EUMETSAT CM SAF CLIMATE MONITORING

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MeteoSwiss

Product User Manual

MeteoSwiss Cloud Data v.4.2.0

CMASK	**Cloud Mask**
CFC	**Cloud Fractional Cover**
CTH	**Cloud Top Hight**
CTT	**Cloud Top Temperature**

Document Change Record

Issue/ Revision	Date	DCN No.	Changed Pages/Paragraphs
1.0	10/10/2025	MeteoSwiss/PUM/MET/SwissCLOUD/4.2	First version

Reference Documents

Reference	Title	Code
RD 1	Validation Report Meteosat Cloud Fractional Cover (COMET) Edition 2	SAF/CM/MeteoSwiss/VAL/MET/CFC/2.0
RD 2	Algorithm Theoretical Basis Document Meteosat Cloud Fractional Cover Edition 2	SAF/CM/MeteoSwiss/ATBD/MET/CFC /2.1

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1 Product Description

The MeteoSwiss Cloud data include a binary cloud mask (CMASK), a cloud fractional cover (CFC), cloud top temperature (CTT) and cloud top height (CTH).

CMASK – Binary cloud mask calculated from Meteosat visible and infrared images using the GeoSatClim v.4.2.2 cloud retrieval algorithm.

CFC – Cloud fractional cover. The cloud fractional cover is trained against SYNOP observations.

CTT – Cloud Top Temperature. The cloud top temperature is the temperature as observed by the satellite of the uppermost cloud layer for opaque clouds.

CTH – Cloud Top Height. Cloud Top Height calculated from observed cloud top temperatures by comparing the observed cloud top temperature with ERA5 temperature profiles.

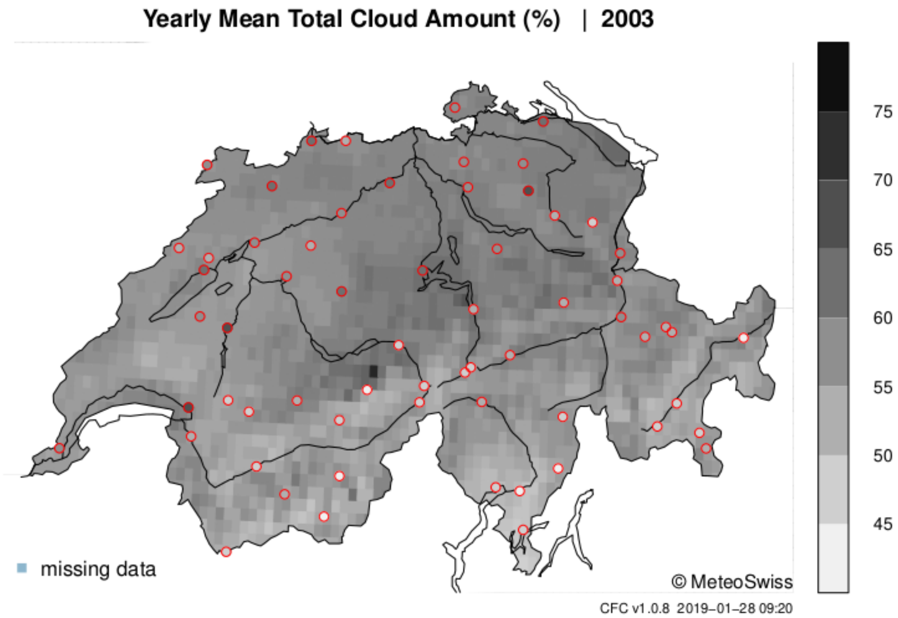


Figure 1: Product example MeteoSwiss Fractional Cloud Cover (CFC). 0.05° lat/lon grid. Jährlicher Wolkenbedeckungsgrad für 2003. Die roten Kreise sind Bodenmessdaten.

The Swiss Meteosat Cloud products are generated in near-real-time and as long-term climate data record for the period 1991-now (ch05h, 0.05° latitude and longitude grid) and/or the period 2004-now (ch02, 0.02° latitude and longitude grid) for entire Switzerland. The following cloud parameters are available:

Parameter	Name	Description	Period and Grid	Temporal
CMASK	Cloud Mask	Binary cloud mask [0,1]	2004-now (0.02°)	H
CFC	Cloud Fractional Cover	Fraction of the sky covered by clouds	1991-now (0.05°) 2004-now (0.02°)	H,D,M,Y Norm9120 Norm0420
CTH	Cloud Top Hight	Cloud Top Height. Analysed from the observed cloud top temperature and ER5 temperature/height profiles.	1991-now (0.05°)	H
CTT	Cloud Top Temperature	Temperature of the uppermost cloud layer observed by the satellite,	1991-now (0.05°)	H

Table 1: Parameters of the MeteoSwiss Cloud products. The parameters are available for Switzerland at a 0.05° (ch05h) and/or 0.02° (ch02) latitude and longitude grid for different time resolutions: H=hourly, D=daily, M=monthly, Y=yearly. For CFC a norm value is available for 1991-2020 and 2004-2020 is provided.

In addition, the following auxiliary data are available:

Ancillary Parameter	Name	Description	Period and Grid	Temporal
PCFC	Probability Cloud Fractional Cover	Probability of correct detection for the cloud fractional cover	2004-now (0.02°)	H
CMASKSCORE	Cloud Mask Score	Cloud Mask score indicating the successfully passed cloud tests	2004-now (0.02°)	H
IR	Infrared Temperature	Top-of-atmosphere Meteosat Infrared Brighntness Temperature measured at 10.8 micrometer wavelength	1991-now native satellite resolution	Instantaneous: 15 min for MSG and 30 min for MFG
VIS	Meteosat visible radiance	Top of Atmosphere visible Meteosat radiance	1991-now Native satellite resolution	Instantaneous: 15 min for MSG and 30 min for MFG
SAA	Solar azimuth angle	Pixel-wise solar azimuth angle	1991-now Native satellite resolution	Instantaneous: 15 min for MSG and 30 min for MFG

SZA	Solar zenith angle	Pixel-wise solar zenith angle	1991-now Native satellite resolution	Instantaneous: 15 min for MSG and 30 min for MFG
SCAN_TIME	Meteosat scan time	Precise scan time per satellite pixel	1991-now Native satellite resolution	Instantaneous: 15 min for MSG and 30 min for MFG

Table 2: Auxiliary data available for the MeteoSwiss cloud products.

1.1 Short Algorithm Description

GeoSatClim represents a comprehensive satellite-based processing system for deriving clouds from Meteosat observations. The software was developed at MeteoSwiss as part of its engagement within the CM SAF consortium [RD2] with funding from EUMETSAT's SAF framework for 20 years+.

The system utilizes Meteosat Visible Infra-Red Imager (MVIRI) and Spinning Enhanced Visible and Infrared Imager (SEVIRI) data from Meteosat First and Second Generation (MFG and MSG) satellites, respectively. Calibration factors published by EUMETSAT are employed for MVIRI and SEVIRI, though infrared coefficient factors for MVIRI utilize those from John et al. (2019). These coefficient factors enable conversion of Meteosat digital number counts to Top Of Atmosphere (TOA) radiances, which are subsequently converted to reflectance for visible channels and brightness temperature for infrared channels.

Cloud-snow discrimination represents a critical algorithmic component, particularly relevant for Alpine regions where snow and cloud surfaces exhibit similar optical properties in visible wavelengths. The algorithm employs sophisticated multi-spectral techniques leveraging differential absorption characteristics. The distinction between water and ice clouds utilizes a simple formula where the fraction of water clouds depends on brightness temperature, with values constrained between minimum and maximum thresholds of 245K and 265K respectively. LUT values for ice and water clouds are subsequently combined linearly using the fraction of water clouds.

The topographic treatment incorporates comprehensive corrections for complex terrain effects. Orthorectification addresses the slant viewing geometry of non-nadir Meteosat pixels, which generates artificial geometric shifts in mountainous terrain. This correction utilizes surface elevation datasets projected onto orthorectified Meteosat grids to generate appropriate pixel relocations. Cloud parallax correction accounts for geometric shifts caused by elevated cloud positions, which can amount to up to 10 km displacement for 10 km high clouds at 45° longitude or latitude.

The Cloud Fractional Cover data is based on only two heritage channels from MFG MVIRI and MSG SEVIRI. The calibrated visible and inter-calibrated infrared radiances firstly serve as input to a daily recurring parametric estimation of clear sky background fields with diurnal cycle models of brightness temperature and reflectance. These clear sky inversions are constrained by previously cloud masked reflectance and brightness temperatures. The resulting clear sky background fields together with the all sky instantaneous reflectance and brightness temperatures yield continuous cloud mask scores of pixel wise state and spatiotemporal variability. CFC is retrieved from these scores by use of a Bayesian classifier. It is based on the conditional occurrence probability of scores and two-dimensional score combinations given SYNOP observed CFC classes. The use of such two dimensional score combinations featuring both the state and variability of specific reflectance or brightness temperature features is a substantial and useful addition to the commonly used naïve Bayesian classifier [RD2]. The use of a Bayesian classifier has the benefit of instantaneous and pixel wise CFC estimates. This means that Meteosat CFC is not built from the spatial aggregation binary cloud mask estimates as often done. The use of a Bayesian classifier also yields posterior retrieval probabilities for each CFC value.

1.2 Highlights

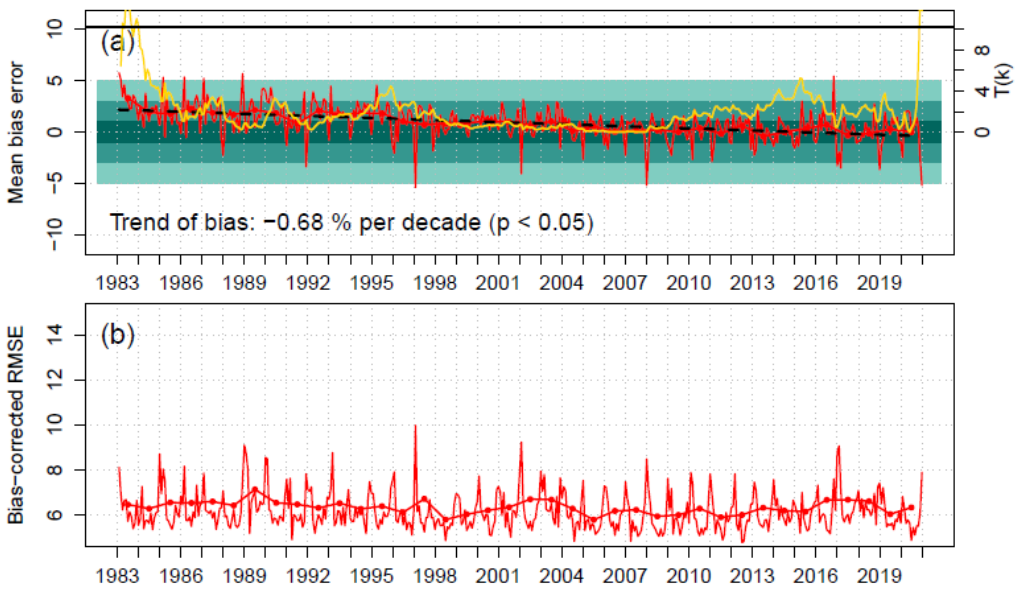
- Heritage: Corresponds to CFC measured at WMO/SYNOP sites
- Near-realtime climate data issued with a latency of 1 day
- Applicability: Instantaneous and pixel wise CFC estimates with posterior retrieval probability as part of the dataset
- Precision: Inter-calibrated input radiance time series from EUMETSAT
- Accuracy: Meets optimal GCOS daily and monthly requirements and decadal stability. Meets those requirements for many of the individual locations.

1.3 Validation

Averaged over all reference sites in Europe, Meteosat CFC complies with monthly GCOS optimal requirements for accuracy and precision as compared to SYNOP (see figure 2 and figure 3). Taking accuracy and precision requirements simultaneously into account – monthly optimal, target and threshold requirements are met by 20%, 61% and 80% of sites, respectively.

The Meteosat CFC accuracy and precision results together with the reported decadal stability <1%,fulfilling the target decadal stability requirements, demonstrate of the Meteosat CFC is suitable for climate monitoring, climate model evaluation and regional climate analysis applications. The Meteosat CFC corresponds to CFC measured at WMO SYNOP sites.

Figure 2: Mean bias error (a, red line) and bias-corrected root mean square error (b, red line) of Meteosat CFC as compared to SYNOP observations in Europe. The yellow line indicates the Standard Normal Homogeneity Test (SNHT).



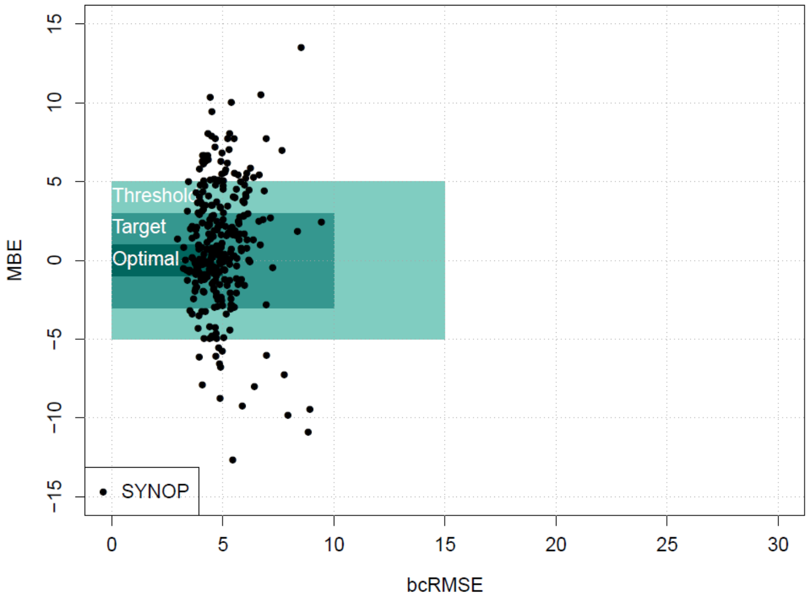


Figure 3: Performance statistics of the MeteoSwiss CFC monthly means as compared to synoptic observations at 290 sites. MBE=mean bias error. Bc-RMSE=bias corrected root mean square area.

1.4 Recommended Application

The MeteSwiss CFC is useful to extend existing ground-based SYNOP CFC estimates with spatial information. Meteosat CFC can be used to evaluate and improve NWP or climate model-based cloud cover diurnal cycles (e.g. the timing and phase of convective cloud formation). The usability of Meteosat CFC in climates with substantial snow and near surface fog has to be tested. Despite the high decadal stability, the applicability of Meteosat CFC in trend analyses has to be thoroughly evaluated and cross-checked with quality screened ground based reference time series.

2 Data format description

The MeteoSwiss's climate monitoring cloud products are provided as NetCDF (Network Common Data Format) files (http://www.unidata.ucar.edu/software/netcdf/). The data files are created following NetCDF Climate and Forecast (CF) Metadata Convention version 1.8 (https://cfconventions.org/Data/cf-conventions/cf-conventions-1.8/cf-conventions.html) and NetCDF Attribute Convention for Dataset Discovery version 1.3 (http://wiki.esipfed.org/index.php/Attribute_Convention_for_Data_Discovery_1-3). For data processing and conversion to various graphical packages input format, MeteoSwiss recommends the usage of the climate data operators (CDO), available under GNU Public License (GPL) from MPI-M (http://www.mpimet.mpg.de/~cdo).

2.1 Spatial gridding

The presented MeteoSwiss Cloud Data are provided on a regular latitude and longitude grid (table 3). The geographic reprojection from the native Meteosat grid onto the latitude longitude grid is carried out using a spatial nearest neighbour search. Please note that with the selected grid we more or less represent the native grid resolution which is about 0.01° for the Meteosat rapid HRV scans, about 0.03° for the SEVIRI sensor and about 0.05° for the MVIRI sensor over Switzerland.

Lon min	Lon max	Lat min	Lat max	Spacing (lon, lat)	Projection	Datum
5.750	10.750	45.750	47.875	0.02°	latitude - longitude	WGS 84
5.025	10.975	45.025	48.975	0.05°	latitude - longitude	WGS 84

Table 3: Characteristics of the MeteoSwiss Cloud Data geographical coverage.

For the high-resolution data processing (ch02) we merge 0.03° SEVIRI (thermal) and 0.01° HRV scans (optical) for the cloud retrieval and therefore decided for an intermediate 0.02° latitude and longitude grid.

With the ch05h time series back to 1991 we provide a true climate time series over the 0.05° MVIRI and 0.03° SEVIRI period which is not altered by downscaling artifacts. We have therefore decided for the 0.05° MVIRI grid resolution.

Hence, we provide the highest possible spatial resolution as observed by the satellite sensor for each time series. Table 6 gives information on the geographical coverage. The 0.05° data are slightly larger than Switzerland and also cover those regions outside Switzerland which are relevant for the Swiss hydrological catchment.

2.2 Temporal aggregation

The MeteoSwiss Cloud Data are Level-3 presented as hourly, daily, monthly and yearly means. Re-projected, instantaneous fields are aggregated into hourly, daily and monthly means. The spatial and temporal aggregation is conducted using the GeoSatClim re-projection and aggregation tools. Hourly means are derived as an arithmetic mean from two slots for MVIRI and four slots for SEVIRI:

- MVIRI: the 0-hour mean is composed of 2 full disc scans starting at 0 and 30 minutes after 00:00 UTC

- SEVIRI: the 0-hour mean is composed of 4 full disc scans starting at 0, 15, 30 and 45 minutes after 00:00 UTC

The hourly averaging is performed if at least one measurement is within the hourly interval. The daily mean is the mean of all hourly means if at least four valid hourly means are present. The monthly mean is the mean of all daily means if at least 20 valid daily means are present. The monthly mean diurnal cycle is a vector of 24 values containing the mean hourly values for the respective month for hours with at least 20 valid hourly means.

2.3 File naming and packing

Hourly, daily and monthly data are packed into monthly files to simply the data transfer, which follows the naming convention:

[satellite].[variable].[t]_[region].lonlat_[yyyy][mm]01000000.nc

Where satellite is the satellite identifier (msg, mfg), variable is the cloud component (CFC), t is time interval (m=monthly, d=daily, h=hourly), region (ch02, ch05h), yyyy=year, mm=month.

Example Cloud Fractional Coverage (CFC) data for September 2025 for the ch05h grid:

msg.CFC.H_ch05h.lonlat_20250901000000.nc (720 hourly mean steps in one file)

msg.CFC.D_ch05h.lonlat_20250901000000.nc (30 daily mean steps in one file)

msg.CFC.M_ch05h.lonlat_20250901000000.nc (1 monthly mean step in one file)

2.4 General Variables

Name	**Description**
lon	*geographical longitude of grid-box centre [degree_east]*
lat	*geographical latitude of grid-box centre [degree_north]*
time	*time of averaging/composite time period; in case of diurnal cycles, this vector has 24 elements [days counted from 1970- 01-01]*
lon_bnds	*geographical longitude of grid-box edges [degree_east]*
lat_bnds	*geographical latitude of grid-box edges [degree_north]*
time_bnds	*time edges*
record_status	*overall status of each record (timestamp) in this file. If a record is flagged as not ok, it is recommended not to use it.*

grid_mapping	*projection parameters*
SATID	*spacecraft ID (unique number defined by MSGGS or GSDS or NORAD or COSPAR):* *19 = MFG 4, 20 = MFG 5, 21 = MFG 6, 22 = MFG 7,* *321 = MSG 1, 322 = MSG 2, 323 = MSG 3, 324 = MSG 4*

Table 4: General Variables.

2.5 Global Attributes

Name	**Description**
institution	Data produced at Federal Office of Meteorology and Climatology MeteoSwiss
title	Satellite-based Climate Data Record of MeteoSwiss
summary	This file contains Climate Data using the software GeoSatClim from the Satellite Application Facility on Climate Monitoring (CM SAF)
id	not assigned
variable_id	NA
product_version	*4.2.0*
creator_name	not assigned
creator_email	not assigned
creator_url	www.meteoswiss.admin.ch
institution	*Federal Office of Meteorology and Climatology MeteoSwiss*
project	*Satellite Application Facility on Climate Monitoring (CM SAF)*
references	Information on the data is available at https://www.meteoswiss.admin.ch/climate/the-climate-of-switzerland/spatial-climate-analyses.html
Conventions	CF-1.8, ACDD-1.3
standard_name_vocabulary	*Standard Name Table (v28, 07 January 2015)*
date_created	*creation date*
time_coverage_start	*starting date*

time_coverage_end	*ending date*
time_coverage_duration	*time duration*
time_coverage_resolution	*time resolution*
geospatial_lon_units	*degrees_east*
geospatial_lon_min	*Minimum longitude*
geospatial_lon_max	*Maximum longitude*
geospatial_lon_resolution	*Grid spacing in °*
geospatial_lat_units	*degrees_north*
geospatial_lat_min	*Minimum longitude*
geospatial_lat_max	*Maximum longitude*
geospatial_lat_resolution	*Grid spacing in °*
licence	*The GeoSatClim product ("Climate Product") is subject to the Federal Office of Meteorology and Climatology MeteoSwiss Data Policy. By accessing or using the Climate Product, users agree to comply with the terms outlined in Policy, including the following attribution: "Source MeteoSwiss". The Climate Product was generated using the EUMETSAT software GeoSatClim provided through the Climate Monitoring Satellite Application Facility (CM SAF). The Climate Product contains modified EUMETSAT Meteosat data since 1991, as well as additional data and products obtained from the European Centre for Medium-Range Weather Forecasts (ECMWF), NASA's Combined ASTER and MODIS Emissivity over Land (CAMEL) emissivity data, and CMIP6 aerosol data and elevation data from the SwissTopo DHM25 as ancillary fields.*
platform	*MFG or MSG*
platform_vocabulary	*GCMD Platforms, Version 8.6*
instrument	*MVIRI or SEVIRI*
instrument_vocabulary	*GCMD Instruments, Version 8.6*

Table 5: Global attributes.

2.6 Variables

[Parameter] (time, lat, lon)

field containing the mean parameter values. For a detailed description see table 1.

Parameter	**Unit**	**Valid range**	**Type**	**Scale**	**Offset**	**Fill Value**
CMASK		[0 or 1]	float	1.0	0.0	9.96921e+36
CFC	%	[0,100]	float	1.0	0.0	9.96921e+36
CTH	m	[0,10000]	float	1.0	0.0	9.96921e+36
CTT	K	[260,360]	float	1.0	0.0	9.96921e+36
VIS	mW·m-2·sr-1·(cm-1)-1	[0,2]	float	1.0	0.0	9.96921e+36
IR	K	[220,350]	float	1.0	0.0	9.96921e+36
SAA	degree	[0,360]	float	1.0	0.0	9.96921e+36
SZA	degree	[0,180]	float	1.0	0.0	9.96921e+36

Table 6: Parameters with specifications of the MeteoSwiss Cloud Data. For a detailed description please refer to table 1.

3 Feedback

3.1 User feedback

Users of the MeteoSwiss Cloud Data are encouraged to provide feedback on the product and services to the MeteoSwiss CM SAF team. MeteoSwiss is keen to learn of what use the MeteoSwiss Cloud Data are. So please feedback your experiences as well as your application area to MeteoSwiss.

Please provide your feedback to our customer service (e-mail kundendienst@meteoswiss.ch).

3.2 Specific requirements for future products

Beside your general feedback you are cordially invited to provide your specific requirements on future products for your applications. Please provide your requirements to our staff or via our customer service (e-mail address kundendienst@meteoswiss.ch).

4 Copyright and Disclaimer

The user of the MeteoSwiss Cloud Data agrees to respect the following regulations:

4.1 Copyright

This GeoSatClim products ("MeteoSwiss Cloud Data") are subject to the Federal Office of Meteorology and Climatology MeteoSwiss Data Policy. By accessing or using this Climate Product, users agree to comply with the terms outlined in Policy, including the following attribution: “Source MeteoSwiss”. The Climate Products were generated using the EUMETSAT software GeoSatClim provided through the Climate Monitoring Satellite Application Facility (CM SAF). The Climate Products contain modified EUMETSAT Meteosat data since 1991, and are also based on additional data and products obtained from the European Centre for Medium-Range Weather Forecasts (ECMWF), NASA's Combined ASTER and MODIS Emissivity over Land (CAMEL) emissivity data, and CMIP6 aerosol data and elevation data from the SwissTopo DHM25 as ancillary fields.”

4.2 Acknowledgement and Identification

When exploiting the MeteoSwiss Cloud Data you are kindly requested to acknowledge this contribution accordingly and make reference to MeteoSwiss and the CM SAF, e.g., by stating “The work performed was done by using data from MeteoSwiss generated with the software GeoSatClim from EUMETSAT’s Satellite Application Facility on Climate Monitoring (CM SAF)”. It is highly recommended to identify the product version used clearly.

4.3 Re-distribution of CM SAF data

Please do not re-distribute the MeteoSwiss Cloud Data to third parties. The use of the MeteoSwiss products is granted free of charge to every interested user, but an essential interest exists to know how many and what users MeteoSwiss has. This helps to ensure of the MeteoSwiss operational services as well as its evolution according to user needs and requirements.