EUMETSAT Satellite Application Facility on Climate Monitoring

Product User Manual

Meteosat Solar Surface Irradiance and effective Cloud Albedo Climate Data records

METEOSAT_HEL

The SARAH climate data records

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Surface Incoming Shortwave Radiation (SIS):	**CM-23201**
Direct Normal Irradiance (DNI):	**CM-23231**

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Author	Jörg Trentmann Christine Träger-Chatterjee Richard Müller	CM SAF Scientists		01.11.2014
Editor	J. Trentmann	DRR Coordinator		01.11.2014
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1 The EUMETSAT SAF on Climate Monitoring (CMSAF)

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 (CDRs) derived from operational meteorological satellites.

In particular the generation of long term data records is pursued. The ultimate aim is to make the resulting data records 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 records 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 records 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 records also serve the improvement of climate models both at global and regional scale.

As an essential partner in the related international frameworks the CM SAF 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 an 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 record assessments performed by research organisations such as WCRP (World Climate Research Programme),
- 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 (PUM) provides relevant information to the user on the shortwave Meteosat climate climate data record.
The generated 31 year long (1983-2013) continuous surface radiation climate data records are based on observations from the Meteosat First and Second Generation satellites and are called SARAH: Surface Solar Radiation Data records – Heliosat. The Digital Object Identifier (DOI) of the SARAH data set is 10.5676/EUM_SAF_CM/SARAH/V00.
The document enables the user to perform an appropriate use of the data including background information of the applied retrieval methods. The Meteosat climate data records are derived from the Meteosat First Generation and Second Generation satellite images.
This manual describes available products including example images, gives basic algorithm descriptions and a brief overview of the accuracy. It also discusses potential difficulties affecting the scientific interpretation. Additionally, a technical description of the data including information on format as well as on access and handling tools (e.g. mapping and display tools) is provided in the final sections.
CM SAF data products are distinguished between operational monitoring products and data records (Schulz et al., 2009). Operational monitoring products are disseminated with appropriate timeliness for climate monitoring (8 weeks after observation at the latest) to support operational climate monitoring applications of National Meteorological and Hydrological Services. The timeliness requirement means that this type of product is not a priori suitable for monitoring of inter-annual variability and trends with high confidence. Bias errors due to e. g. sensor degradations and orbital shifts as well as inter-satellite biases are not corrected for in the operational monitoring product. However, the characterisation of relatively strong anomalies on the monthly scale should be feasible. Concerning the retrospective produced data records, errors due to sensor degradations, orbital changes and inter-satellite biases are minimised. Those data records are aimed at providing time series suitable for analysing variability at longer scales than inter-annual. **This Product User Manual describes exclusively the CM SAF Meteosat solar climate data record SARAH, hence generated data records covering a fixed period.**

Long time series are needed for climate monitoring and analysis. For this reason there is a need to employ the satellite information of the first generation of Meteosat satellites (Meteosat-2 to Meteosat-7) to generate climate information. The MVIRI (Meteosat Visible-InfraRed Imager) instrument on-board the Meteosat First Generation satellites is a passive imaging radiometer with three spectral channels a visible channel covering 0.5-0.9 microns , and infra-red channel covering 5.7-7.1 microns and 10.5-12.5 microns. MVIRI comes with a spatial resolution of 2.5km for the visible and 5km for the IR channels, sub-satellite point respectively.
The second generation of Meteosat satellites is equipped with the Spinning Enhanced Visible and InfraRed Imager (SEVIRI) and the Geostationary Earth Radiation Budget (GERB) instrument. The GERB instrument is a visible-infrared radiometer for earth radiation budget studies. It provides accurate measurements of the shortwave (SW) and longwave (LW) components of the radiation budget at the top of the atmosphere. SEVIRI employs twelve spectral channels, which provide more information of the atmosphere compared to its forerunner. Several retrieval algorithms have been developed in order to use the additional information gained by the improved spectral information of MSG mainly for now-casting applications (e. g. nowcasting SAF algorithm, Mueller et al., 2009). However, these algorithms can not be applied to the MVIRI instrument on-board the Meteosat First Generation satellites as they use spectral information that is not provided by MVIRI.

Hence, in order to be able to provide a long time series covering more than 20 years there is a need for a specific climate algorithm that can be applied to the Meteosat First and Second Generation satellite instruments. Moreover, the retrieved climate variable must have climate quality. This is the reason why the same algorithm used for MVIRI is also applied to SEVIRI.
The algorithm consists of two parts, the modified Heliosat method, described in section 3.2.2, is used for the retrieval of the effective cloud albedo CAL (section 3.2). In a second step the MAGIC approach, described in section 3.3.2, is used for the calculation of the all sky surface radiation based on CAL (section 3.3 and 3.4). The combination of these methods is referred as MAGICSOL. The solar radiation climate data records generated with MAGICSOL are referred as SARAH: Surface Solar Radiation Data records – Heliosat.

The MAGICSOL method does meet the above mentioned requirements for the generation of climate data records and is in detail described in RD.2. The method provides the effective cloud albedo, the solar surface irradiance, i. e., all components of the GCOS Essential Climate Variables (ECVs) surface radiation budget and cloud properties.
The applied method needs only the broadband visible channel as satellite information and can therefore be applied to MFG and across different satellite generations. The application to other geostationary satellites, e. g., in the US and Asia is also possible. Hence, the method has not only the power to provide long time series of ECVS, but also to provide ECVs, which cover the complete geostationary ring.

2.1 Applicable Documents

Reference	Title	Code
AD.1.	CM SAF Product Requirement Document	SAF/CM/DWD/PRD/2.3

2.2 Reference Documents

Reference	Title	Code
RD.1	Validation Report. Meteosat Solar Surface Irradiance and effective Cloud Albedo Data Sets. METEOSAT_HEL	SAF/CM/DWD/VAL/METEOSAT_HEL/1.0
RD.2	Algorithm Theoretical Baseline Document (ATBD) Meteosat Solar Surface Irradiance and effective Cloud Albedo Data Sets. METEOSAT_HEL	SAF/CM/DWD/ATBD/METEOSAT_HEL/1.3

Version history since CDOP-1

The following table lists product versions according to the release history of the Meteosat climate data records from the first release in January 2011 to the respective new release. The version history is also available for each product on www.cmsaf.eu.

The table follows the official versioning of the CM SAF work plan and of the Web User Interface. However, for the version 2 of the CM SAF radiation climate data records a specific name is assigned, SARAH. Thus, the name allows a clear distinction of the data records.

Version	Document code	Time range	Major changes
1	MVIRI_HEL	Jan 1983 – Dec 2005	• First version based on modified Heliosat version 1.0 • MAGIC version 0x86
2	METEOSAT_HEL	Jan 1983 – Dec 2013	• Second version of data record covering MFG and MSG time period, hence longer time period covered. • Improved algorithms & accuracy. • Improved aerosol information. • Name of the data set: SARAH

3 Description of Meteosat climate data records

The Meteosat processing provides climate data records of effective cloud albedo, solar surface irradiance and direct irradiance. The applied method, i. e., MAGICSOL described in detail in the Algorithm Theoretical Baseline document RD.2 (SAF/CM/DWD/ATBD/METEOSAT_HEL/1.3), provides also information on the clear sky reflection which can be used to derive the surface albedo and the surface solar net budget. These records enable the calculation of the surface short-wave net radiation budget. The effective cloud albedo, the solar surface irradiance and the direct irradiance are available on a regular 0.05x0.05 degree grid. The spatial coverage covers the Meteosat disk up to a scanning angle of 68 degree as illustrated in Figure 3-1. The data records are available as hourly, daily and monthly means. All SARAH data records are introduced in Table 3-1 with associated acronyms and units. Table 3-2 provides an overview of all available surface irradiance and effective cloud albedo data records and products.

Table 3-1: *Overview of SARAH data records discussed in this PUM.*

Acronym	Product title	Unit
SIS	Surface Incoming Shortwave Irradiance	W / m^2
CAL	Effective Cloud Albedo	Dimensionless
DNI	Direct Normal Irradiance at surface	W / m^2

Table 3-2 *Overview of CM SAF surface irradiance and effective cloud albedo products and data records.*

Acronym / Identifier	Product title	Type	Satellite & Instrument	Period & Coverage
SIS CM-54	Surface Incoming Shortwave Radiation	Data record	MFG MVIRI	1983-2005 Meteosat disk
SIS CM-49	ditto	Product	MSG SEVIRI/GERB	2007-today Meteosat disk
SIS CM-48	ditto	Product	MSG SEVIRI/GERB	2005-2007 Europe
SIS CM-50	ditto	Product	NOAA AVHRR	2005-today Europe
SIS CM-51	ditto	Product	MSG/NOAA merged	2007-today Meteosat disk & Northern Europe
SIS CM-23201	**ditto**	**Data record**	**MFG/MSG**	**1983-2013 Meteosat disk**
CAL CM-111	Effective Cloud Albedo	Data record	MFG MVIRI	1983-2005 Meteosat disk
CAL CM-23081	**dito**	**Data record**	**MFG/MSG**	**1983-2013 Meteosat disk**
SID CM-106	Direct Irradiance at Surface	Data record	MFG MVIRI	1983-2005 Meteosat disk
SID CM-105	Ditto	Product	MSG SEVRI/GERB	2009-today Meteosat disk
DNI CM-23231	**Direct Normal Irradiance at surface**	**Data record**	**MFG/MSG**	**1983-2013 Meteosat disk**

Figure 3-1 gives an overview of the processed and available area.

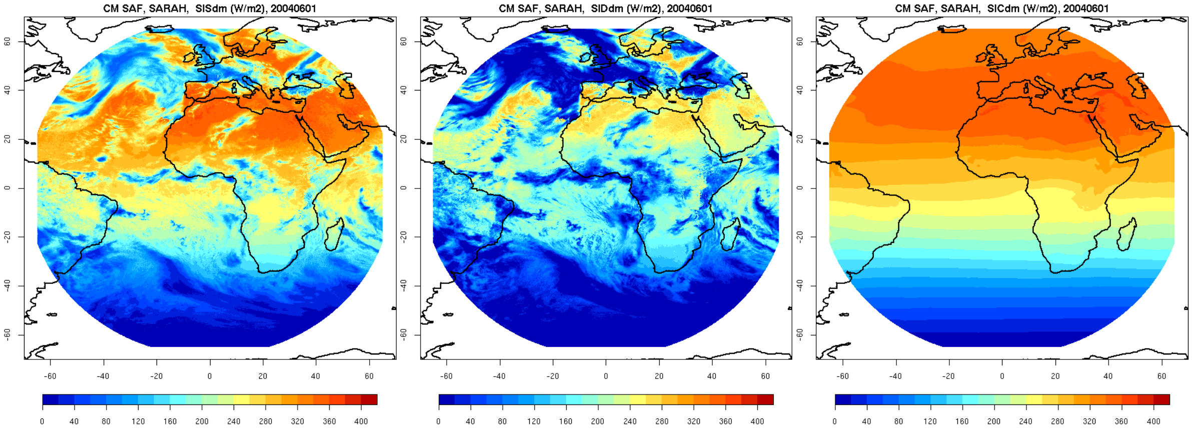

Figure 3-1 Area coverage for CM SAF Meteosat climate data records, illustrated here for daily means of SIS, direct irradiance and blue sky irradiance.

3.1 Basic processing of Meteosat images

The processing of the METEOSAT data is done in satellite projection. The results are transferred to the regular latitude-longitude-grid using a subroutine of MAGIC (Mueller et al., 2009). For the retrieval of the effective cloud albedo, the Heliosat algorithm is used (Hammer et al., 2003). The original version of the Heliosat method has been modified to generate a data record that meets climate quality. The effective cloud albedo derived with the modified Heliosat version is used in combination with the clear sky surface radiation model MAGIC (Mueller et al., 2009) to derive the surface radiation products from the geostationary Meteosat satellites number 2 to 7. The derived parameters and methods are described in more detail in the following sections. The complete model (cloud and clear sky) is called MAGICSOL and described in more detail in the CM SAF ATBD (SAF/CM/DWD/ATBD/METEOSAT_HEL).

The Heliosat method does not require calibrated radiances as input, but is directly based on image counts. To consider the aging of the satellite instruments and the transitions between the satellites of the Meteosat series a self-calibration method has been developed and applied. The self-calibration method overcomes the need for well calibrated radiances, which are not available for Meteosat First Generation.

From the Heliosat algorithm the effective cloud albedo is derived. Together with information about the atmospheric clear sky state (water vapour, aerosols, ozone) the effective cloud albedo is used as input for the MAGIC method to calculate the direct irradiance and the solar surface irradiance.

In the following sub-sections a brief description of each individual surface radiation product is given with associated information on averaging methods, validation procedures and known limitations.

3.2 Effective Cloud Albedo (CAL)

3.2.1 Product Definition

The effective cloud albedo is defined as the amount of reflected irradiance for all sky relative to the amount of reflected irradiance for clear sky. Reflected irradiance is not transmitted to the surface. It is therefore an essential variable within the Earth's radiation budget. The effective cloud albedo is the central cloud information used to derive the solar surface irradiance. It is dimensionless. CAL will be provided for the Meteosat disk, covering Europe and Africa on a regular 0.05x0.05 degree latitude-longitude grid. The data record will compile monthly, daily and hourly means covering the period 1983-2013.

3.2.2 Basic Retrieval approach

The original Heliosat method is described in several publications, e. g. in Hammer et al., 2003, and Cano et al., 1986. It is used to retrieve the effective cloud albedo. The effective cloud albedo is defined as:

$$CAL = \frac{R - R_{\mathrm{sfc}}}{R_{\max} - R_{\mathrm{sfc}}} \qquad \textbf{(Equation 3-1)}$$

Here R_{max} is a measure for the maximum cloud reflection, R_{sfc} is the clear sky reflection, dominated by the surface albedo and R is the observed irradiance. R_{max} and R_{sfc} are determined by statistical methods from the observed radiance (R) on a monthly basis. Hence all quantities are based on the observation of the reflections. No additional information (e. g., from a model) is required for the retrieval of the effective cloud albedo. The effective cloud albedo describes the amount of reflected irradiance for all sky relative to the amount for clear sky, normalised to the maximum cloud reflection .
The method for the derivation of R_{max} and R_{sfc} has been modified relative to the original Heliosat method to meet the needs for the retrieval of a climate data record. The methods are described in detail in the Algorithm Theoretical Baseline Document (ATBD: SAF/CM/DWD/ATBD/METEOSAT_HEL). Here only a brief overview of the modifications is given:

- Implementation of a self-calibration method for the calculation of R_{max}.. The self calibration method uses the reflections of a stable cloud target in the Southern Atlantic Ocean to correct for changes in the reflections introduced by changes of satellites or aging of satellites. Details are discussed in the MAGICSOL ATBD [RD.2].

3.2.3 Details on processing, gridding and averaging

Monthly and daily means are calculated by arithmetic averaging, using Equation 3-2.

$$CAL_{mean} = \frac{\sum_{i=1}^{n} CAL_i}{n} \qquad \textbf{(Equation 3-2)}$$

Here i is a loop over the hourly means for the calculation of the daily means and a loop over daily means for the calculation of monthly means. For the hourly means the averaging is performed by Equation 3-3.

$$\boldsymbol{CAL_{mean} = 0.25 \cdot CAL(h) + 0.5 \cdot CAL(h+0.5) + 0.25 \cdot CAL(h+1)} \qquad \textbf{(Equation 3-3)}$$

Here, h is the respective hour, e. g. h=12 means 12 GMT. Hence for 12 GMT the hourly mean is generated with the 12:00, 12:30 and 13:00 h slots, with the weights given in Equation 3-3.
The conversion from the irregular satellite projection to the regular 0.05x0.05 degree grid is done with a MAGIC subroutine.

3.2.4 Input data

METEOSAT images of the broadband channel in openMTP format. Level 1.5 rectified image data of digital counts (not radiances) are used. The respective data are called *“Rectified Image Data”* and provided by EUMETSAT (EUM TD 06). Calibrated or inter-calibrated radiances are not needed by the applied Heliosat method, the respective issues are resolved

by an implemented self-calibration method, described in more detail in the ATBD [RD.2]. This approach follows the EUMETSAT recommendation given in EUM TD 05 "…it is necessary to rely to a great extent on vicarious, or external, calibration techniques in order to maintain product quality."
Data from all operational MFG satellites (Metoesat-2, 3, 4, 5, 6, 7) at 0,0 degree position have been used. Further details of the METEOSAT input data are described in EUMETSAT documentations (EUM TD 06 and EUM TD 04). From 2006 onwards the data from the MSG satellites carrying the Spinning Enhanced Visible and Infrared Imager (SEVIRI) is used. SEVIRI is a radiometer that measures the earth's disk every 15 min in 12 spectral bands spanning visible and infrared wavelengths. The SEVIRI broadband high-resolution-visible channel (HRV) closely matches the spectral properties of the MVIRI broadband channel. However, since it does not cover the full disk, it cannot be used to extend the full disk MVIRI-based CDR. Due to this failure an artificial HRV channel is generated according to the approach of Posselt et al., 2014.
For this purpose the two narrow band visible channels are used. They are centered at around 0.6 µm (VIS006) and 0.8 µm (VIS008) and have a spatial resolution of around 3 km at nadir. Further details and evaluation of the approach are given in Posselt et al., 2014. The data is provided in High Rate Information Transmission (HRIT) format. This is a CGMS standard format, agreed upon by satellite operators, for the dissemination of digital data, originating from geostationary satellites to users, via direct broadcast. Please see:
http://www.eumetsat.int/website/home/Data/Products/Formats/index.html
for fruther details on the data format.

3.2.5 Product example

Figure 3-2 provides an example of the monthly mean CAL product for June 2003.

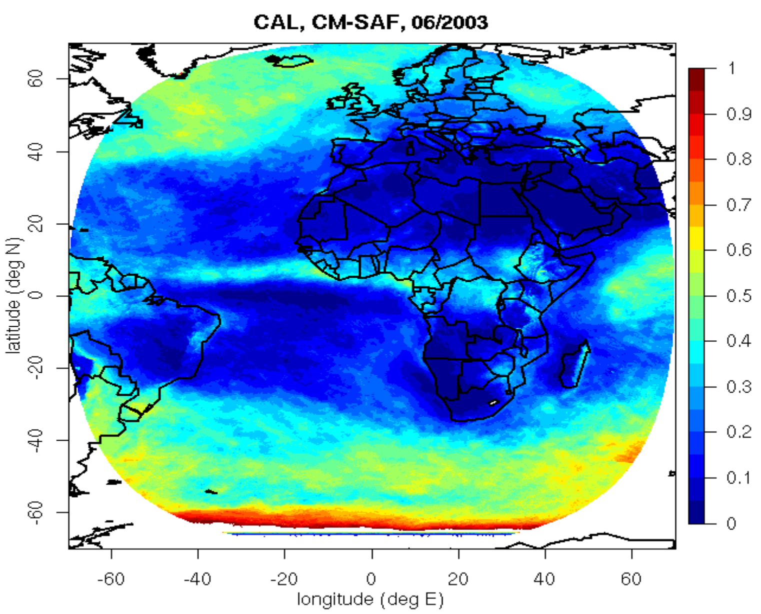

Figure 3-2 Example of the CAL monthly means for June and November 2003.

3.2.6 Validation

The Product Requirement Document (PRD) [AD.1] lists specific product requirements which have to be fulfilled by the products. The achieved accuracy for the CAL product is summarized in Table 3-3. CAL can not be directly validated against ground measurements, which is a limitation of the validation.

Table 3-3 *Accuracy achieved for CAL. The 90 % limit compiles all regions, no region is excluded.*

Product	Summary on mean error (absolute)
CAL (METEOSAT)	*90 % of absolute bias values below 0.1 for monthly means, 0.15 for daily means respectively.* *Bias below 0.15 for hourly means.* *Higher bias values occur in the Alpine and other mountainous regions, e. g. due to uncertainties in area to point comparison and errors introduced by snow coverage.*

The detailed results of the validation are presented in the CM SAF Validation Report [RD.2: SAF/CM/DWD/VAL/METEOSAT_HEL]. The numbers given in Table 3-3 are worst case accuracies derived from the accuracy of SIS summarised in Table 3-4.

3.2.7 Limitations

- Below is a list of known deficiencies and limitations of the CAL CDR:
- ρ_{sfc} can only be retrieved accurately if a certain amount of clear sky cases are present within each month. In some regions and seasons, this is not always the case. In regions and periods with long-lasting clouds higher uncertainties occur. Here cloud contamination of ρ_{sfc} leads to lower values of CAL, hence to significant errors in CAL. This artefact occurs pre-dominantly for slant geometries (border of Heliosat coverage, or wintertime above a latitude of +/- 60 degrees). It is expected that the target accuracy of 0.1 (0.15) for monthly (daily) means is not met any more in those regions and higher uncertainties might occur. The sensitivity of this artefact on CAL accuracy is discussed in more detail in the ATBD (RD.2). However, as long-lasting clouds are a pre-requisite for the occurrence of this artefact, the effect on solar irradiance is usually rather small.
- The anisotropy of the cloud reflection leads to uncertainties in the effective cloud albedo in the order of 1-2 %. An improved correction of the anisotropy effect will be included in the next release of the CAL CDR.
- The relatively high clear sky reflection over bright surfaces (snow and specific desert areas) reduces the contrast between clear sky reflection and cloudy sky reflection and leads to higher uncertainties in the calculation of CAL.

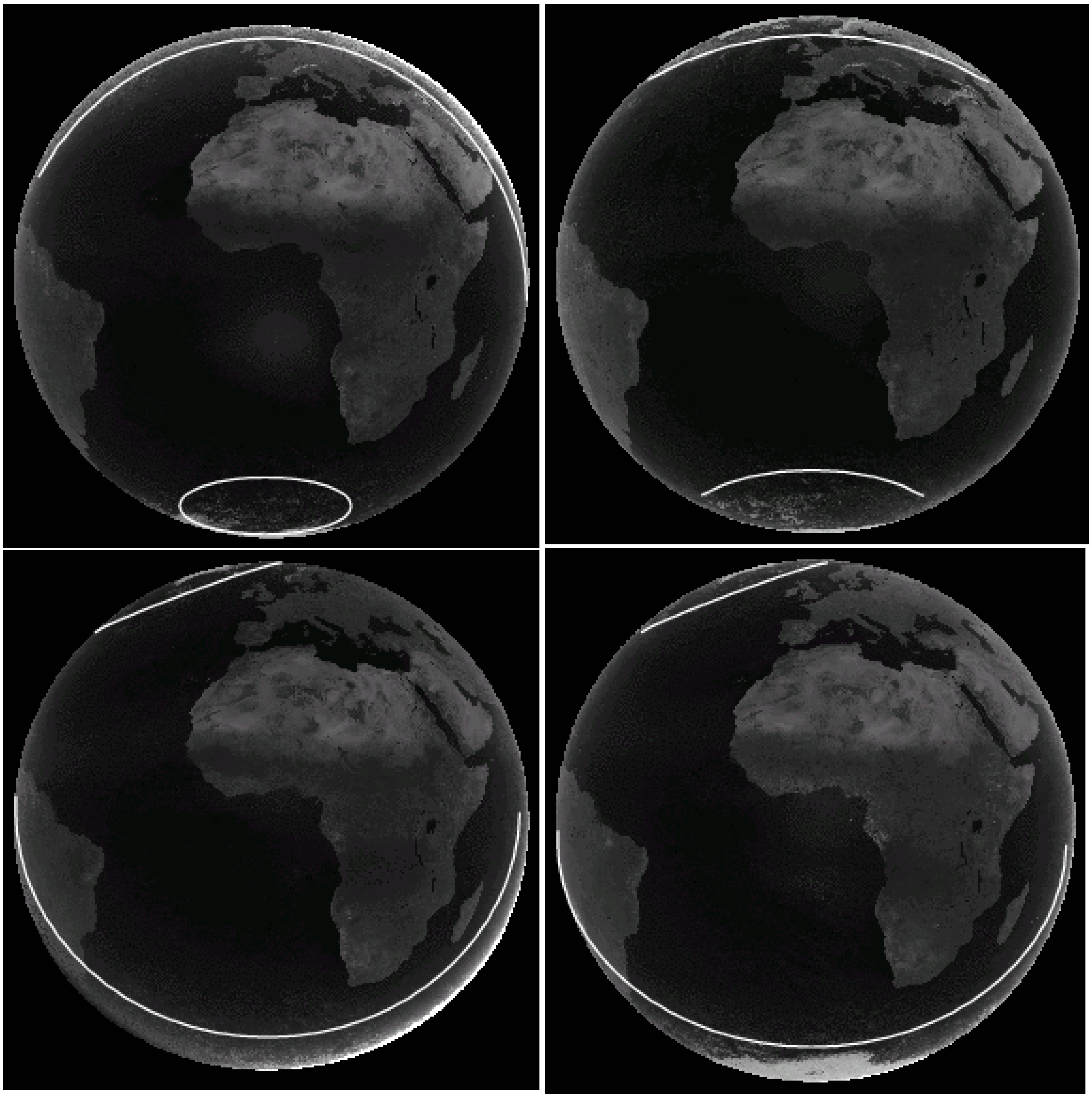

Figure 3-3: Examples of R_{sfc} images, here for 2000 ,12 GMT, from top left to bottom right, December, March, June and September.

The white speckle patterns beyond the white lines close to the border of the disk are due to significant cloud contamination of R_{sfc}. However, close to the poles, some white regions are not an artefact but due to ice (Greenland & Arctic in the September image). Cloud contamination occurs also in a small band around sunrise and sunset at the East and West border of the disk, respectively. However, the core of the Meteosat disk is almost not affected.

3.3 Surface Incoming Solar Radiation (SIS)

3.3.1 Product definition

The surface incoming solar (SIS) radiation is the radiation flux (irradiance) reaching a horizontal plane at the Earth surface in the 0.2 – 4 µm wavelength region. It is expressed in W/m^2.

3.3.2 Basic Retrieval approach

The surface incoming solar radiation (SIS) is retrieved using the Heliosat method. The Heliosat method is based on the conservation of energy. As a consequence the basic relation between the solar irradiance and the effective cloud albedo is as follows:

$$SIS = SIS_{CLS} \cdot (1 - CAL) \qquad \textbf{(Equation 3-4)}$$

Here, SIS is the solar surface irradiance, SIS_{CLS} the clear sky irradiance and CAL is the effective cloud albedo, also called cloud index n in former publications (e. g. Cano et al, 1986). For effective cloud albedo values above 0.8 the above equation are modified in order to consider the saturation and absorption effects within optically thick clouds. The modification of the equation for small and large values of CAL is based on ground measurements and is described in detail in the ATBD [AD3] and given in the Appendix, Section 7.3, of this document.
When CAL is known, SIS can be calculated from the clear sky solar irradiance. The algorithm to calculate the clear sky solar surface irradiance uses RTM based LUTs for the calculation of SIS_{CLS} .
The radiative transfer model (RTM) libRadtran (Mayer and Kylling, 2005) was used for the generation of the LUT. The LUT contains SIS values for a wide range of atmospheric states and 32 spectral bands. The SIS value for the actual atmospheric state is then calculated by interpolation between the states. The atmospheric states cover different values for water vapour, ozone, aerosol optical depth, aerosol single scattering albedo, and asymmetry parameter. Several aerosol types were included (Hess et al., 1998). Additionally, Modified Lambert Beer (MLB)-LUTs are used (Mueller et al., 2004). A specific aerosol optical thickness and aerosol type can be assigned to each pixel depending on the provided aerosol background map. The aerosol optical thickness and type is assigned to each pixel depending on the aerosol map derived from the aerosol information provided by the European Centre for Medium-Range Weather Forecasts (ECMWF), see Benedetti et al., 2009 and Morcrette et al., 2009 for further details. Water vapour amounts (monthly means) are taken from ERA-40 and ERA-interim reanalysis, both provided by the ECMWF. The interpolation between the LUTs is done with a linear interpolation scheme.

3.3.3 Details on processing, gridding and averaging

Daily averages are calculated following a method by Möser (1983) (also published in Diekmann et al., 1988), see Equation 3-5 for calculation of SIS mean.

$$SIS_{DA} = SIS_{CLSDA} \frac{\sum_{i=1}^{n} SIS_i}{\sum_{i=1}^{n} SIS_{CLS\,i}} \qquad \textbf{Equation 3-5}$$

SIS_{DA} is the daily average of SIS. SIS_{CLSDA} is the daily averaged clear sky SIS, SIS_i the calculated SIS for satellite image i and SIS_{CLSi} the corresponding calculated clear sky SIS. n is the number of images available during a day.

The applied equation for averaging accounts for data gaps (missing values) and zero values. However, the larger the number of available images per day, the better the daily cycle of cloud coverage can be resolved, increasing the accuracy of the daily average of SIS. A minimum number of three available pixels per day is required to derive the daily mean for this specific pixel. The monthly average is calculated from the daily means of this month on pixel basis as arithmetic mean with a required number of 20 existing daily means. The hourly means are calculated as arithmetic average using Equation 3-3 with SIS instead of CAL. The conversion from the irregular satellite projection to the regular 0.05x0.05 degree grid is done with the climate data operators, see section 5.1 for details of the CDO tools.

3.3.4 Input data

- CAL from METEOSAT processing, available for each pixel in satellite resolution, CAL is described in detail section 3.2 of this document.
- Total water vapour from the ERA-interim Reanalysis have been used from 1989 onwards. From 1983 to 1988 ERA-40 Reanalysis data have been used (Uppala et al., 2005 and Betts et al., 2009). Monthly means on 0.5x0.5 degree latitude-longitude grid. The pixel value is derived by spatial interpolation and assignment of the respective monthly mean.
- Ozone content, climatological value from standard profiles of the Max-Planck institute of air chemistry (Krämer et al., 2003).
- Lookup tables.
- Surface albedo from SARB/CERES (see section 7.2 for details), only needed for the clear sky model.

Information about the aerosol optical thickness and type is derived from the aerosol information MACC provided by the European Centre for Medium-Range Weather Forecasts (ECMWF). The MACC data results from a data assimilation system for global reactive gases, aerosols and greenhouse gases. It consists of a forward model for aerosol composition and dynamics (Morcrette et al., 2009} and the data assimilation procedure described in detail in (Benedetti et al., 2009). MACC has been evaluated to perform significantly better than Kinne et al. and GADS/OPAC climatology (Hess et al., 1998, Köpke et al. 1997), see Mueller and Träger-Chatterjee (2014) for further details. Monthly long term means on 0.5x0.5 degree latitude-longitude grid. The pixel value is derived by spatial interpolation and assignment of the respective monthly mean.

3.3.5 Product example

Figure 3-4 provides an illustration of the SIS product.

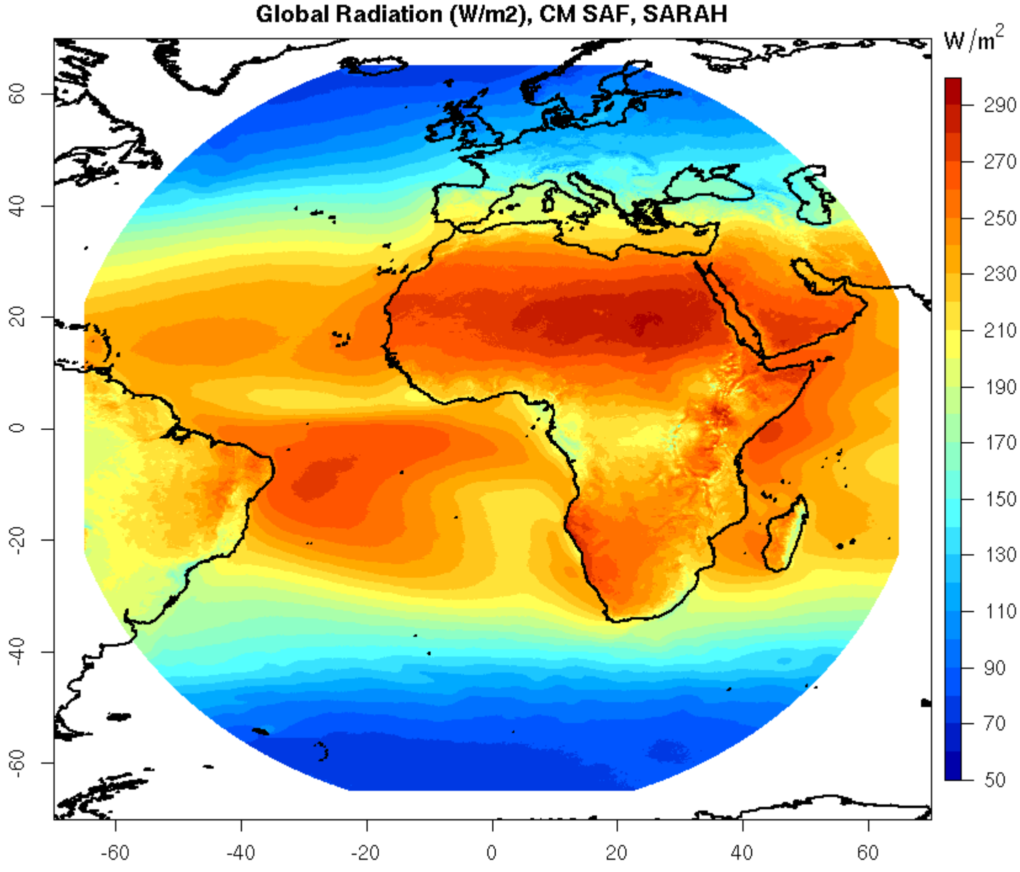

Figure 3-4: Illustration of the SIS product. Long term mean 1983-2013.

3.3.6 Validation

The Product Requirement Document (PRD) [AD.1] lists specific product requirements which have to be fulfilled by the products. The achieved accuracy for the SIS product is shown in Table 3-4. The validation has been performed against referent ground measurements of the Baseline Surface Radiation Network (BSRN). The measurements of the BSRN stations starts in 1993 and the density of the network over Africa is relative thin. Hence, the BSRN validation results do not cover the complete time series of the CDR and do not cover all climate regions in Africa. This is a limitation of the CDR validation.

Table 3-4 *Accuracy achieved for SIS. The 90 % limit includes all regions, no region is excluded.*

Product	Summary on mean error (absolute)
SIS for METEOSAT	*Mean Absolute Bias below 8 W/m² and 90 % of absolute bias values below 10 W/m² (+ uncertainty of ground based measurements) for monthly means, 20 W/m² for daily means respectively. Mean bias below 1 W/m² for monthly, daily hourly means. Optimal accuracy achieved.*

Product	Summary on mean error (absolute)
	Higher bias values occur in the Alpine and other mountainous regions, e. g. due to uncertainties in area to point comparison and snow coverage.

The detailed results of the validation are presented in the CM SAF Validation Report [RD.2: SAF/CM/DWD/VAL/METEOSAT_HEL]. Here the main validation results are given in Table 3-5.

Table 3-5: *Summary of validation results for SIS: N Number of comparisons. MAB: mean of absolute bias values for monthly / daily means. SD: standard deviation. AC: Correlation of anomalies. Frac$_{mon}$: Fraction of cases (months/days) with a MAB greater than 10 W/m² (monthly means) and 20 W/m² (daily means), respectively. Basis of the results has been the comparison with 15 BSRN stations. For comparison the values of monthly mean validation of the former CM SAF data set is also given in the last line of the table.*

SIS	N	Bias [W/m^2]	MAB [W/m^2]	SD [W/m^2]	AC	Frac$_{mon}$ > target accuracy [%]
Monthly Means	1672	1.3	5.5	7.3	0.92	5.6
Daily means	48605	1.1	12.1	17.9	0.95	11.3
Monthly mean (CDR MVIRI only, CM-54)	878	4.2	7.8	8.2	0.89	10.1

The bias in the Alpine region depends strongly on the region of interest which is discussed in detail in Dürr et al., 2010.

Using the BSRN stations the temporal stability of the SARAH SIS CDR has been investigated. The temporal stability (1994 to 2013) is with -0.8 W/m²/dec [-1.7, 0.1] very good, see Figure 3-5. This is a clear hint that the data can be used for trend analysis. Compared to surface radiation from the GEBA in Europe (1983 to 2011) the temporal stability of SARAH was determined to be slightly negative (- 1.1 W/m^2/dec).

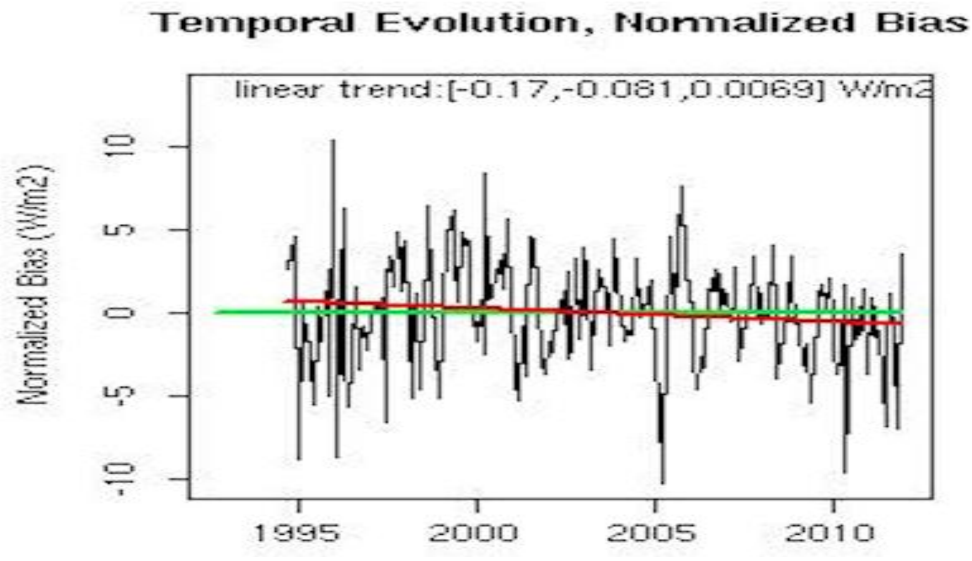

Figure 3-5: Comparison of SARAH SIS CDR with BSRN ground measurements. Compared to BSRN there is no significant trend apparent, which indicates the temporal stability of the SIS CDR.

3.3.7 Limitations

Below is a list of known deficiencies and limitations of the SIS product:

- 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 SIS.
- The accuracy of aerosol information is not well defined in several regions of the world due to missing ground measurements. Any uncertainty in the aerosol information affects the accuracy of SIS, especially in regions that are dominated by cloud free sky. For the current Heliosat data record a climatology has been used. Monthly, daily and hourly variations in the aerosol optical depth are therefore not considered.

3.4 Direct normal irradiance (DNI)

3.4.1 Product definition

The direct normal irradiance (DNI) is the radiation flux (irradiance) at the surface normal to the direction of the sun in the 0.2 - 4 µm wavelength region. It is expressed in W/m^2. It is derived by normalisation of the direct irradiance SID with the cosine of the solar zenith angle (see Equation 3-7). SID is the radiation flux (irradiance) reaching a horizontal plane in the 0.2 – 4 µm wavelength region at the surface directly without scattering.

3.4.2 Algorithm outline

3.4.2.1 Clear sky

The algorithm for the calculation of SID under clear sky conditions is described in detail in Mueller et al., 2009 and also documented in the public license gnu-MAGIC project, http://sourceforge.net/projects/gnu-magic. It is a fast method to calculate solar irradiance (including the direct irradiance) for large areas, which uses an eigenvector hybrid LUT approach for the fast and accurate calculation of SID. The aerosol optical thickness and type is assigned to each pixel depending on the aerosol map derived from the aerosol information provided by the European Centre for Medium-Range Weather Forecasts (ECMWF). Monthly means of water vapour amounts are taken from the ERA-40 and ERA-interim reanalysis both provided by the ECMWF. The interpolation within the LUTs is done with a linear interpolation scheme. The atmospheric input and interpolation routine is identical for SIS and SID, with exception of a background surface albedo map, which is not needed for SID.

3.4.2.2 Cloudy sky situations

For the consideration of clouds on the clear sky irradiance a formula of Müller et al. (2009) is used, which describes the relation of the direct irradiance (all sky) SID_{allsky} to that of the clear sky direct irradiance SID_{clear} (Equation 3-6).

$$SID_{allsky} = SID_{clear} \cdot ((1 - CAL) + 0.38 \cdot CAL))^{2.5} \qquad \textbf{(Equation 3-6)}$$

where CAL is the effective cloud albedo. This formula is an adaptation from the diffuse model of Skartveit et al., 1998. The direct irradiance is zero for CAL values above 0.6 regarding the applied Equation 3-6. DNI is subsequently derived from SID by normalisation with the solar zenith angle (Equation 3-7).

$$DNI = SID / \cos(SZA) \qquad \textbf{(Equation 3-7)}$$

where SID is the direct irradiance and SZA is the solar zenith angle.

3.4.3 Details on processing, gridding and averaging

The calculation of the direct normal irradiance (DNI) is done on METEOSAT pixel basis using all available METEOSAT images. The daily average SID is calculated by arithmetic averaging:

$$DNI_{DA} = \frac{\sum_{i=1}^{n} DNI_i}{n} \qquad \textbf{(Equation 3-8)}$$

DNI_{DA} is the daily average of DNI and DNI_i is the DNI for satellite image i, n is the number of images available during a day.
The monthly average DNI is calculated from the daily means on pixel basis as the arithmetic mean (Equation 3-2) if at least 20 daily means per month are available. Hourly means are also calculated by arithmetic averaging.
The hourly means are calculated as arithmetic average using Equation 3-3 with DNI instead of CAL. The conversion from the irregular satellite projection to the regular 0.05x0.05 degree grid is done with a MAGIC subroutine .

3.4.4 Input data

The input is identical to that of SIS with exception of the background surface albedo map which is not needed for SID. The input data is therefore described in **section 3.3.4**. CAL, total water column, ozone contend, aerosol information and look-up tables are used according to section 3.3.4.

3.4.5 Product example

Figure 3-6 provides examples of DNI product, here the long term mean from 1983-2013.

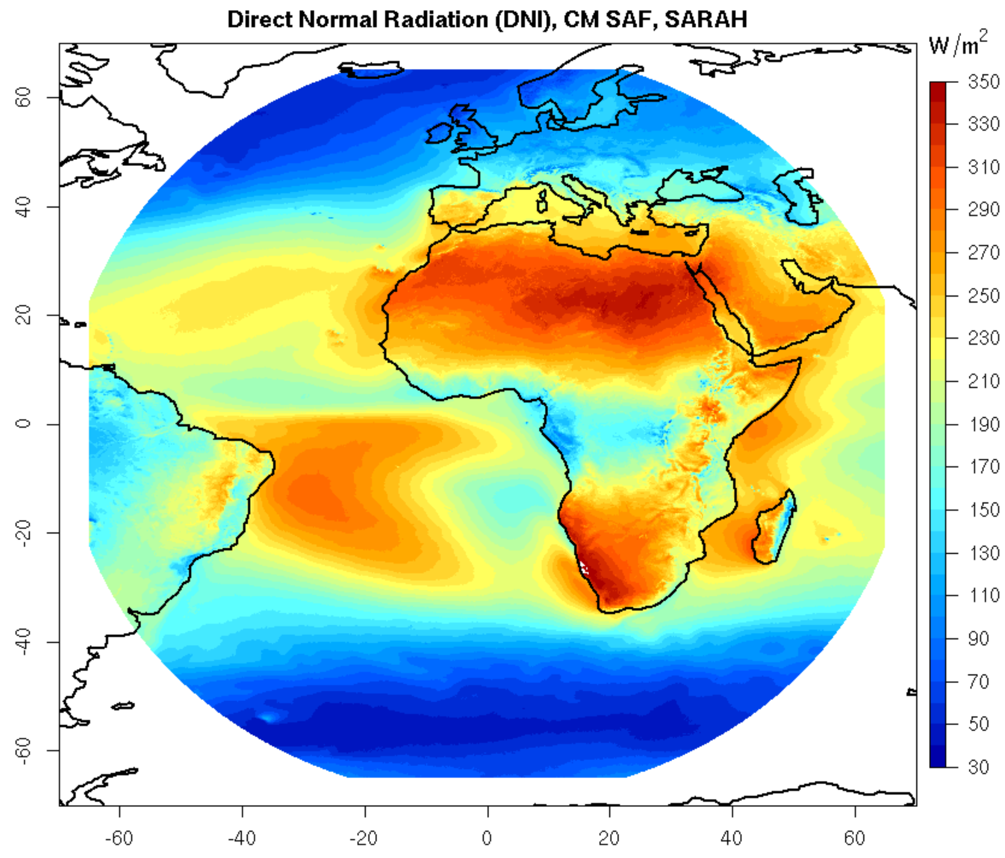

Figure 3-6 Illustration of the DNI product. Long term mean for 1983-2013.

3.4.6 Validation

The Product Requirement Document (PRD) [AD.1] lists specific product requirements which have to be fulfilled by the products. The achieved accuracy for the DNI product are shown in Table 3-6 and Table 3-7. Please see section 3.3.6 for validation limitations.

Table 3-6: *Accuracy achieved for DNI. The 90 % limit includes all regions, no region is excluded.*

Product	Summary on mean error (absolute)
DNI for METEOSAT	*MAB (Mean Absolute Bias) below 18 W/m² and 85 % of absolute bias values below 20 W/m² (+ uncertainty of ground based measurements) for monthly means.* *Very low bias of 2.5 W/m² for monthly, daily hourly means.* *Higher bias values occur in the Alpine and other mountainous regions, e. g. due to uncertainties in area to point comparison and snow coverage.*

The detailed results of the validation are presented in the CM SAF Validation Report [RD.2: SAF/CM/DWD/VAL/METEOSAT_HEL].

Table 3-7: *Summary of validation results for DNI: N Number of comparisons. MAB: mean of absolute bias values for monthly/daily means. SD: standard deviation. AC: Correlation of anomalies. $Frac_{mon:}$ Fraction of cases (months) with an accuracy outside of 30 W/m² (monthly means) and 40 W/m² (daily means). Basis of the results has been the comparison with 15 BSRN stations.*

DNI	N_{mon}	Bias [W/m^2]	MAB [W/m^2]	SD [W/m^2]	AC	$Frac_{mon}$ > threshold
Monthly means	1541	3.3	17.5	22.9	0.87	16.4
Daily means	41253	3.8	34.0	48.4	0.9	32.8

The bias in the Alpine region depends strongly on the region of interest which is discussed in detail in Dürr et al., 2010.

3.4.7 Limitations

Below is a list of some of known deficiencies and limitations of the DNI product (see SIS Limitations)

- The relatively high clear sky reflection over bright surfaces reduces the contrast between clear sky reflection and cloudy sky reflection. This leads to higher uncertainties and errors in the calculation of CAL and subsequent of DNI.
- The accuracy of aerosol information is not known in several regions of the world due to missing ground measurements.
- DNI is quite sensitive to the AOD (aerosol optical depth) in clear sky situations, which introduces a certain amount of uncertainty as the accuracy of monthly AOD can only be expected to be +/- 0.1. More over, for the current Heliosat data record a

climatology has been used. Monthly, daily and hourly variations in the aerosol optical depth are therefore not considered, which increases the uncertainty in daily and hourly values significantly. However, due to missing ground based measurements it is not evident nor proven that information about the temporal variation of aerosols gained from satellite would perform significantly better for the generation of a long term data records of monthly and daily means than a best-of aerosol climatology. Indeed, Kinne et al. (Kinne et al., 2006) discussed the limited accuracy of aerosol information retrieved from satellites. More over, dynamic aerosol information with appropriate coverage does not exist for the complete period of the Heliosat data record. Hence, uncertainties in DNI introduced by uncertainties in the AOD are mainly related to the lack of accurate and homogeneous input alternatives of aerosol information (especially over land) with high spatial and temporal resolution. However, due to the relative large sensitivity of DNI on aerosol optical depth the limited accuracy of the aerosol information is a significant reason for the lower accuracy of DNI relative to SIS.

3.5 Planned improvements

- Improvement of atmospheric input

a. Further evaluation of new aerosol climatology/information (e. g. higher temporal/spatial resolution) in order to improve the accuracy of SIS and DNI, ongoing activity. Significant improvements has already gained for the current SARAH release. The further evaluation is aimed for CDOP-2. If further improvements of the aerosol information are possible they will be implemented as soon as possible. Due to the complex matter of the task a potential implementation of new aerosol information will probably take place in CDOP-3.
b. Study to investigate the effect of a higher temporal resolution of water vapour, e. g. the use of daily means instead of monthly means, CDOP-2. If a higher resolution leads to significant improvements in the accuracy of surface radiation an updated water vapour input will be implemented in CDOP-3 (2018).

- Improvement of algorithms.

c. Development and evaluation of methods for the correction of broken clouds effect for the direct beam irradiance. The implementation is aimed for CDOP-2 and the SARAH Edition 2, which is planned to be released end of 2016 (DRR is foreseen for summer 2016).
d. Evaluation of potential improvements in the retrieval of clear sky reflection in order to minimise cloud contamination. The evaluation is aimed for CDOP-2, but the implementation will probably take place in CDOP-3 (2018).

- Analysis and evaluation of benefits and drawbacks of modifications with minor or regional effect on accuracy.

e. Evaluation of potential to improve the cloud detection over snow. The evaluation is aimed for CDOP-2, but the implementation will probably take place in CDOP-3 (2018).
f. Develop a correction for the determination of the cloud albedo under high viewing angles (slant viewing geometries). This effect could result in a small overestimation of the cloud albedo due to larger pixel sizes and enhanced likelihood of clouds in the satellite pixel. This effect can be estimated by comparison of the cloud albedo derived from the Meteosat Prime satellite and the

Meteosat East satellite. It is aimed to implement this correction in the next Edition of SARAH in CDOP-2, end 2016.

g. Detection of cloud shadows. With the classical HELIOSAT, cloud shadows receive a low cloud index value since they are dark, and thus the global radiation for these areas will be at maximum. This could potentially remove some of the remaining bias and spread. However, this is a item for CDOP-3

4 Data description

This section describes the output formats for the surface radiation parameters. Each surface radiation parameter is gridded onto a regular lat-lon grid with a size of 0.05x0.05°. The time resolution ranges from hourly mean values (=instantaneous), daily mean values, to monthly mean values.

4.1 Product Names

Product types are:

- Surface incoming solar radiation (SIS), also known as global irradiance.
- Surface direct normal radiation (DNI).
- Effective cloud albedo (CAL), also known as cloud index.

Time resolution:

- Daily mean value.
- Monthly mean value.
- Hourly mean (instantaneous) values.

4.2 Data Format and Ordering

CM SAF‘s climate monitoring products of surface radiation are provided as netCDF (Network Common Data Format, http://www.unidata.ucar.edu/software/netcdf/) files. The netCDF software functions as an I/O library, callable from C, FORTRAN, C++, Perl, or other language for which a netCDF library is available. The library stores and retrieves data in self-describing, machine-independent datasets. Each netCDF dataset can contain multidimensional, named variables (with differing types that include integers, reals, characters, bytes, etc.), and each variable may be accompanied by ancillary data, such as units of measure or descriptive text .

A netCDF consists of dimensions, variables, and attributes. These components can be used together to capture the meaning of data and relations among data. The dimensions of the CM SAF radiation CDRs are longitude, latitude and time (see Table 7-1). Each netCDF file contains one variable (SIS, DNI or CAL) at the given time resolution (hourly, daily or monthly means) together with the data values for the dimensions (see Table 7-2). The variables as well as the dimension variables are accompanied by attributes following the netCDF Climate and Forecast (CF) Metadata Convention 1.4 (http://cfconventions.org/). The attributes that are included in the CM SAF surface radiation datasets are listed in Table 7-3.

All data records are provided in separated files, one file for each time step. The data records cover monthly, daily and hourly values.

Below a list of relevant product acronyms ($product) and acronyms for the averaging period ($mean):

SIS: Surface Incoming Shortwave Radiation**.** Also called solar surface irradiance

DNI: Direct Normal Irradiance at surface

CAL: Effective cloud albedo

As additional data layer SID (Direct Irradiance at Surface) and SISblue (Blue Sky Irradiance) are available.

mm: Monthly mean
dm: Daily mean
hm: Hourly mean

Ordered files will follow the following naming convention
$Product$mean$Year$MonthDayHour$Version
Further details on the naming are given in the Web User Interface and the naming convention document available at the CM SAF web page: www.cmsaf.eu -> Products -> "Naming convention" item.

4.3 Data ordering via the Web User Interface (WUI)

Information on the CM SAF services are provided through the CM SAF homepage www.cmsaf.eu. The web page includes information and documentation on the CM SAF and the CM SAF products, information on how to contact the user help desk. It provides also the link to the WUI (http://wui.cmsaf.eu), which allows to search the product catalogue and to order products.
On the WUI "webpage" (http://wui.cmsaf.eu), 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.
Copyright note:

4.3.1 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.

4.4 Data volume:

The data amount depends on the data request of the user, in detail on the size of the selected region and the duration of the covered time period. The user will be informed about the data volume of his request within the WUI ordering process Below the maximum values for one parameter covering the complete Meteosat disk and time period are given:
Monthly Means: 1.7 GB
Daily Means: 65 GB
Hourly means: 2.5 TB

4.5 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.

4.6 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 4.4) 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.

4.7 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.

5 Tools and Auxiliary data

This section describes currently available tools to read, display, re-project and modify the CM SAF products. All tools and auxiliary data shortly described here, are accessible from the CM SAF main webpage (www.cmsaf.eu).

All tools and auxiliary data described are free of charge. They come with no warranty and are based on best effort basis. When encountering problems, please contact the User help desk (Section 4.4).

5.1 Climate data operators (CDO)

To allow easy access to CM SAF datasets the possibility to import CM SAF data has recently been integrated into the ‚climate data operators' (CDO) which is a well-established conversion tool in the climate modelling community (https://code.zmaw.de/projects/cdo).

This package was originally developed for processing and analysis of data produced by a variety of climate and numerical weather prediction models (e. g. for file operations, simple statistics, arithmetic, interpolation or the calculation of climate indices). Besides the conversion between different file formats, cdo offers possibilities for pre-processing the data for validation studies, especially interpolation to other grid types and selection of regions, including methods for interpolation of non-continuous datasets such as e. g. cloud types.

The CM SAF Meteosat climate data records are provided on a regular latitude longitude grid, whereby the latitude and longitude are given and described in the netCDF-files. CDO employs this information for spatial operations on these final products. A link to this tools is available on the CM SAF web site (www.cmsaf.eu). CDO has been used for the averaging of DNI and for modification of the netcdf header.

Please refer to the CDO-manual for detailed instructions how to import and process CM SAF products.

5.2 R scripts for data analysis and visualization (GUI)

The statistical package R is a free software environment for statistical computing and graphics (http://www.r-project.org/). CM SAF provides scripts and software written in R to support climate analysis and visualisation of the CM SAF Meteosat CDRs.. The respective tools are accessible from www.cmsaf.eu and allow, after installation, to read, analyse and visualise the cloud and radiation products. These tools are free of charge and come as they are.

CM SAF is interested in your experiences with the tool and encourage you to report all observed problems to the user help desk (Section 4.4).

5.3 Auxiliary Data

This section gives an overview of available auxiliary datasets which will be helpful for further processing and interpretation of CM SAF products. All auxiliary datasets are accessible via the webpage www.cmsaf.eu in the folder 'Data Access'. Table 5-1 lists the available auxiliary datasets and their respective coverage.

Table 5-1: *Table of available auxiliary datasets. AOD=Aerosol Optical Depth, ssa=single scattering albedo, gg=asymmetry parameter, the aerosol data is available as ASCII files from the CM SAF web page in the menu >add on products<.*

Region	Surface albedo [-]	Aerosols [AOD,ssa,gg]	Water vapour [mm]
CM SAF full disc area ("MA") (METEOSAT)	X	X	x
Global ("GL").		x	x

6 References

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7 Appendix

7.1 Appendix A: Description of the netCDF file format

The netCDF metafile definitions follows the cf 1.4 convention, please see http://cfconventions.org/ for details

Table 7-1: *Dimensions in the netCDF files*

Dimension	Size	Description
Lon	2601	Longitude
Lat	2601	Latitude
Time	1	Time

Table 7-2: *Variables in the netCDF file*

Variable	Type	Dimension	Description
Lat	float	(lat)	Longitude [°E]
Lon	flot	(lon)	Latitude [°N]
Time	float	(time)	Time [days since 01.01.1983]
SIS, DNI or CAL	short	(lon,lat,time)	Radiation variable or Effective Cloud Albedo

Table 7-3*: Variable attributes in the netCDF files*

Attribute name	Type	Description
units	string	the units of the variable
long_name	string	a more descriptive variable name
standard_name	string	a pre-defined variable name according to the standard name table in order to enable users of data from different sources to determine whether quantities were in fact comparable
coordinates	string	identifies the coordinate variables
_FillValue	same as variable	This value is considered to be a special value that indicates undefined or missing data; it is used to pre-fill disk space allocated to the variable.
missing_value	same as variable	deprecated, included for backward compatibility, describes the same as the [_FillValue]
comments	string	Miscellaneous information about the data or methods used to produce it.

7.2 Appendix B: SARB/CERES albedo

http://www-surf.larc.nasa.gov/surf/pages/bbalb.html
The albedo is calculated in a two step process. The first step is to determine scene type for a given 10 minute region. The SARB group uses the 17 scene types as specified by the International Geosphere/Biosphere Programme, plus "Tundra", "Sea Ice" and "Fresh Snow" scenes. Each has an associated spectral albedo curve between 0.2 and 4.0 micro meters. These spectral curves are integrated to give a broad band albedo for the region

7.3 Appendix C: Complete equations for the effective cloud albedo - solar irradiance relation

The effective cloud albedo is related to the solar irradiance via the clear sky index. The clear sky index is defined as:

$$k = SIS / SIS_{CLS}$$

Here SIS_{CLS} is the solar irradiance for cloud free skies. The relation between the effective cloud albedo CAL and the clear sky index is mainly given by:

$$k = 1 - CAL$$

This relation is defined by physics, in detail by the law of energy conservation (Dagested, 2005). However, above a CAL value of 0.8 empirical corrections are needed in order to consider:

- The effect of statistical noise, which could lead to CAL values above 1 and below 0 (occurs very seldom, however has to be considered).
- The effect of saturation occurring in optically thick clouds.

In these regions the n-CAL relation was determined from the statistical regression using the ground-based measurements at European sites and fitted to get the best performance at all the ground sites. The equations given below provide the complete n-CAL relation for all possible CAL values. It is important to note that the empirical fit has been performed in the 80s and used since then without refitting.

$$\begin{aligned} CAL < -0.2 &: k = 1.2, \\ -0.2 \le CAL \le 0.8 &: k = 1 - CAL, \\ 0.8 < CAL \le 1.1 &: k = 2.0667 - 3.6667 \cdot CAL + 1.6667 \cdot CAL^2, \\ CAL > 1.1 &: k = 0.05 \end{aligned}$$

As a consequence of the definition of the clear sky index, the surface solar irradiance for the full-sky situation (G) is given by,

$$SIS = k \cdot SIS_{CLS} ,$$

where SIS_{CLS} is the clear sky surface solar irradiance calculated using the MAGIC code (Mueller et al., 2004, 2009, 2012).

8 Glossary – List of Acronyms in alphabetical order

Abbreviation	Explanation
AVHRR	Advanced Very High Resolution Radiometer
AOD	Aerosol Optical Depth
BSRN	Baseline Surface Radiation Network
CAL	Effective Cloud Albedo
CDOP	Continuous Development and Operational Phase
CDO	Climate Data Operators
CDR	Climate Data Record
CM SAF	Satellite Application Facility on Climate Monitoring
DWD	Deutscher Wetterdienst
ECMWF	European Centre for Medium-Range Weather Forecast
ECV	Essential Climate Variable
ERA	ECMWF ReAnalysis
FD	Flux dataset (ISCCP)
FRAC	Fraction of days larger than the target value.
GADS/OPAC	Global Aerosol Data Set / Optical Properties of Aerosols and Clouds
GCOS	Global Climate Observing System
GERB	Geostationary Earth Radiation Experiment
GEWEX	Global Energy and Water Cycle Experiment
HRIT	High Rate Information Transmission
ISCCP	International Satellite Cloud Climatology Project
K	Clear sky index
LUT	RTM based Look-Up-Table
PRD	Product Requirement Document
PUM	Product User Manual
MAB	Mean of absolute bias values over several days or months
MVIRI	Meteosat Visible-InfraRed Imager
NCEP	National Center for Environmental Prediction
NOAA	National Oceanic and Atmospheric Administration
RTM	Radiative Transfer Model
SARAH	Surface Solar Radiation Data records – Heliosat
SD	Standard deviation
SEVIRI	Spinning Enhanced Visible and InfraRed Imager
SID	Surface Incoming Direct radiation, commonly called direct irradiance
SIS	Surface Incoming Solar radiation, commonly called global irradiance or surface solar irradiance
SSA	Single Scattering Albedo
SZA	Solar Zenith Angle