EUMETSAT Satellite Application Facility on Climate Monitoring

Product User Manual
CM SAF MSG Surface Albedo
Edition 1

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Applicable Documents

Reference	Title	Code
AD 1	CM SAF Service Specification Document	SAF/CM/DWD/SeSp/2.2
AD 2	Validation Report CM SAF Clouds, Albedo and Radiation Surface Albedo from SEVIRI (CLAAS-SAL) Edition 1	SAF/CM/FMI/VAL/SEV/SAL/1.2
AD 3	CM SAF Product Requirements Document	SAF/CM/DWD/PRD/2.0
AD 4	SYSTEMATIC OBSERVATION REQUIREMENTS FOR SATELLITE-BASED DATA PRODUCTS FOR CLIMATE - 2011 Update	GCOS-154

Reference Documents

Reference	Title	Code
RD 1	Algorithm Theoretical Basis Document Surface Albedo from SEVIRI (CLAAS-SAL)	SAF/CM/FMI/ATBD/SEV/SAL/1.2
RD 2	Algorithm Theoretical Basis Document Cloud Products from SEVIRI	SAF/CM/DWD/ATBD/SEV/CLD/1.2

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1. Introduction

The purpose of this document is to provide interested users with information on the features, quality and usage of the first edition of the CMSAF CLoud property dAtAset using SEVIRI Surface Albedo (CLAAS-SAL) dataset of the Climate-SAF project. The first part of the document introduces the product and its significance. The second part discusses the features and quality of the product in more detail, and the third part describes the end user product format.

Surface albedo is one of the factors governing the Earth's radiation budget, which in turn drives the climate of our planet. (Shortwave) Surface albedo is the dimensionless ratio of the reflected (solar) radiation flux to the incoming (solar) radiation flux. It has been designated as one of the Essential Climate Variables (ECV) of the GCOS, as required by IPCC and UNFCCC (GCOS Secretariat, 2011). Because of surface albedo's significance to the radiation budget, its continuous monitoring is of importance in understanding climate change. All products have been developed and evaluated with respect to requirement goals defined in [AD 3]. The finally achieved product accuracies are described in [AD 2]. Of specific interest here are requirements in [AD 4] as outlined by the Global Climate Observing System (GCOS) community and issued by the United Nations World Meteorological Organisation (WMO) in 2012.

The CLAAS-SAL dataset spans the period from 2004-2011. The albedo products, distributed as pentad and monthly means at 0.05 degree resolution, are composed from image data from the Spinning Enhanced Visible and Infra-Red Imager (SEVIRI) instruments on board the Meteosat Second Generation (MSG) geostationary satellites. The characteristics of the time series and its usage are described in the following chapters. The purpose of this document is not to be a detailed guide to the workings of the algorithm itself. Although processing flow is described, readers interested in the nuts and bolts of the SAL algorithm are encouraged to read the CLAAS-SAL Algorithm Theoretical Baseline Document (ATBD) [RD 1], available on the CM-SAF project website.

1.1 Suggested usage and limitations

The CLAAS-SAL dataset has been validated against in-situ reference data from Europe and Africa. Validation criteria have been fulfilled for all studied sites, although there is a shortage of quality-controlled reference data so that generalizations of product quality should be considered carefully. Special care needs to be taken when utilizing CLAAS-SAL over regions with a high variability in aerosol concentrations in the atmosphere. In general, users are also strongly recommended to examine the number of observations-datafield within each CLAAS-SAL product. Cases where the temporal mean albedo of an area is derived from only a few observations are vulnerable to errors in cloud masking and/or BRDF and atmospheric corrections. The pentad mean products are generally more vulnerable to retrieval errors than the monthly mean products for these reasons.

1.2 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. CM SAF CLoud property dAtAset using SEVIRI – Surface ALbedo (CLAAS-SAL)

2.1 Product Definition

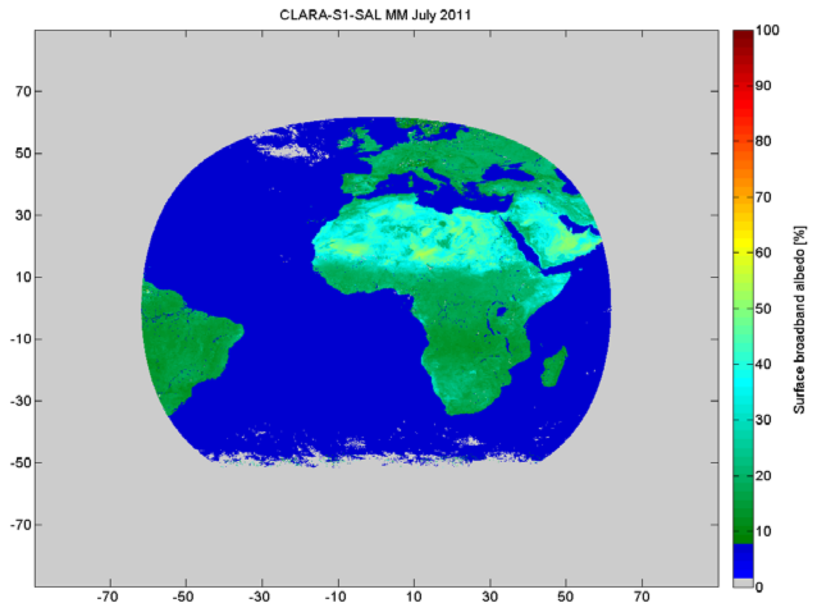
The physical quantity that CLAAS-SAL describes is the black-sky surface albedo, mathematically written as (Schaepman-Strub et al., 2006)

$$\alpha(\theta_s,\phi_s)=\int_0^{2\pi}\int_0^{\pi/2} f_r(\theta_s,\phi_s;\theta_r,\phi_r)\cos(\theta_r)\sin(\theta_r)d\theta_r d\phi_r \qquad (1)$$

The black-sky surface albedo is the integral of radiation reflected from a single incident direction towards all viewing directions in the zenithal and azimuthal planes. The spectral dependency of albedo is omitted here; a full (black-sky) broadband albedo would be obtained by integrating the spectral directional-hemispherical reflectance over the waveband under investigation. CLAAS-SAL is a broadband albedo product, defined with a wavelength range of 0.3 - 4 µm.

2.2 Products and availability

The CM SAF SAL products are available as pentad (five-day) and monthly means in a global equally spaced lat/long grid at 0.05 degree spatial resolution. Area shown in Figure 1.



Projection	Geographic
Ellipsoid	WGS-84
Region (deg)	long: -89.975 -> 89.975, lat: 89.975 -> -89.975
Resolution	0.05 degrees
Size	3600 columns, 3600 lines

Figure 1: CLAAS-SAL monthly mean lat/long grid example and parameters.

2.3 CLAAS-SAL algorithm

AVHRR channels 1 and 2 (0.58-0.68 µm and 0.725-1 µm) are used for the AVHRR-SAL product generation as radiance sources. The overall processing flow of CLAAS-SAL is shown in Figure 4. The necessary preprocessing of the satellite data for use with SAL is done by the NWC-SAF software package. Details on the package and cloud mask derivation may be found at Derrien and LeGléau (2005). The package converts observed satellite radiances to TOA reflectances for CLAAS-SAL, and performs the critical cloud masking operation. Sun-satellite geometry data are also provided. Other auxiliary data, such as the water vapour content in the atmosphere or surface pressure, are based on the ERA-Interim model analysis done at ECMWF. Land use information is based on the Global Land Cover 2000 database (European Commission, Joint Research Centre, 2003, http://www-gem.jrc.it/glc2000).

The radiance data record used in the generation of the entire CLAAS dataset family is the level 1.5 data record provided by EUMETSAT. This data record has been calibrated, geolocated and cleaned for artefacts. However, it has been noted that the solar channel calibration in the level 1.5 record is not optimal (Ham and Sohn, 2010). As a result, the algorithm of Meirink et al. (2012) was applied to the solar channel data to recalibrate them. This method is based on linear regression of collocated and spectrally homogenized SEVIRI-MODIS solar channel images, considering MODIS as a reference because of its well-known high radiometric accuracy. The SEVIRI channels 1 and 2 were off MODIS by approximately -8% and -6%, respectively. The data record was corrected for this effect before CLAAS processing. More details are available in [RD 2] and in the publication.

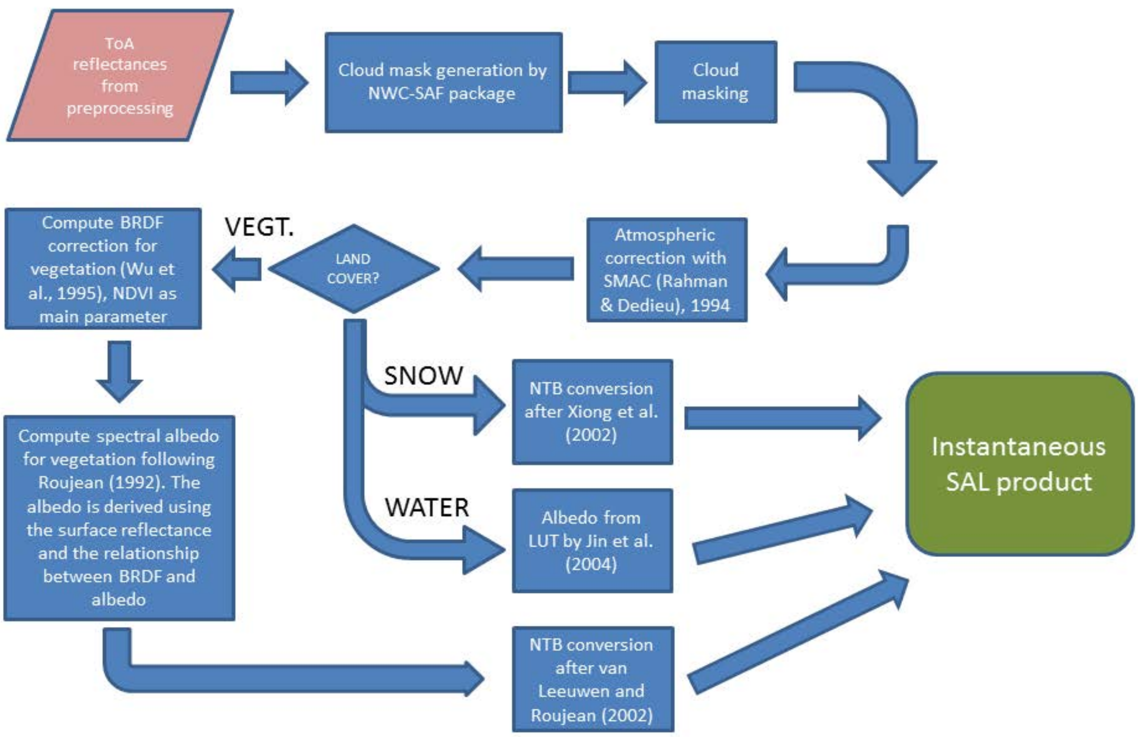


Figure 2: The process flow of the CLAAS-SAL product computation.

The product processing proceeds as follows (for details the reader is referred to the SAL ATBD [RD.1]):

- The ToA reflectances are provided by the NWC-SAF processing software, as discussed above. The reflectances have then been recalibrated using the KNMI method discussed above.
- SMAC atmospheric correction applied for all observed reflectances.
  - AOD is currently set to 0.1 everywhere, the ozone content of the atmosphere is set to 0.35, surface pressure and water vapour content of the atmosphere are derived from ERA-Interim data.
- The surface reflectances are expanded into hemispherical spectral albedos by applying a BRDF algorithm based on the work of Roujean et al. (1992) and Wu et al. (1995). The BRDF algorithm is applied to both 0.6 and 0.8 µm channel separately.
- Snow albedo algorithm utilizes empirical sampling of pentad/monthly BRDF. The instantaneous images are kept as directional-directional reflectances, temporal averaging forms desired hemispherical-directional reflectances (black-sky albedo, i.e. CLAAS-SAL). Details in [RD 1].
  - Motivation: No robust, universal snow BRDF models available for anisotropy correction.
- The spectral albedos are processed to a shortwave broadband albedo via a narrow-to-broadband (NTB) conversion. The conversion is both instrument and pixel land cover specific. The land cover information comes from GLC2000 land use classification data.
  - For water pixels, the BB albedo is taken from a LUT after Jin et al. (2004).
  - For snow pixels, the instantaneous BB directional reflectance is computed from the channel-specific spectral directional reflectances (see above) by an NTBC algorithm by Xiong et al. (2002).
  - For other types of land cover, the NTBC conversion takes place based on an algorithm by van Leeuwen and Roujean (2002).
- A normalization of the instantaneous albedo retrievals to a sun zenith angle (SZA) of 60 degrees to better enable averaging for the distributed products was planned but not carried out due to technical reasons. The typical effect on the mean albedo over a pentad or a month is estimated to be 0.01 – 0.02 with respect to a mean albedo normalized to a SZA of 60 degrees.

2.3.1 CLAAS-SAL topography correction:

The topography affects the satellite image in first order in two ways: 1) the altitude difference with respect to sealevel will cause the geolocation of the pixel to be shifted and 2) the inclination of the slopes of the terrain within a pixel will alter its reflectance value. As the BRDF calculations are based on a horizontal plane assumption, erroneous values will be obtained for inclined slopes. In addition, the slope distribution of the terrain covered by the pixel may contain slopes that are not seen at all by the sun or the satellite. These kinds of situations will cause even larger errors than small slope inclinations.

The topography correction is calculated in two parts. First, the apparent location of a pixel is computed and pixels are moved to their actual locations on a flat plane (within 1 pixel accuracy). Then, a high-resolution DEM is fitted into the satellite data and viewing/illumination geometry data is applied to compute the number of slopes within the satellite pixel that are illuminated, in shadow or illuminated/viewable but not within the BRDF model validity range. The unseen/shadowed slopes are assumed to have the same physical albedo as the observed slopes. The observed reflectance is corrected for assuming that the slopes that could not contribute to the observed reflectance would contribute to the albedo of the area equally much as the slopes that were visible in the observed satellite image. For more details, the reader is encouraged to see the ATBD [RD 1].

2.4 Validation

The CLAAS-SAL dataset has been validated prior to release against ground truth data from 3 sites in Europe and Africa. Product accuracy requirement (25% relative) was fulfilled at all sites, although results from the African site (Niamey) pointed to increased retrieval errors during high AOD loading conditions. This is to be expected, as this dataset release utilizes a fixed AOD in processing.

As an example, we show the validation results from the Lindenberg validation site in Germany. Figure 3 shows the validation and satellite data as a timeseries. Overall, there is no significant under- or overestimation in the spatiotemporal SAL means. Wintertime snowfall events are partly tracked; the reader should note that the SAL averaging in space and time and the representativeness of the validation site measurement over the larger area unavoidably affect retrieval precision.

Figure 4 shows the relative retrieval errors of the pentad and monthly mean CLAAS-SAL products. The accuracy requirement of the product is fulfilled, though we note a trend in the retrieval errors toward underestimations as time goes by. This has also been noted in the EDR-SAL validations and seems to be connected to a slight increasing trend in the in situ albedo. The satellite-derived albedo of the grid cell surrounding Lindenberg has remained quite stable (at approximately 0.2).

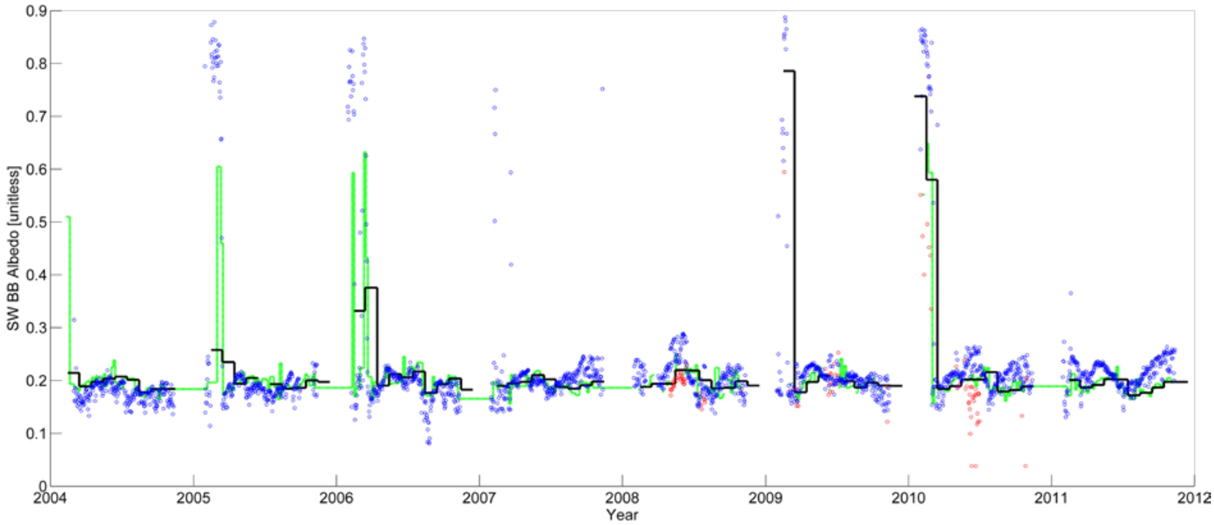


Figure 3: CLAAS-SAL and in situ albedo over Lindenberg. Blue circles indicate daily albedo means at the validation site, red circles indicate instantaneous CLAAS-SAL retrievals (if recorded), and the black and green (dashed) lines indicate the CLAAS-SAL monthly and pentad mean albedo, respectively.

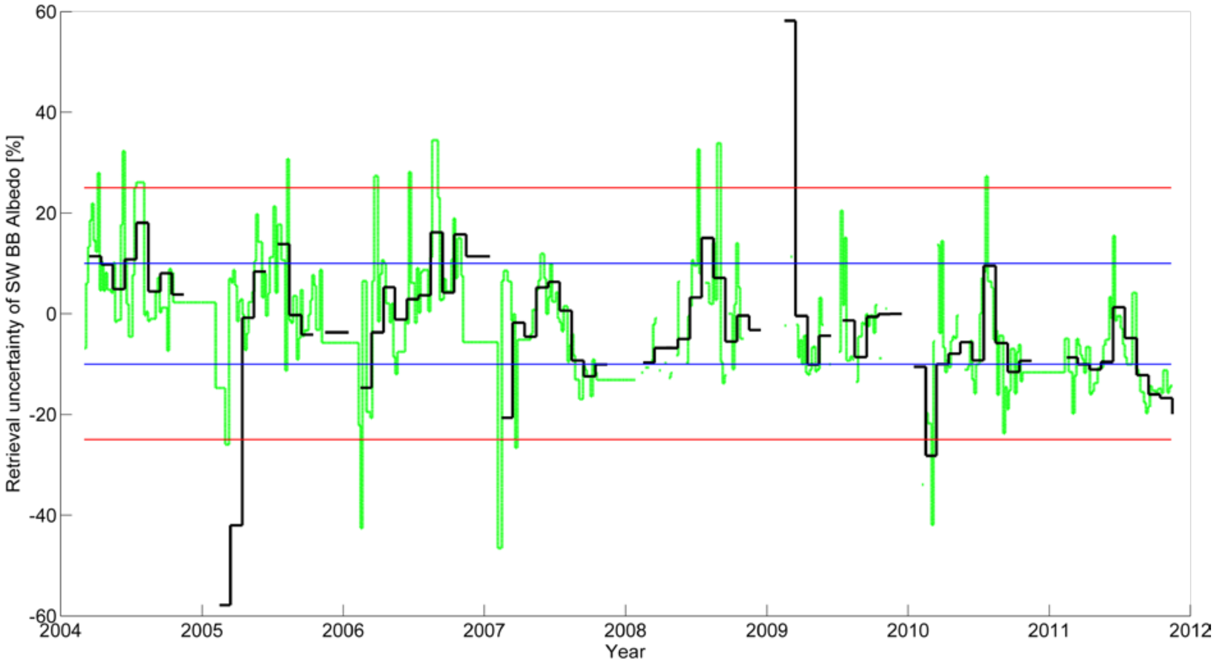


Figure 4: CLAAS-SAL relative retrieval error over Lindenberg. the black and green (dashed) lines indicate the retrieval error of the monthly and pentad means. Red dashed line shows 25% and the blue dashed line 10% relative error levels.

2.5 Limitations

The computation of surface broadband albedo is a complex task with several possible sources of error. A detailed listing and study of each factor is beyond the scope of this manual, the interested reader may find a detailed analysis in [RD 1]. However, it is important to mention here the most important error sources of the algorithm:

- The accuracy of the cloud mask is critical to the SAL product quality. Cloud overestimation in the mask is not a problem since the weekly and monthly SAL end products generally have sufficient sampling to compensate. However, underestimation of clouds may lead to sporadic instantaneous surface albedo retrieval overestimations of several hundred per cent (relative). Over snow-covered areas, the underestimation of cloud cover typically leads to an underestimation of the instantaneous surface albedo. The end products are resistant to such effects because they are the result of averaging of instantaneous products, leading to mitigation of sporadic errors. The quantification of the robustness of SAL end products to cloud mask errors is yet to be performed.

- The current atmospheric correction is a compromise between the need to avoid introducing artificial retrieval errors into product and a desire to correctly account for the atmospheric physics affecting the surface albedo retrieval. We currently use an atmospheric model to account for the second-order atmospheric variables that affect surface albedo retrievals, namely columnar water vapour and surface pressure. Ozone content of the atmosphere is kept constant. However, the most important atmospheric variable affecting the surface albedo retrievals is the aerosol optical depth (AOD) in the atmosphere. Variations in AOD are both regional and global; their effect in space-observed surface reflectances is substantial. Yet an accurate derivation of AOD from satellite observations to support surface albedo retrievals often requires assumptions on the albedo of the underlying surface. Through making these assumptions, the product contains an internal correlation between the AOD and the albedo of the terrain underneath, which is an undesired combination. To avoid this, we currently choose to use a fixed AOD content in the atmosphere everywhere. Though additional albedo retrieval errors will occasionally occur as a result, we make this choice consciously.

- Errors in the land use classification data are another source of retrieval error that should be considered. The LUC data is not continuously updated, therefore man-made or natural changes in land cover are generally not correctly picked up by CLAAS-SAL, which is dependent on LUC data to choose a proper surface albedo subroutine. Also, the algorithm does not yet properly delineate between desert areas and other barren terrain, leading to increased retrieval errors for desert. However, the relatively short timespan of the dataset ameliorates this issue.

2.6 Outlook

As the albedo development in CM SAF is focusing on polar orbiter retrievals, there are currently no plans to extend the CLAAS data record or reprocess it in the foreseeable future.

3. Data Description

CM SAF's climate monitoring datasets 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).

3.1 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 CLAAS-SAL product 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]
lat geographical latitude of pixel centre [degree_north]
lon geographical longitude of pixel centre [degree_east]

Each data file contains the following 2-dimensional variables:

sal contains the CLAAS-SAL product data [percent]
nobs contains the numbers of valid satellite observations for each SAL pixel[unitless]
stdv contains the standard deviation of the CLAAS-SAL product per pixel [percent]

Table 1: CLAAS-SAL variables in a NetCDF file

Variable	Size	Type
time	1 x 1	double
lat	720 x 1	double
lon	1440 x 1	double
sal	1440 x 720 x 1	single
nobs	1440 x 720 x 1	int32
stdv	1440 x 720 x 1	single

The data file also contains an array of global attributes for data documentation and improved usability purposes. These attributes are contained in each CLAAS-SAL product, and are listed in Table 2.

Table 2: CLAAS-SAL product attributes

Name	Description
title	General description of products
summary	summary of product
product_class	product type and temporal averaging
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

Digital_Object_Identifier	DOI assigned to this dataset
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, “AVHRR GAC edition 1” for gridded products
cdm_data_type	data type, “grid” for gridded products
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]
time_coverage_resolution	temporal coverage resolution of the data [ISO8601 duration]
geospatial_lat_units	latitude attributes unit [degree_north]
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 [degree_east]
geospatial_lon_resolution	longitude grid resolution
geospatial_lon_min	longitude bounding box minimum
geospatial_lon_max	longitude bounding box maximum
dataset_version	SEVIRI dataset version
cmsaf_sev_major_version_number	SEVIRI major edition version
cmsaf_sev_minor_version_number	SEVIRI minor edition version
cmsaf_sev_parameter_name	SEVIRI parameter name.
cmsaf_parameter_id	SEVIRI parameter ID
processed_satellites	satellite overpasses (id and number) processed for this mean
processed_orbit_nodes	satellite orbit nodes processed for this mean "ascending, descending" for all files
cmsaf_parameter_id	CM SAF product identifier code (61 for CLAAS-SAL)
cmsaf_parameter_code	CM SAF product name
L3_processor	Software version of the GAC averaging & reprojection software
L2_processors	Versions of the L2 software used to generate the product [SAL and NWCSAF software versions applied for dataset generation]
Level1_intercalibration	intercalibration version applied
reference_documents	Identifier codes and names of the GAC product documents applicable for this data.

In addition to the global attributes, each variable also has attached attributes. The variable-specific attributes are listed with explanations in Table 3.

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]
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	same as _FillValue
cell_methods	method used to derive data that represents cell values

4. Data ordering via the Web User Interface (WUI)

The Web User Interface is available at http://wui.cmsaf.eu. This platform gives the user direct access to the CM SAF data ordering interface, together with a description of its diverse functionalities (such as product searching or product ordering). The user is refered to this description since it is the central and most up to date WUI documentation available. However, the WUI key features are briefly described in the following sections.
Further user services, including information and documentation about CM SAF and CM SAF products, are available from the CM SAF homepage (http://www.cmsaf.eu).

4.1 Product ordering process

The user needs to be registered and logged in to order products. A login is provided upon registration, and all products are delivered free of charge (please note the copyright disclaimer given in Section 6.1). After product selection, it is possible to choose a type of data transfer (temporary ftp account (the default setting), CD/DVD, or email). Each order will be confirmed per email. A second email will inform the user when the data is ready; if the ftp data transfer was selected, this second email will provide the information on how to access the ftp server.

4.2 Contact User Help Desk staff

Shall a user encounter any problem or have questions, the CM SAF User Help Desk (email: contact.cmsaf@dwd.de) is available at any time. Further User Help Desk contact information (phone/fax,etc) are available on the CM SAF homepage (www.cmsaf.eu) or on the Web User Interface homepage (http://wui.cmsaf.eu).
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4.3 User Problem Report

The users are encouraged to report any problems or difficulties encountered while using CM SAF products or services and to provide feedback to the CM SAF team. Users can either contact the User Help Desk (see Section 4.2) or use the “User Problem Report” page. A link to the “User Problem Report” is available either from the CM SAF homepage (www.cmsaf.eu) or the Web User Interface homepage (http://wui.cmsaf.eu).

4.4 Service Messages / log of changes

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

5. Feedback

5.1 User feedback

Users of CM SAF products and services are encouraged to provide feedback on CM SAF products and services to the CM SAF team throught the User Help Desk (contact.cmsaf@dwd.de). Furthermore, the CM SAF team is always keen to learn about the user's applications or field of expertise, so it is highly appreciated that the users provide CM SAF with feedback on their particular applications and experiences with CM SAF data.

5.2 Specific requirements for future products

EUMETSAT CM SAF is a user-driven service and is committed to considering the needs and requirements of its users when planning new products or for improvements of existing ones. Consequently, beside general feedback, the users are cordially invited to provide CM SAF with their specific requirements for future products. The users can provide their requirements directly to the CM SAF staff or by emailing the User Help Desk (contact.cmsaf@dwd.de).

5.3 User Workshops

In order to widen its audience and support its users with the exploitation of its data, CM SAF organizes training workshops on regular basis (approximatly every year). Furthermore, through regular (approximately every four years) CM SAF user workshops the CM SAF product baseline is revisited. The participation of the users in any of these workshops is highly appreciated. at the users are refered to the CM SAF webpage (www.cmsaf.eu) to get the latest news on the upcoming events.

6. Copyright

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

6.1 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 a user wishes 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.***

6.2 Acknowledgement and Identification

When exploiting EUMETSAT/CM SAF data, the user is kindly requested to acknowledge this contribution accordingly and to make reference to 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)". Furthermore, it is highly recommended to clearly refer to

the product version used, for example by identifying the CM SAF data records using the digital object identifier (doi). All information about the CM SAF doi are available from http://www.cmsaf.eu/DOI.
The doi for this data set is provided on the title page of this document.

6.3 Re-distribution of CM SAF data

The user is not allowed to re-distribute CM SAF data to third parties. The use of CM SAF products is granted free of charge to every interested user, but it is essential for the sustainability of CM SAF that the CM SAF team keeps track of the CM SAF users and how many they number. This helps to maintain the CM SAF operational services and ensures that the evolution of its products is in accordance with user needs and requirements. Each new user must become registered with CM SAF in order to have access to the data.

7. References

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8. Abbreviations

AOD	Aerosol Optical Depth
AVHRR	Advanced Very High Resolution Radiometer (NOAA)
BB	Broadband
BRDF	Bidirectional Reflectance Distribution Function
BSRN	Baseline Surface Radiation Network
CLAAS	CLoud property dAtAset using SEVIRI
CLARA	CM SAF cLouds, Albedo and RAdiation
CM SAF	Satellite Application Facility on Climate Monitoring
DEM	Digital Elevation Model
DWD	Deutscher Wetterdienst
ECMWF	European Center for Medium-Range Weather Forecasts
ECV	Essential Climate Variable
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
EPS	Enhanced Polar System
FMI	Finnish Meteorological Institute
GC-Net	Greenland Climate Network
GCOS	Global Climate Observing System
GME	DWD Global Model
IPCC	Intergovernmental Panel on Climate Change
KNMI	Royal Netherlands Meteorological Institute
LUC	Land Use Classification
LUT	Look-Up Table
MODIS	Moderate Resolution Imaging Spectroradiometer
NOAA	National Oceanic and Atmospheric Administration
NTB (C)	Narrow-to-Broadband (Conversion)
NWC-SAF	Nowcasting Satellite Application Facility
NWP	Numerical Weather Prediction
OSI-SAF	Ocean and Sea Ice Satellite Application Facility
PNG	Portable Network Graphics
PPS	Polar Platform System
RMIB	Royal Meteorological Institute of Belgium
SAF	Satellite Application Facility
CLAAS-SAL	CM SAF cLouds, Albedo and Radiation - Surface ALbedo product
SEVIRI	Spinning Enhanced Visible and Infra-Red Imager
SGP	Southern Great Plains (a BSRN site in the United States)
SMAC	Simplified method for the atmospheric correction of satellite measurements in the solar spectrum
SMHI	Swedish Meteorological and Hydrological Institute
SZA	Sun Zenith Angle
TOA	Top of Atmosphere
UNFCCC	United Nations Framework Convention on Climate Change
USGS	United States Geological Survey
VZA	Viewing Zenith Angle