EUMETSAT Satellite Application Facility on Climate Monitoring

Product User Manual

FTH edition 1.0

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Free Tropospheric Humidity **CM-139**

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Applicable documents

Reference	Title	Code
AD 1	Memorandum of Understanding between CM SAF and LMD, Paris, France	
AD 2	CM SAF Product Requirements Document	SAF/CM/DWD/PRD/2.0

Reference Documents

Reference	Title	Code
RD 1	Validation Report on FTH	SAF/CM/VAL/FTH/1.1
RD 2	Algorithm Theoretical Basis Document FHT edition 1.2	SAF/CM/ATBD/FTH/1.2

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1 The EUMETSAT SAF on Climate Monitoring (CM SAF)

The importance of climate monitoring with satellites was recognized in 2000 by EUMETSAT Member States when they amended the EUMETSAT Convention to affirm that the EUMETSAT mandate is also to “contribute to the operational monitoring of the climate and the detection of global climatic changes". Following this, EUMETSAT established within its Satellite Application Facility (SAF) network a dedicated centre, the SAF on Climate Monitoring (CM SAF, http://www.cmsaf.eu).
The consortium of CM SAF currently comprises the Deutscher Wetterdienst (DWD) as host institute, and the partners from the Royal Meteorological Institute of Belgium (RMIB), the Finnish Meteorological Institute (FMI), the Royal Meteorological Institute of the Netherlands (KNMI), the Swedish Meteorological and Hydrological Institute (SMHI), the Meteorological Service of Switzerland (MeteoSwiss), and the Meteorological Service of the United Kingdom (UK MetOffice). Since the beginning in 1999, the EUMETSAT Satellite Application Facility on Climate Monitoring (CM SAF) has developed and will continue to develop capabilities for a sustained generation and provision of Climate Data Records (CDR’s) derived from operational meteorological satellites.
In particular the generation of long-term data sets is pursued. The ultimate aim is to make the resulting data sets suitable for the analysis of climate variability and potentially the detection of climate trends. CM SAF works in close collaboration with the EUMETSAT Central Facility and liaises with other satellite operators to advance the availability, quality and usability of Fundamental Climate Data Records (FCDRs) as defined by the Global Climate Observing System (GCOS). As a major task the CM-SAF utilizes FCDRs to produce records of Essential Climate Variables (ECVs) as defined by GCOS. Thematically, the focus of CM SAF is on ECVs associated with the global energy and water cycle.

Another essential task of CM SAF is to produce data sets that can serve applications related to the new Global Framework of Climate Services initiated by the WMO World Climate Conference-3 in 2009. CM SAF is supporting climate services at national meteorological and hydrological services (NMHSs) with long-term data records but also with data sets produced close to real time that can be used to prepare monthly/annual updates of the state of the climate. Both types of products together allow for a consistent description of mean values, anomalies, variability and potential trends for the chosen ECVs. CM SAF ECV data sets also serve the improvement of climate models both at global and regional scale.
As an essential partner in the related international frameworks, in particular WMO SCOPE-CM (Sustained COordinated Processing of Environmental satellite data for Climate Monitoring), the CM SAF - together with the EUMETSAT Central Facility, assumes the role as main implementer of EUMETSAT’s commitments in support to global climate monitoring. This is achieved through:

- Application of highest standards and guidelines as lined out by GCOS for the satellite data processing,
- Processing of satellite data within a true international collaboration benefiting from developments at international level and pollinating the partnership with own ideas and standards,
- Intensive validation and improvement of the CM SAF climate data records,
- Taking a major role in data set assessments performed by research organisations such as WCRP. This role provides the CM SAF with deep contacts to research organizations that form a substantial user group for the CM SAF CDRs,
- Maintaining and providing an operational and sustained infrastructure that can serve the community within the transition of mature CDR products from the research community into operational environments.

A catalogue of all available CM SAF products is accessible via the CM SAF webpage, www.cmsaf.eu/. Here, detailed information about product ordering, add-on tools, sample programs and documentation is provided.

2 Introduction

This CM SAF Product User Manual provides information on the MVIRI/SEVIRI based free tropospheric humidity product (CM-139, FTH_MVIRI) using ECMWF Re-Analysis ERA-Interim and cloud cover as well as cloud top pressure information from ISCCP-DX (version 0, accessible via NOAA/NESDIS/NCDC: ftp://eclipse.ncdc.noaa.gov/pub/isccp/dx and ASDC at NASA/LaRC: http://eosweb.larc.nasa.gov/PRODOCS/isccp/table_isccp.html). MVIRI observations from METEOSAT 2-7 (ISCCP-DX) and SEVIRI (DWD archive) observations from METEOSAT8 (reprocessed EUMETSAT product) and METETOSAT9 (operational EUMETSAT product) are employed. The retrieved products have a spatial and temporal resolution of 0.625° and 3 hours, respectively.

Laboratoire Météorologie Dynamique (LMD) has developed a retrieval algorithm to convert raw clear sky radiances of the 6.3□ m channel of METEOSAT2-7 into the free tropospheric humidity (FTH) product (Roca et al., 2003; Brogniez et al., 2004; Roca et al., 2011). Also work on the construction of the clear sky radiance archive over the period 1983-1997 with special emphasis on the temporal homogeneity of the final database (Picon et al., 2003) has been carried out. Clear sky was defined using the ISCCP-DX data set. LMD has finished the production of the FTH and clear sky radiance data set for MFG with a temporal sampling of 3 hours and a spatial resolution of 0.625° for the period 1983-2005 for the nominal position.

Within a Research and Operation activity the retrieval and homogenization developments at LMD were transferred into the environment at CM SAF in order to sustain and increase the availability of long temporal records related to atmospheric humidity at CM SAF. Also in close cooperation with LMD the time series could be extended into the SEVIRI period and covers now the period July 1983 to December 2009 (Roca et al., 2009; Roca et al., 2012).

The CSR record forms the basic input to the FTH retrieval and has been generated jointly by CM SAF and CNRS. The CSR record for the period July 1983 – June 2005 was provided by CNRS. As described in RD 2, new homogenization coefficients are applied to the CSR data from January 2001 onwards. The extension of the CSR record (July 2005 – December 2009) has been carried out at CM SAF using the approach describes in RD 2. The quality of the CSR record is summarized in the Appendix of RD 1. The CSR record has not been cloud clarified. Instead original radiance observations comprise the CSR record.

CM SAF activities related to the generation of FTH data set from MVIRI and SEVIRI observations were part of a pilot project within the Sustained, Coordinated Processing of Environmental Satellite Data for Climate Monitoring (SCOPE-CM). The aim of the SCOPE-CM is to establish a network of facilities ensuring continuous and sustained provision of high-quality satellite products related to the Essential Climate Variables (ECV), on a global scale, responding to the requirements of the Global Climate Observing system (GCOS).

The FTH processing and validation software as implemented at DWD is the property of CNRS and CM SAF/DWD. The FTH product is released under CM SAF ownership. The Clear Sky Radiance (CSR) data record is release under CNRS and CM SAF ownership (July 1983 – June 2005 and July 2005 onwards, respectively).

This manual provides a technical description of the data set including information on the file format as well as on the data access. Furthermore, details on the implementation of the processing chain and on the retrieval algorithm are available in the Algorithm Theoretical Basis Document [RD 2]. Basic accuracy requirements are defined in the Product Requirement Document [AD 2], and a detailed validation of the FTH product is available in the validation report [RD 1].

3 Product definitions

The CM SAF FTH data set from METEOSAT2-5 and METEOSAT7-9 provides relative humidity values within ±45° longitude and ±45° latitude. The product is available at 3-hourly temporal resolution and as monthly averages (straightforward averages over all valid observations) on a regular latitude/longitude grid with a spatial resolution of 0.625° × 0.625°. The temporal coverage of the data sets ranges from July 1983 to December 2009. The METEOSAT6 period, March 1997-May 1998, is not covered. FTH is not valid for a fixed layer – rather the layer position and thickness depends on atmospheric condition, in particular water vapour content in the free troposphere (see RD 2). To illustrate the product Figure 1 shows exemplary monthly averaged FTH products during a winter and summer month as well as an exemplary instantaneous FTH product. Strong minima in FTH over northern and southern Africa during boreal summer as well strong maxima in FTH at the Inter Tropical Convergence Zone (ITCZ) are evident.

The FTH product is available in netCDF format including extensive metadata.

The auxiliary CSR data set has identical technical specifications and is provided as additional data layer in the FTH product file.

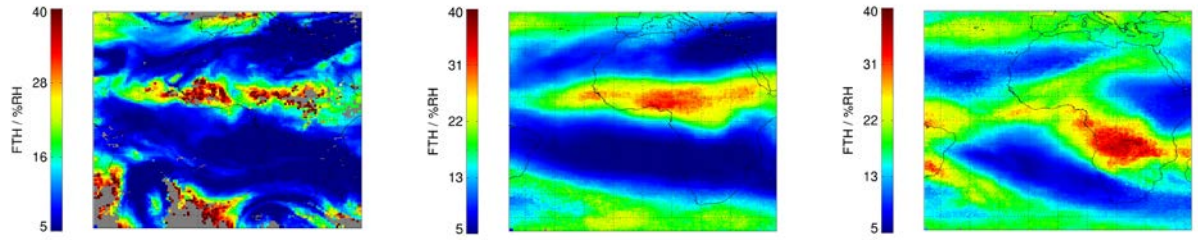

Figure 1: Instantaneous FTH at 12 UTC on 15 July 2009 (left panel) and monthly averaged FTH for July (middle panel) and January (right panel) 2009.

3.1 FTH Retrieval

The basic retrieval was developed by Soden and Bretherton (1996) and links the natural logarithm of the clear sky radiance at 6.3 µm channel to the mean relative humidity (RH, in % defined with respect to water only) of a broad layer of the troposphere. A linear regression is applied to retrieve the fitting parameters (a and b) of the CSR-to-FTH retrieval by using a representative dataset of thermodynamic profiles and sampling in the satellite field of view. Implemented are a=-0.1248 and b=33.46 as determined in Roca et al. (2009). The vertical averaging operator is the local relative humidity Jacobian (e.g. Roca et al., 2003; Brogniez, 2004; Brogniez et al., 2004).

A scaling parameter which represents the deviation from a standard tropical profile where the 240-K isotherm is located at 300 hPa (see Soden and Bretherton (1996) theory) and a correction of the satellite viewing angle θ are also implemented.

More details on the retrieval are given in the ATBD [RD-2].

The average relative bias (-2.9%), RMSD (15.5%) and decadal stability (0.5±0.45%) have been determined through comparison against the Analysed RadioSoundings Archive (ARSA), and details are outlined in the validation report [RD-1].

3.2 General limitations of the FTH data set

The validation of the FTH product exhibited an increase in bias between summer 1988 and summer 1990 and a maximum in bias in January 1996, with generally spurious biases in 1996. Therefore and though significant efforts have been dedicated to the homogenisation of the METEOSAT time series, the quality of the FTH retrieval would benefit from a recalibrated and intercalibrated FCDR of METEOSAT. The recovery of METEOSAT 6 data would close data gaps in the time series.

The identification of clear sky and low level clouds relies on ISCCP-DX data, and the FTH quality depends on the cloud classification quality. Strongest quality degradation can be expected when high level clouds are not correctly identified. For data until February 1997 coastal areas exhibit spurious quality due to issues in cloud detection.

It could be shown that the quality of the retrieval decreases when applied to observations in mid-latitudes. Therefore, the application of the retrieval is restricted to the tropics, i.e., to an area within ±45°N/S and ±45°E/W.

The retrieval is not reliable over elevated terrain with surface pressures less than 700 hPa because the weighting function might reach the surface. Surface properties would then affect the observations for which the retrieval was not designed and which will degrade the quality of the FTH product.

4 Outlook

The main task for the future will be to increase the spatial and temporal resolution of the FTH product to 0.25° and 1 hour, respectively. This requires the availability of radiances and a cloud mask for METEOSAT observations with the same or better resolutions. CM SAF is currently developing a new cloud mask which is intended to meet these requirements. Also, EUMETSAT CAF is working on the development of a METEOSAT FCDR which will be used by CM SAF as input to the FTH retrieval.

It is currently not foreseen to change the retrieval scheme. Depending on the FCDR definitions it might however be needed to recompute the regression coefficients.

The release of this updated FTH product is scheduled for summer 2016.

Finally, CM SAF will develop a geo-ring FTH demonstrator product. In its first version the geo-ring demonstrator will utilise geostationary observations from ISCCP, GSICS coefficients and a common reference channel.

5 Data filename and format description

CM SAF's climate monitoring FTH product is 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 1.6 (http://cf-pcmdi.llnl.gov/) and NetCDF Attribute Convention for Dataset Discovery version 1.0.

For data processing and conversion to various graphical packages input format, CM SAF recommends the usage of the climate data operators (CDO), available under GNU Public License (GPL) from MPI-M (http://www.mpimet.mpg.de/~cdo).

5.1 Filename convention

The product filenames follow the CM SAF filename convention and are consequently built as follows:

FTH<Averaging_type><Date><Time><Version><Projection_identifier><Data_source><processing level><area>.nc

- Averaging type: can be "in" for three hourly product files or "mm" for monthly mean product files.
- Date: date in yyyymmdd format. For the monthly average data products the first day of the month is taken for the day value ("dd").
- Time: time as hhmm.
- Version: version number of dataset to which the product file belongs. For the dataset described in this document the version number is "001".
- Projection identifier: for the regular longitude/latitude grid (0.625°x0.625°) which is used for the FTH product, the projection identifier is "22".
- Data source: 00448
- Processing level: "01
- Area: METEOSAT disk – "MF" (here within 45° N/S and E/W)

Examples:

- FTHmm200906010000001220044801MF.nc is a file containing the FTH monthly mean (mm) product, for June 2009.

- FTHin200906011200001220044801MF.nc is a file containing the FTH product at 12 UTC on the 1st June 2009.

5.2 Data file contents

A common NetCDF file consists of dimensions, variables, and attributes. These components can be used together to capture the meaning of data and relations among data. All FTH product files are built following the same design principles.

Each data file contains the following coordinate variables:

time

3hourly: date and time [Julian day since 01 January 1970]
monthly average: date of the first day in month [Julian day since 01 January 1970]

time_bnds
two-element array defining the 3hourly/monthly time period [Julian day since 01 January 1970]

latitude
geographical latitude of grid-box centre [degree_north]

longitude
geographical longitude of grid-box centre [degree_east]

Each data file contains the following 3-dimensional variables:

fth, csr
parameter grid box mean values of free tropospheric humidity (fth) and clear sky radiances (csr). Note: The monthly mean FTH was not computed from monthly mean CSR.

numo
total number of observations counted during the averaging period (not available for the 3hourly product)

stdv
root mean squared variance (not available for the 3hourly product)

Each file extracted from the CM SAF database has one record of the dimension (time, lat, lon) with the time dimension as the record dimension. This allows it to concatenate the individual records into an aggregated file. Global attributes are summarised in Table 1 and possible variable attributes in Table 2 (Appendix A).

6 Data ordering via the Web User Interface (WUI)

User services are provided through the CM SAF homepage www.cmsaf.eu. The user service includes information and documentation about the CM SAF and the CM SAF products, information on how to contact the user help desk and allows to search the product catalogue and to order products.

On the main webpage, a detailed description how to use the web interface for product search and ordering is given. We refer the user to this description since it is the central and most up to date documentation. However, some of the key features and services are briefly described in the following sections.

6.1 Product ordering process

You need to be registered and logged in to order products. A login is provided upon registration, all products are delivered free of charge. After the selection of the product, the desired way of data transfer can be chosen. This is either via a temporary ftp account (the default setting), or by CD/DVD or email. Each order will be confirmed via email, and the user will get another email once the data have been prepared. If the ftp data transfer was selected, this second email will provide the information on how to access the ftp server.

6.2 Contact User Help Desk staff

In case of questions the contact information of the User Help Desk (e-mail address contact.cmsaf@dwd.de, telephone and fax number) are available via the CM SAF main webpage (www.cmsaf.eu) or the main page of the Web User Interface.

6.3 Feedback/User Problem Report

Users of CM SAF products and services are encouraged to provide feedback on the CM SAF product and services to the CM SAF team. Users can either contact the User Help Desk (see chapter 5.2) or use the “User Problem Report” page. A link to the “User Problem Report” is available either from the CM SAF main page (www.cmsaf.eu) or the Web User Interface main page.

6.4 Service Messages / log of changes

Service messages and a log of changes are also accessible from the CM SAF main webpage (www.cmsaf.eu) and provide useful information on product status, versioning and known deficiencies.

7 Copyright and Disclaimer

The user of CM SAF data agrees to respect the following regulations:

7.1 Copyright

All intellectual property rights of the CM SAF products belong to EUMETSAT. The use of these products is granted to every interested user, free of charge. If you wish to use these products in publications, presentations, web pages etc., EUMETSAT's copyright credit must be shown by displaying the words "copyright (year) EUMETSAT" on each of the products used.

7.2 Acknowledgement and Identification

When exploiting EUMETSAT/CM SAF data you are kindly requested to acknowledge this contribution accordingly and make reference to the CM SAF, e.g. by stating "The work performed was done (i.a.) by using data from EUMETSAT's Satellite Application Facility on Climate Monitoring (CM SAF)". It is highly recommended to clearly identify the product version used. An effective way to do this is the citation of CM SAF data records via the digital object identifier (doi). The doi of the FTH data record is 10.5676/EUM_SAF_CM/FTH_METEOSAT/V001 (see also http://www.cmsaf.eu/DOI).

7.3 Re-distribution of CM SAF data

Please do not re-distribute CM SAF data to 3rd parties. The use of the CM SAF products is granted free of charge to every interested user, but we have an essential interest to know how many and what users the CM SAF has. This helps to ensure of the CM SAF operational services as well as its evolution according to users needs and requirements. Each new user shall register at CM SAF in order to retrieve the data.

7.4 Feedback

We are keen to learn of what use the CM SAF data are. So please feedback your experiences and your application area of the CM SAF data. EUMETSAT CM SAF is user driven service and is committed to consider the needs and requirements of its users in the planning for product improvements and additions. Users are invited to provide their specific requirements on future products for their applications.

8 References

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9 Appendix A

Table 1: Global NetCDF attributes

Name	Description
title	dataset title, "´FTH-MM" for all files containing monthly averages, “FTH-3h” for all 3hourly products
Conventions	conventions followed, "CF-1.5" for all files
Metadata_Convention	conventions followed, "Unidata Dataset Discovery v1.0" for all files
institution	institution where the data was produced
identifier_product_doi	doi
creator_url	URL contact information for the creator of the data
creator_email	email contact information for the creator of the data
references	references that describe the data or methods used to produce it
cdm_data_type	data type, here “grid”
filename	original filename
time_coverage_start	temporal coverage start of the data [ISO8601 date]
time_coverage_end	temporal coverage end of the data [ISO8601 date]
time_coverage_duration	temporal coverage duration of the data [ISO8601 duration]
geospatial_lat_units	latitude attributes unit
geospatial_lat_resolution	latitude grid resolution
geospatial_lat_min	latitude bounding box minimum
geospatial_lat_max	latitude bounding box maximum
geospatial_lon_units	longitude attributes unit
geospatial_lon_resolution	longitude grid resolution
geospatial_lon_min	longitude bounding box minimum
geospatial_lon_max	longitude bounding box maximum
processed_satellite_id	satellites id’s processed for this mean, Note: spectral response function has been aligned to that of METEOSAT 5.
cmsaf_parameter_id	CM SAF product identifier
cmsaf_parameter_code	CM SAF product name
intercalibration	Intercalibration/homogenisation version applied
date_created	date on which the data was created [ISO8601 date]
history	provides an audit trail for modifications to the original data

Table 2: Attributes assigned to variables.

Name	Description
long_name	long descriptive name
standard_name	standard name that references a description of a variable's content in the CF standard name table
units	physical unit [udunits standards]
valid_min	smallest valid value of a variable
valid_max	largest valid value of a variable
_FillValue	This number represents missing or undefined data. Missing values are to be filtered before scaling.
cell_methods	method used to derive data that represents cell values

10 Glossary

ARSA	Analysed RadioSoundings Archive
ASDC	Atmospheric Science Data Center
ATBD	Algorithm Theoretical Baseline Document
AVHRR	Advanced Very High Resolution Radiometer
CDO	Climate Data Operators
CDOP	Continuous Development and Operations Phase
CM SAF	Satellite Application Facility on Climate Monitoring
CNRS	Centre national de la recherche scientifique
CSR	Clear Sky Radiance
DWD	Deutscher Wetterdienst (German MetService)
ECMWF	European Centre for Medium Range Forecast
ECV	Essential Climate Variable
EPS	European Polar System
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
FCDR	Fundamental Climate Data Record
FMI	Finnish Meteorological Institute
FTH	Free Tropospheric Humidity
GCOS	Global Climate Observing System
GSICS	Global Space based Inter-Calibration System
IOP	Initial Operations Phase
ISCCP-DX	International Satellite Cloud Climatology Project, DX type
KNMI	Koninklijk Nederlands Meteorologisch Institut
LaRC	Langley Research Center
LMD	Laboratoire Météorologie Dynamique
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheric Administration
MVIRI	Meteosat Visible Infra-Red Imager
NetCDF	Network Common Data Format
NWP	Numerical Weather Prediction
PRD	Product Requirement Document
PUM	Product User Manual
RMIB	Royal Meteorological Institute of Belgium
RMSD	Root Mean Square Difference
SAF	Satellite Application Facility
SCOPE-CM	Sustained, Coordinated Processing of Environmental Satellite Data for Climate Monitoring
SEVIRI	Spinning Enhanced Visible and InfraRed Imager
SMHI	Swedish Meteorological and Hydrological Institute
WUI	Web User Interface