EUMETSAT Satellite Application Facility on Climate Monitoring

Product User Manual

Meteosat Surface Radiation

Spectral Resolved Irradiance

Edition 1

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Applicable documents

Reference	Title	Code
AD 1	CM SAF Product Requirements Document	SAF/CM/DWD/PRD/2.0

Reference Documents

Reference	Title	Code
RD 1	Validation Report Spectrally Resolved Irradiance SRI, Edition 1.0	SAF/CM/VAL/MSG/SRI/1.1
RD 2	Algorithm Theoretical Basis Document Surface Radiation Products	SAF/CM/ATBD/SRI/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, http://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 CM SAF spectrally resolved irradiance data sets derived from MVIRI and SEVIRI/GERB instruments onboard of the Meteosat satellites.
This manual briefly describes the historical development of CM SAF and the MSG surface radiation data sets. A technical description of the data sets including information on the file format as well as on the data access is provided. Further details on the implementation of the retrieval processing chain, and individual algorithm descriptions are available in the Algorithm Theoretical Basis Document [RD 2]. Basic accuracy requirements are defined in the product requirements document [AD 1]. A detailed validation of the MSG-based surface radiation parameters is available in the Validation Report [RD 1].

3 Product definitions

The CM SAF spectrally resolved irradiance data set is derived from MVIRI and SEVIRI/GERB satellite observations, providing Meteosat disk coverage. The instantaneous Meteosat observations are used to derive the spatio-temporal averaged data sets. The products are available as monthly and daily averages on a regular latitude/longitude grid with a spatial resolution of 0.05° × 0.05° degrees. The temporal coverage of the data sets ranges from 1 January 1991 to 31 December 2011. The product covered in this document is:

Spectrally Resolved Irradiance, SRI – CM-107

The algorithm theoretical baseline of these products is documented in the ATBD, [RD 2]. Table 1 presents a summary of the accuracy of the different products contained in the CM SAF MSG surface radiation data set. For more information on the validation strategy and more detailed accuracy information, the reader is referred to the corresponding validation report [RD 1].
All products have been developed and evaluated with respect to requirement goals defined in the PRD [AD 1]. The finally achieved product accuracies are described in the validation report [RD 1].

Table 1: Summary of the accuracy of the CM SAF MSG spectrally resolved irradiance. Between 400 and 1200nm the difference between surface measurements and satellite based date are in the order of the measurement uncertainty.

Data Set	Threshold / Target / Optimal Accuracies in W/m2	Dataset Accuracy
SRI	15 / 10 / 8 * fraction of spectral band of VIS corresponds roughly in relative units ~ 12 / 8 / 6 % per band	Target accuracy achieved in all bands. < 5 %, 400-1100 nm < 12% 1100-1500 nm

3.1 SRI Retrieval Outline

Here a brief overview of the retrieval methods used to generate the CM SAF MSG surface radiation data sets is given. More detailed information can be found in the ATBD [RD 2]
The retrieval of the surface incoming solar radiation is based on the method presented in *Mueller et al.,* (2012). As auxiliary data sources, the integrated water vapour from the ERA-Interim data set (*Dee et al.,* 2011), aerosol information from the Kinne data base (Kinne *et al.,* 2005) and the surface albedo from the SARB/CERES team (http://www-surf.larc.nasa.gov/surf/) are used.
The effective cloud albedo derived with the MAGICSOL method [RD 2] is used to treat the effect of clouds on the clear sky solar irradiance. This broadband effective cloud albedo is transferred to the spectral bands by application of a look up table in order to consider the spectral effect of Mie-scattering induced by clouds. This look up table is calculated with a state of the art Radiative Transfer Model (libradtran, www.libradtran.org).
For clear-sky pixels, no additional satellite information is required to calculate the surface incoming solar radiation using the spectral version of the Mesoscale Atmospheric Global

Irradiance Code (MAGIC, http://gnu-magic.sourceforge.net/) referred to as SPECMAGIC. For the calculation of the daily means at least 20 instantaneous observations are needed. Monthly averages are only generated when at least 20 valid daily mean values are available. More details on the retrieval and the specific limitations are given in the ATBD [RD 2]. The overall accuracy of the CM SAF MSG SIS data set has been estimated to be better than 5 % between 400-1100 nm and better than 12 % between 1100-1500 nm, whereby the uncertainty of the measurements have been considered. Further information on the accuracy of the product is contained in the validation report [RD 1].

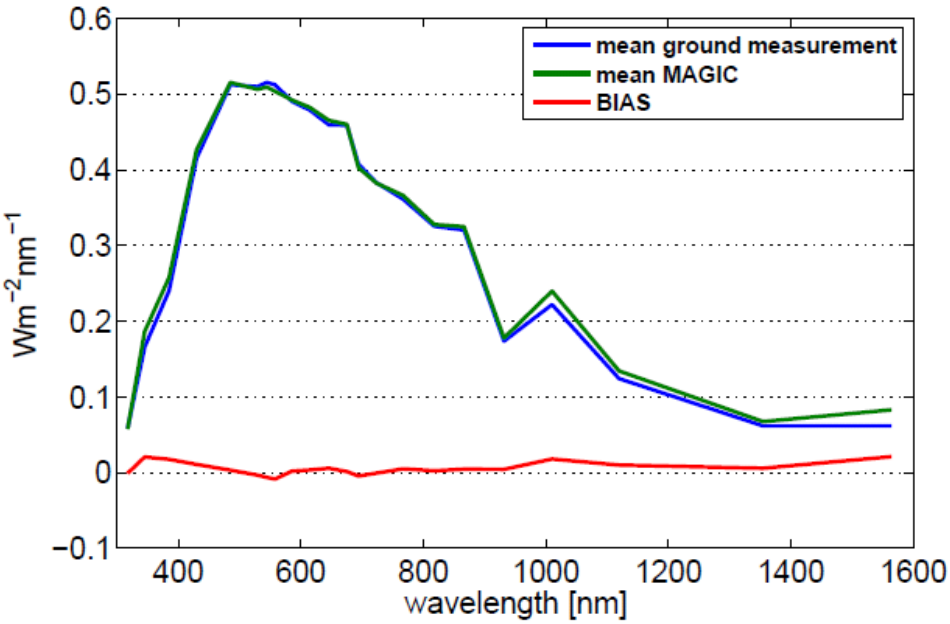

Figure 1: Example of the CM SAF spectrally resolved irradiance in comparison with ground measurements in Stuttgart. The bias (difference) is given in addition.

Figure 1 presents an illustrative example of the CM SAF MSG SIS data set. Shown is monthly mean of the surface solar irradiance for March 2009.

3.2 General limitations and recommendations

Here, general limitations of the application of the CM SAG MSG surface radiation data sets are presented. More specific limitations and shortcomings for each data set can be found in the ATBD [RD 2].

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- Over snow the uncertainty of the spectrally resolved irradiance might be significantly higher than the estimated accuracies
- In the of the UV (<=400) and NIR (≥1,200 nm) part of the spectrum relative large relative differences are apparent. Hence, the spectrally resolved irradiance in these spectral regions should be handled with care. However, due to the difficulties of measuring spectrally resolved irradiance the differences apparent in this region might be also due to measurement uncertainties.
- The uncertainty of SRI in the UV depends strongly on the used ozone information. Climatological values might lead to high deviations in regions with large temporal variations in ozone.
- The high clear-sky reflection over bright surfaces (e.g., desert regions) reduces the contrast between clear-sky reflection and cloudy-sky reflection. This leads to higher uncertainties in CAL and errors in the calculation of SRI.

- In regions with long-lasting cloud cover the detection of a minimum which constitutes a clear sky situation might fail. This results in an underestimation of the effective cloud albedo and errors in SRI.
- The accuracy of aerosol information is unknown in several regions of the world due to missing ground measurements. Any uncertainty in the aerosol information affects the accuracy of SRI, especially in regions that are dominated by cloudless sky.

4 Outlook

Future tasks will involve the improvement of the retrieval algorithm of the surface incoming solar radiation with respect to an improved calculation of the effective cloud albedo over bright surfaces and in regions with long-lasting clouds. The accuracy of the used aerosol information will be improved. The relative large relative differences occurring in the NIR (<1200nm) and UV will be further investigated and analysed. Overall, further evaluations of the data sets will be conducted.

5 Data format description

CM SAF's climate monitoring MSG surface radiation 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 1.5 (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 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 CM SAF MSG surface radiation products files are built following the same design principles.

Each data file contains the following coordinate variables:

time
: start of averaging/composite time period
[days counted from 1970-01-01]

time_bnds
: two-dimensional array defining the averaging/composite time period
[days counted from 1970-01-01]

latitude
: geographical latitude of grid-box centre [degree_north]

longitude
: geographical longitude of grid-box centre [degree_east]

Each data file contains a subset of the 20 Kato bands:

SRI[0:31]
: parameter grid box mean value, the name depends on the parameter

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. Possible global attributes are summarized in Table 2 and possible variable attributes in Table 3.

6 Data ordering via the Web User Interface (WUI)

The internet address http://wui.cmsaf.eu allows direct access to the CM SAF data ordering interface. On this webpage a detailed description how to use it 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.

Further user service including information and documentation about CM SAF and the CM SAF products are available from the CM SAF home page (http://www.cmsaf.eu).

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 (Please not the copyright disclaimer given in section 4.1). 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) are available via the CM SAF home webpage (www.cmsaf.eu) or the home page of the Web User Interface (http://wui.cmsaf.eu).

6.3 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 section 2.2) or use the “User Problem Report” page. A link to the “User Problem Report” is available either from the CM SAF home page (www.cmsaf.eu) or the Web User Interface home page (http://wui.cmsaf.eu).

6.4 Service Messages / log of changes

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

7 Feedback

7.1 User feedback

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

EUMETSAT CM SAF is an user driven service and is committed to consider the needs and requirements of its users in the planning for product improvements and additions. Please provide your feedback e.g. to our User Help Desk (e-mail address contact.cmsaf@dwd.de).

7.2 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 e.g. to our staff or via our User Help Desk (e-mail address contact.cmsaf@dwd.de).

7.3 User Workshops

CM SAF is organizing on regular basis training workshops in order to facilitate the use of our data. Furthermore through our regular (approximately every four years) user's workshop we revisit our product baseline. Your participation in any of these workshops is highly appreciated. Please have a look at on the CM SAF home web page (www.cmsaf.eu) to get the latest news on upcoming events.

8 Copyright and Disclaimer

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

8.1 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.***

8.2 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). All information can be retrieved through (http://www.cmsaf.eu/DOI).

The DOI for this data set is provided on the title page of this document.

8.3 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.

9 References

Dee, D., et al. (2011), The ERA-Interim reanalysis: configuration and performance of the data assimilation system, *Quarterly Journal of the Royal Meteorological Society, 137*(656), 553-597.

Kinne, S., M. Schulz, C. Textor et al., 2006, an AEROCOM initial assessment – optical properties in aerosol component modules of global models, *Atmos. Chem. Phys.*, *6*, 1815-1834.

Mueller, R., C. Matsoukas, A. Gratzki, H. Behr, and R. Hollmann (2009), The CM-SAF operational scheme for the satellite based retrieval of solar surface irradiance - A LUT based eigenvector hybrid approach, *Remote Sensing of Environment, 113*(5), 1012-1024.

10 Netcdf conventions

Table 2: Global NetCDF attributes.

Name	Description
Title	dataset title
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
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
source	original data source
cdm_data_type	data type, “grid” for all files
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
cmsaf_major_version_number	CM SAF major release version
Cmsaf_minor_version_number	CMSAF minor release version
processed_satellite	satellites processed for this mean
processed_orbit_node	satellite orbit nodes processed for this mean "ascending, descending" for all files
cmsaf_parameter_id	CM SAF product identifier
cmsaf_parameter_code	CM SAF product name
intercalibration	intercalibration 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 3: 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]
C_format	format string that should be used for C applications to print values for this variable, applies to the scaled (internal) type and value
FORTRAN_format	format string that should be used for FORTRAN applications to print values for this variable, applies to the scaled (internal) type and value
valid_min	smallest valid value of a variable
valid_max	largest valid value of a variable
scale_factor	The data are to be multiplied by this factor after it is read.
add_offset	This number is to be added to the data after it is read. If scale_factor is present, the data are first scaled before the offset is added.
_FillValue	This number represent missing or undefined data. Missing values are to be filtered before scaling.
missing_data	This number represent missing or undefined data. Missing values are to be filtered before scaling. Contains the same value as the _FillValue-attribute.
cell_methods	method used to derive data that represents cell values following the CF Convention

11 Glossary.

AVHRR: Advanced Very High Resolution Radiometer
AOD: Aerosol Optical Depth
CAL: Effective cloud albedo
COT Cloud optical depth
GADS/OPAC: Global Aerosol Data Set / Optical Properties of Aerosols and Clouds
GERB: Geostationary Earth Radiation Experiment
K: Clear sky index.
LUT: Look-up table
MVIRI: Meteosat Visible-InfraRed Imager
NOAA: National Oceanic and Atmospheric Administration
NCEP: National Center for Environmental Prediction
RTM: Radiative Transfer Model
SID: Surface Direct Irradiance (beam).
SIS: Solar Surface Irradiance
SZA: Sun Zenith Angle
SSA: Single Scattering Albedo