamburg.de/icdc/research/samd.html
7: Brian Eaton, Jonathan Gregory, Bob Drach, Karl Taylor, Steve Hankin,
Jon Blower, John Caron, Rich Signell, Phil Bentley, Greg Rappa, Heinke Höck,
Alison Pamment, Martin Juckes, Martin Raspaud, Randy Horne,
Timothy Whiteaker, David Blodgett, Charlie Zender, Daniel Lee, David Hassell,
Alan D. Snow, Tobias Kölling, Dave Allured, Aleksandar Jelenak,
Anders Meier Soerensen, Lucile Gaultier, Sylvain Herlédan, NetCDF Climate and Forecast (CF), Metadata Conventions. , 10 September, 2021.