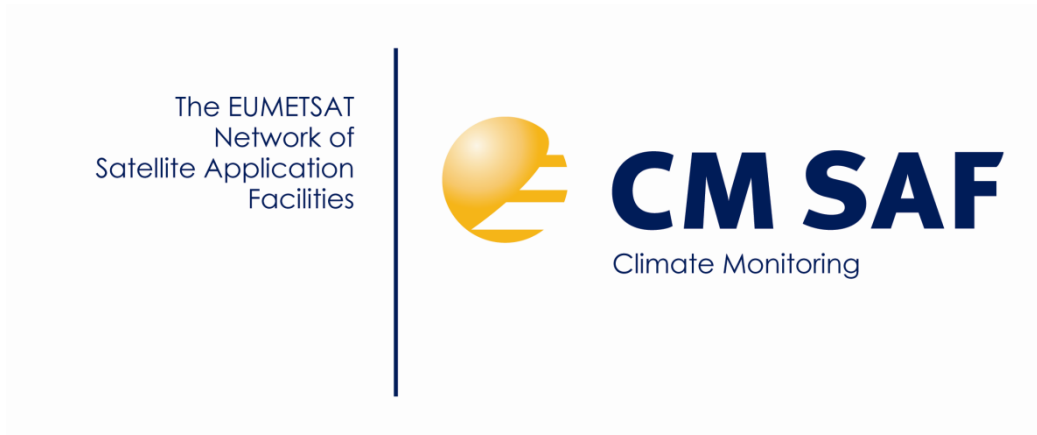# EUMETSAT Satellite Application Facility on Climate Monitoring

Product User Manual

CM SAF Cloud, Albedo, Radiation data record, AVHRR-based, Edition 2 (CLARA-A2)

Surface Albedo

Broadband Surface Albedo   **CM-11221**

Document Signature Table

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Approval	Rainer Hollmann	Science Coordinator		29.07.2016
Release	Martin Werscheck	Project Manager		

Distribution List

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Document Change Record

Issue/ Revision	Date	DCN No.	Changed Pages/Paragraphs
1.0	11.06.2012	SAF/CM/DWD/PUM/GACSAL/V 1	Initial Issue
1.1	08.05.2013	SAF/CM/DWD/PUM/GACSAL/V 1	Document after revision from DRI
2.0	11.05.2016	SAF/CM/DWD/PUM/GAC/SAL	Initial Isssue for DRR 2.2
2.1	29.07.2016	SAF/CM/DWD/PUM/GAC/SAL	Implementation of DRR 2.2 RIDs

Applicable Documents

Reference	Title	Code
AD.1.	CM SAF Product Requirements Document	SAF/CM/DWD/PRD/2.7

Reference Documents

Reference	Title	Code
RD.1.	Algorithm Theoretical Basis Document CM SAF Cloud, Albedo, Radiation data record, AVHRR-based, Edition 2 (CLARA-A2) Surface Albedo	SAF/CM/FMI/ATBD/GAC/SAL, 2.1
RD.2.	SYSTEMATIC OBSERVATION REQUIREMENTS FOR SATELLITE-BASED DATA PRODUCTS FOR CLIMATE - 2011 Update	GCOS-154
RD.3	Validation Report CM SAF Cloud, Albedo, Radiation data record, AVHRR-based, Edition 2 (CLARA-A2) Surface Albedo	SAF/CM/FMI/VAL/GAC/SAL, v2.1

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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 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, 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 record assessments performed by research organisations such as WCRP. This role provides the CM SAF with deep contacts to research organizations that form a substantial user group for the CM SAF CDRs,

Maintaining and providing an operational and sustained infrastructure that can serve the community within the transition of mature CDR products from the research community into operational environments.

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

2 Introduction

The purpose of this document is to provide interested users with information on the features, quality and usage of the second edition of the Global Area Coverage Surface Broadband Albedo (CLARA-A2-SAL) data record of the CM SAF. 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, 2006). The directional-hemispherical reflectance, or black-sky albedo, is one way to estimate the surface albedo. Because of surface albedo's significance to the radiation budget, its continuous monitoring is of importance in understanding climate change. Satellites provide the most cost-effective means to achieve global coverage with a relatively short repeat period. All products have been developed and evaluated with respect to requirement goals defined in [AD.1]. The finally achieved product accuracies are described in [RD.3]. Of specific interest here are requirements in [RD.2] as outlined by the Global Climate Observing System (GCOS) community and issued by the United Nations World Meteorological Organisation (WMO) in 2012.

The CLARA-A2-SAL data record spans the period from 1982 to 2015. The albedo products, distributed as pentad and monthly means at 0.25 degree resolution, are composed from overpass data from the Advanced Very High Resolution Radiometer (AVHRR) instruments on board the National Oceanic and Atmospheric Administration (NOAA) and Metop 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 CLARA-A2-SAL Algorithm Theoretical Baseline Document (ATBD) [RD.1], available on the CM SAF project website.

2.1 Suggested usage and limitations

The CLARA-A2-SAL data record has been validated against a large number of in-situ reference data. Validation criteria have been fulfilled for both vegetated regions and snow/ice-covered areas. Particularly the product accuracy over snow and ice has been shown to be good; therefore we have grounds to recommend using CLARA-A2-SAL for cryospheric studies especially over the Arctic owing to the complete sea ice albedo coverage in CLARA-A2-SAL. The dry, thin atmosphere over the inner parts of Antarctica poses a challenge to the atmospheric correction in CLARA-A2-SAL and may have an effect in product quality there (yet unstudied). Similarly, care needs to be taken when utilizing CLARA-A2-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 CLARA-A2-SAL product. The monthly and especially pentad means with only few observations are vulnerable to retrieval errors in cloud masking, especially in regions with high value of mean solar zenith angles. Therefore a minimum value for nobs not to be underquoted in using the SAL product is 20 for monthly means and 5 for pentads.

Note: The data for year 2015 has not been validated. Also, due to limitation of available data, the AOD data record has been constructed differently for this year. The effect of

the calibration coefficients for AVHRR channel 2 on this year has also not been studied. Knowing this we leave it to the user to pay special attention while/if using the data for 2015. We recommend that timeseries analysis should always be made with and without data for year 2015.

3   Global Area Coverage Surface Albedo edition 2 (CLARA-A2-SAL)

3.1   Product Definition

The physical quantity that CLARA-A2-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. CLARA-A2-SAL is a broadband albedo product, defined with a wavelength range of 0.25 - 2.5 µm for AVHRR.

3.2   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 0.25 degree spatial resolution. Area coverage is shown in Figure 1. The global product is delivered in geographic projection, using WGS-84 ellipsoid, with product limits -179.875 -> 179.875 degrees of longitudes and 89.875->-89.875 degrees latitude (720 columns, 1440 rows, with coordinates indicating the pixel centre). A subset of the data spanning either the Arctic or Antarctic region in 25 km resolution is also delivered. Please contact the CM SAF User Help Desk for details.
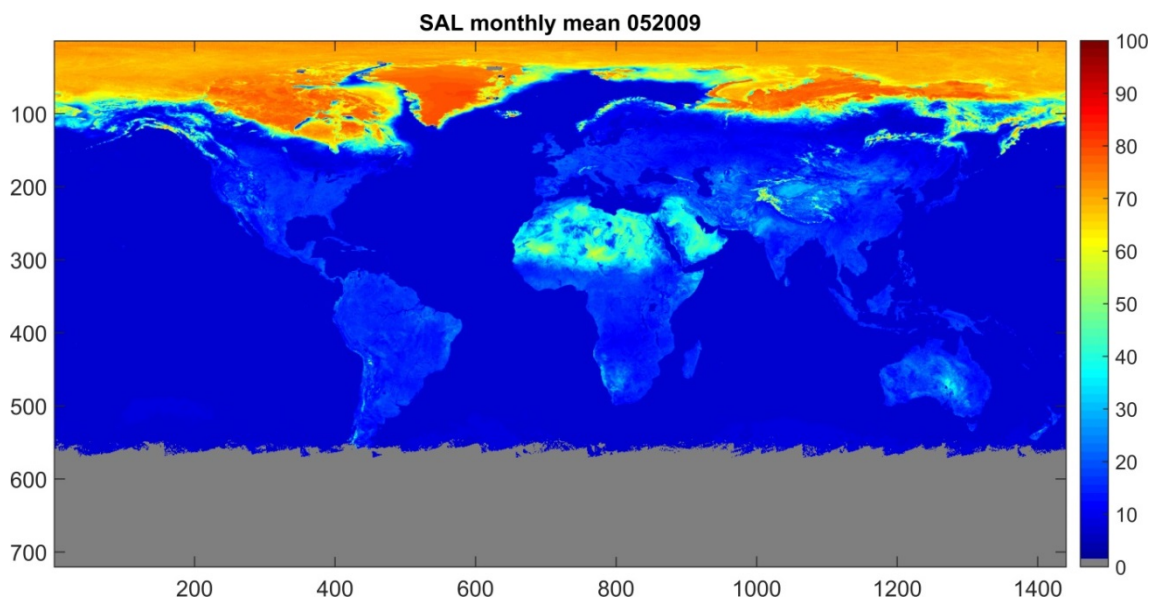

Figure 1: CLARA-A2-SAL monthly mean for September 2009.

3.3   CLARA-A2-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 CLARA-A2-SAL is shown in Figure 2. The necessary preprocessing of the satellite data for use with SAL is

done by the PPS software package. Details on the AVHRR-PPS package and cloud mask derivation may be found at Dybbroe et al. (2005). The package converts observed satellite radiances to TOA reflectances for CLARA-A2-SAL, and performs the critical cloud masking operation. Sun-satellite geometry data are also provided. The aerosol optical depth (AOD) information used in the atmospheric correction is derived from aerosol index data measured by Total Ozone mapping (TOMS) and Ozone monitoring instruments (OMI). The wind speed data required for the ocean surface albedo determination is compiled from Scanning Multi-channel Microwave Radiometer (SMMR), Special Sensor Microwave Imager (SSM/I), Special Sensor Microwave Imager Sounder (SSMIS) and anemometer based wind speed data. 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 4 different land use classifications: USGS 1993, GLC2000, GLOBCOVER 2005 and GLOBCOVER 2009. These land use datasets are also used for land/sea –masking.
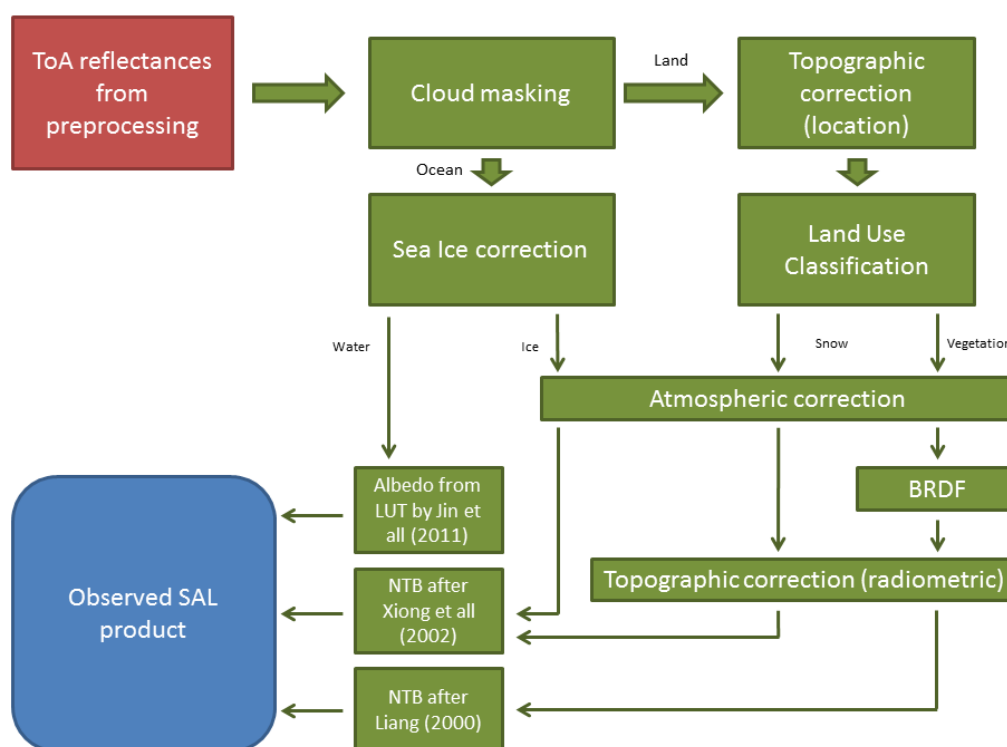

Figure 2: The process flow of the CLARA-A2-SAL product computation.

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

- The ToA AVHRR reflectances are provided by the Polar Platform System (PPS) processing software, as discussed above.
- The classification of snow covered pixels in Arctic and Antarctic sea areas provided

by PPS are verified by using Ocean and Sea Ice Satellite Application Facility (OSI-SAF) sea ice extent data.

- The open water albedo is determined on the basis of the sun zenith angle and the surface wind data using the algorithm by Jin et al. (2004 and 2011).

- Topography correction for geolocation and radiometry is applied for areas (pixels) with slopes exceeding 5 degrees. See [RD.1] for details.

  o Motivation: improvement of retrieval accuracy of albedo over mountainous regions.

- The pixels that are classified as cloud free and not covered by snow are given a land use information using land use classification 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 observed overpasses are kept as directional-directional reflectances, temporal averaging forms desired hemispherical-directional reflectances (black-sky albedo, i.e. CLARA-A2-SAL). Details in [RD.1].

  o Motivation: No robust, universal snow BRDF models available for anisotropy correction. Testing and validation have proven that sufficient sampling of the viewing hemisphere is achieved over most snow-covered regions of the Earth.

- SMAC atmospheric correction applied for all observed reflectances.

  o A dynamic value of AOD is used to land surfaces excluding ice sheets, where a static value of 0.1 is used. The ozone content of the atmosphere is set to 0.35 $\left[\frac{atm}{cm^2}\right]$, surface pressure and water vapour content of the atmosphere are derived from ERA-Interim data.

  o NOAA-18 SMAC coefficients are applied for all NOAA satellites, since the AVHRR radiances are intercalibrated across the AVHRR-GAC FCDR.

- 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 4 different land use classification data records: USGS, GLC2000, GLOBCOVER2005 and GLOBCOVER2009.

  o For water pixels, the BB albedo is taken from a LUT after Jin et al. (2004).

  o For snow pixels, the observed BB directional reflectance is computed from the channel-specific spectral directional reflectances (see above) by an NTBC algorithm by Xiong et al. (2002).

  o For other types of land cover, the NTBC conversion takes place based on an algorithm by Liang (2000).

- A normalization of the observed 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.

3.3.1 AOD time series:

In CLARA-A2-SAL the previously constant AOD value (0.1) has been replaced with a new dynamic AOD time series constructed for the time frame 1982-2014 (Jääskeläinen et al., in preparation). Because no AOD data record at wavelength 550 nm (needed by SMAC) is available for the whole time range, the needed AOD is calculated from the TOMS and OMI Aerosol Index (AI) data, which cover almost the whole time range. The AOD time series has been constructed by studying the relation between AI and AOD (derived from OMI) in the years 2005-2008, during which period there is both AI and AOD at 550 nm (calculated from the OMI-AOD values at the UV wavelength range) available. The information on Sun zenith angle (SZA) is included in the conversion to increase accuracy.

OMI-AI can have both negative and positive values (non-absorbing or absorbing), but only the latter ones are used. For the regression function $AOD= \alpha \cdot AI \cdot cosSZA + \beta$ calculation the AI and AOD data are screened for clouds (using MODIS-AOD), and deseasonalized. Since SMAC cannot be applied to AOD values higher than unity, the regression is made only for AI and SZA values which correspond to the AOD values below 1.

While constructing the AOD time series, to achieve a larger global coverage, the AI data is not screened as much as for the regression. Even though the AI values can be measured for cloudy conditions, the screening for clouds was not implemented in the time series construction. This is because the cloudy pixels are excluded from the SAL calculation by the cloud mask. The AOD time series data is gathered into global daily maps. The possible gaps in these maps are filled by using weighted mean to the whole map. The AOD time series is not applied for sea ice, ice sheets or water. For these areas the constant value of 0.1 is still used. **Note: The original data record was extended to cover the year 2015 by calculating a climatology of the original data record for years 2005-2014. The reason for this was the observed degradation of the OMI instrument in 2015.**

3.4 Validation

The CLARA-A2-SAL data record has been validated prior to release against ground truth data from the Baseline Surface Radiation Network (BSRN), Greenland Climate Network (GC-Net), and the Arctic Research Center of FMI. The validation was performed at 8 sites worldwide, including Greenland and Antarctica. In addition, the CLARA-A2-SAL performance over sea ice was validated against Tara expedition albedo measurements from Arctic summer 2007. **Note: Year 2015 has not been validated, because the required in situ albedo data does not yet exist.**

The **target accuracy** for CLARA-A2-SAL is specified in the Climate-SAF Product Requirements Document (PRD) as **25% relative to the reference** [AD.1]. According to the results in [RD.3], **CLARA-A2-SAL meets the target accuracy at nearly all of the validation sites during the validation period 1992-2014**. The cases where the discrepancy between in situ and CLARA-A2-SAL observations is greater than the requirement typically result from poor comparability between the data owing to heterogeneous land cover around the validation site.

As examples of the achieved accuracy, we show here validation results from the BSRN site of Southern Great Plains (SGP) and the Greenland Climate Network site of Summit station. The SGP site provides the best background for validation of CLARA-A2-SAL, since it is one of the few vegetated validation sites where the land cover is homogeneous enough to

remove comparability issues between the observed CLARA-A2-SAL albedo values and the point-like in situ observation data. Summit is a good candidate for evaluating the snow albedo retrieval in CLARA-A2-SAL, since the site is in the central part of the Greenland Ice Sheet, its albedo is very stable during the summer months when retrievals are possible, and there is no vegetation to interfere with the snow albedo retrieval. For the comparison, only the SAL observations near the in situ observation station are used. The monthly and pentad means are formed using these spatially close observations that have a matching in situ measurement close in time.

Figure 3: CLARA-A2-SAL relative retrieval difference over SGP. Blue circles indicate retrieval differences at observed level; the black and red lines indicate the retrieval difference of the monthly and pentad means. Red dashed line shows 25% and the blue dashed line 10% relative difference levels.

Figure 3 shows the monthly and pentad albedo retrieval differences at SGP. Apart from a scattered snowfall events, the albedo at SGP remains quite stable. CLARA-A2-SAL tracks the mean in situ albedo well in monthly mean scale and also on pentad mean scales, although the occasional cloud misclassifications or snowfall events may cause larger differences. While the observed CLARA-A2-SAL albedo retrieval differences (blue circles) have a larger variability, the mean albedo is tracked correctly. The mean relative retrieval difference of the motnhly means at Southern Great planes over the 18-year validation period was -10.09 and the mean absolute difference was -2.14 % units.
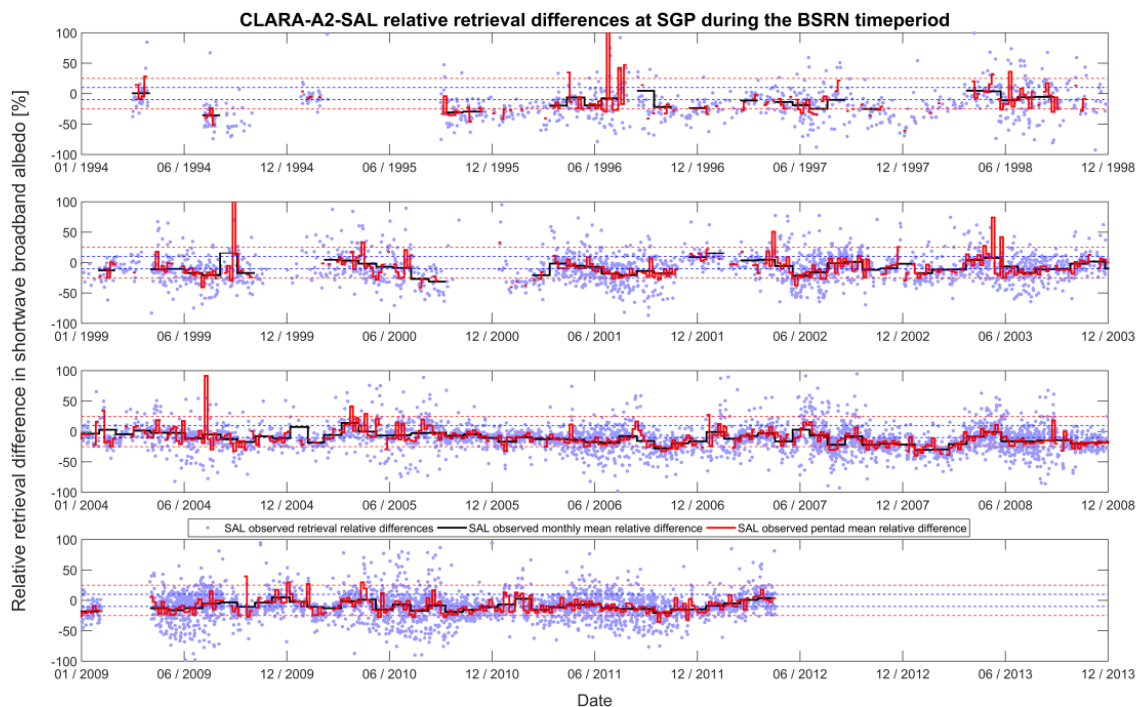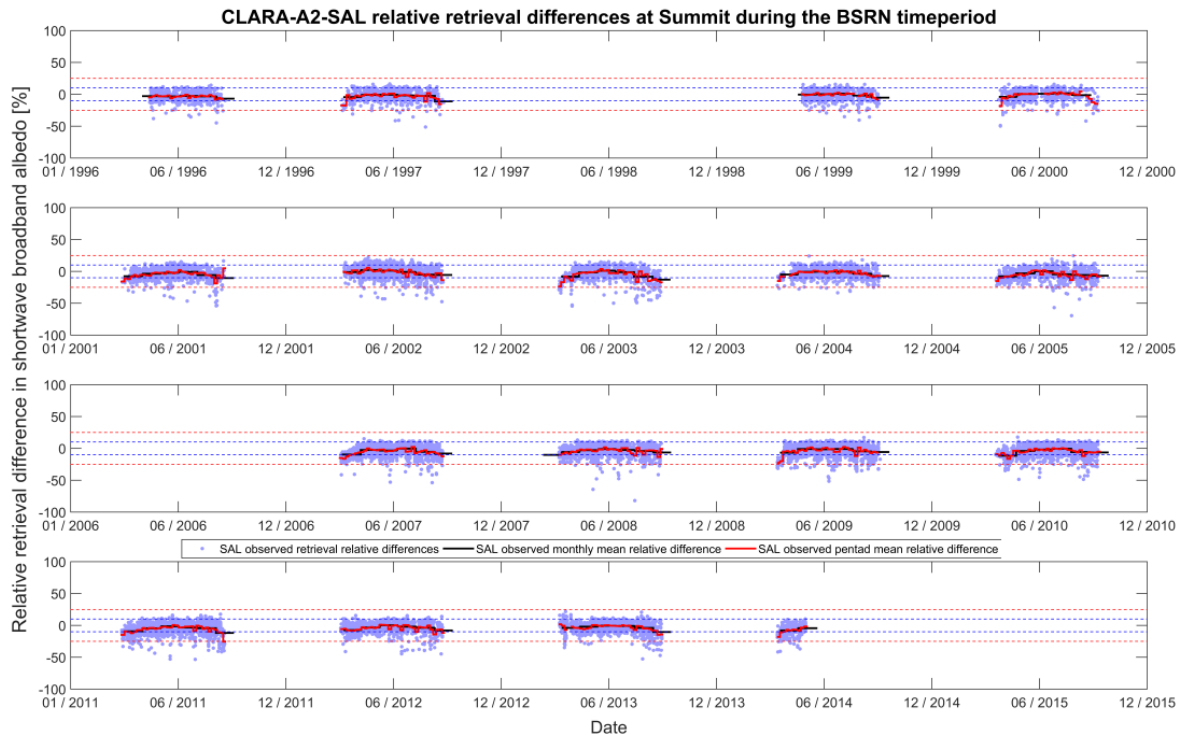
Figure 4: CLARA-A2-SAL relative retrieval difference over Summit station. Blue circles indicate retrieval differences at observed level; the black and red lines indicate the retrieval difference of the monthly and pentad mean. Red dashed line shows 25% and the blue dashed line 10% relative difference levels.

Figure 4 shows similarly the achieved retrieval accuracy at Summit station, Greenland. Both in situ and CLARA-A2-SAL albedo are stable over the 16 years of data that have been analyzed. Again, observed retrievals (which are in fact samples of the on-site bidirectional reflectance) show a range of variability around the mean, yet the mean albedo is stable. The mean relative retrieval difference for the motnhly means at Summit over the 16 analyzed years was -3.88 % and the mean absolute difference was -3.27 % units.

The CLARA-A2-SAL data record has also been compared to MODIS black-sky albedo mean products. Differences between the products are typically less than 5% in relative terms. Details of the study may be found in [RD.3].

GCOS requirements [RD.2] for black-sky surface albedo products are to have an accuracy of 5% and a stability of 1%, spatial resolution of 1 km and temporal resolution of 1 day to 1 week. Since CLARA-A2-SAL is produced using GAC data the requirement for the spatial resolution cannot be met. We are nevertheless working towards improving CLARA-A2-SAL accuracy further in the future data record editions.

3.5 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 observed 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 observed surface albedo. The end products are resistant to such effects because they are the result of averaging of observed 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 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 have produced a dynamic AOD timeseries from AI data for the purpose of atmospheric correction of satellite based surface products.

- 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 CLARA-A2-SAL, which is dependent on LUC data to choose a proper surface albedo subroutine. A known location where errors do occur is the ablation zone in West Greenland for Arctic SAL. There broken terrain, ice flows and progressing snow melt in summer seasons cause the LUC classification to be inaccurate, leading to major retrieval errors. Also, the algorithm does not yet properly delineate between desert areas and other barren terrain, leading to increased retrieval errors for desert. Since the CLARA-A2-SAL data record also covers 34 years in time, inaccuracies in the land use classifications are unavoidable. Their effect and source is also very difficult to localize in time or space, but are more likely to occur the longer the time from the observations used in the land use classification.

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3.6 Outlook

There will be a new edition of CLARA datatset in the next phase (CDOP-3) of CM SAF. Improvements for the next data record are currently being studied. The algorithm improvements will focus on the following areas:

1. Atmospheric correction. It is planned to futher improve the AOD data record used in the atmospheric correction accuracy. Furthermore, it is planned also to include non-static O3 content data from e.g. TOMS timeseries.

2. Land use classification/BRDF effects. An accurate and temporally variable LUC data record would minimize BRDF correction errors in CLARA-A2-SAL. Derivation of such a data record over the CLARA-A2-SAL coverage period is not a trivial task, but we are studying options to accomplish this.

3. It is planned to include data records on blue-sky and white-sky albedos as well as the black-sky albedo.

4 Data Description

CM SAF's climate monitoring CLARA A2 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 1.6 (http://cf-pcmdi.llnl.gov/) and NetCDF Attribute Convention for Data record Discovery version 1.3.

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).

4.1 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 CLARA-A2-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]
> *time_bnds* two-dimensional array defining the averaging/composite time period [days counted from 1970-01-01]
> *latitude* geographical latitude of pixel centre [degree_north]
> *longitude* geographical longitude of pixel centre [degree_east]

Each data file contains the following 2-dimensional variables:

> *sal* contains the CLARA A2-SAL product data [percent]
> *nobs_sal* contains the numbers of valid satellite observations for each pixel with valid SAL retrieval result [unitless]
> *sal_std* contains the standard deviation of the CLARA A2-SAL product per pixel [percent]
> *sal_median* contains the median of the CLARA A2-SAL product per pixel [percent]
> *sal_skewness* contains the skewness of the CLARA A2-SAL product per pixel [percent]
> *sal_kurtosis* contains the kurtosis of the CLARA A2-SAL product per pixel [percent]
> *SZA* contains the mean sun zenith angle of the CLARA A2-SAL product per pixel [degrees]; The SZA considers only pixels with valid SAL retrieval
> *SZA_std* contains the standard deviation of the sun zenith angle of the CLARA A2-SAL product per pixel [degrees]; The SZA_std considers only pixels with valid SAL retrieval

Table 1: CLARA-A2-SAL variables in a NetCDF file

Variable	Size	Type
time	1 x 1	double
time_bnds	2 x 1	double
latitude (lat)	720 x 1	single
longitude (lon)	1440 x 1	single
sal	1440 x 720 x 1	int32
sal_median	1440 x 720 x 1	int32
nobs_sal	1440 x 720 x 1	int32
sal_std	1440 x 720 x 1	int32
SZA	1440 x 720 x 1	int32

SZA_std	1440 x 720 x 1	int32
sal_skewness	1440 x 720 x 1	int32
sal_kurtosis	1440 x 720 x 1	int32

The products are available as monthly means and pentad means. Table 1 describes the global product, but the data is also available in equal area polar projection for both Arctic and Antarctic areas. In the polar products the lat/lon variable are given as a 2 dimensional array (321x321 for the Antarctic and 361x361 for the Arctic). The sal, sal_median, nobs_sal, sal_std variables are given in 361x361x1 grid for the Arctic product and 321x321x1 grid for the Antarctic product.

The data file also contains an array of global attributes for data documentation and improved usability purposes. These attributes are contained in each CLARA A2-SAL product, and are listed in Table 2.

Table 2: CLARA-A2-SAL product attributes

Name	Description
title	
summary	short description of the data
ID	DOI assigned to this data record
product version	2.0
creator_name	institution where the data was produced
creator_email	email contact information for the creator of the data
creator_url	URL contact information for the creator of the data
institution	The institution holding the rights to the data
project	project under which the data record was produced
references	references that describe the data or methods used to produce it
keywords_vocabulary	GCMD Science Keywords, Version 8.1
keywords	the keywords of the standard described in 'keywords_vocabulary' relevant to the data record
Conventions	conventions followed,
standard_name_vocabulary	Standard Name Table (v28, 07 January 2015
date_created	The date, when the level 3 file was created
geospatial_lat_units	latitude attributes unit [degree_north]
geospatial_lat_min	latitude bounding box minimum
geospatial_lat_max	latitude bounding box maximum
geospatial_lon_units	longitude attributes unit [degree_east]
geospatial_lon_min	longitude bounding box minimum
geospatial_lon_max	longitude bounding box maximum
geospatial_lat_resolution	latitude grid resolution
geospatial_lon_resolution	longitude grid resolution
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]
platform_vocabulary	GCMD Platforms, Version 8.1
platform	NOAA POES > NOAA Polar Orbiting Environmental Satellites
instrument_vocabulary	GCMD Instruments, Version 8.1
instrument	AVHRR>Advanced Very High Resolution Radiometer

CMSAF_platform_and_orbits	
CMSAF_L1_processor	intercalibration version applied
CMSAF_L2_processor	Versions of the L2 software used to generate the product [SAL and PPS software versions applied for CLARA-SAL generation]
CMSAF_L3_processor	Software version of the GAC averaging & reprojection software
date_modified	
date_metadata_modified	
history	

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

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
calender	definition of calender used
bounds	This attribute is only used for the time variable and defines the time range over which the product is defined. Bounds is connected to the variable time_bnds

5   Data ordering via the Web User Interface (WUI)

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

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

Copyright note:
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, EUMETSAT's copyright credit must be shown by displaying the words "copyright (year) EUMETSAT" on each of the products used

5.1 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.

5.2 Contact User Help Desk staff

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

5.3 Feedback/User Problem Report

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

5.4 Service Messages / log of changes

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

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Abbreviations

AOD	Aerosol Optical Depth
AVHRR	Advanced Very High Resolution Radiometer (NOAA)
BB	Broadband
BRDF	Bidirectional Reflectance Distribution Function
BSRN	Baseline Surface Radiation Network
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	Koninklij Nederlands Meteorologisch Instituut (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
CLARA-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