EUMETSAT Satellite Application Facility on Climate Monitoring

Product User Manual

SEVIRI cloud mask data set

CM-21012

DOI: 10.5676/EUM_SAF_CM/CMA_SEVIRI/V001

Reference Number:	SAF/CM/DWD/PUM/SEV/CLM
Issue/Revision Index:	1.1
Date:	13.09.2014

Document Signature Table

	Name	Function	Signature	Date
Author	Anke Kniffka Martin Stengel	CM SAF scientist CM SAF scientist		07/07/2014 13/09/2014
Editor	Rainer Hollmann	Science Coordinator		19/09/2014
Approval		CM SAF Steering Group		
Release	Martin Werscheck	Project Manager		

Distribution List

Internal Distribution	
Name	**No. Copies**
DWD Archive	1
CM SAF Team	1

External Distribution		
Company	**Name**	**No. Copies**
PUBLIC		1

Document Change Record

Issue/ Revision	Date	DCN No.	Changed Pages/Paragraphs
1.0	11/08/2014	SAF/CM/DWD/PUM/SEV/CLM	First official version submitted for DRR 2.17
1.1	13/09/2014	SAF/CM/DWD/PUM/SEV/CLM	Implementation of RIDs from DRR 2.17 (HR_02, HR_03, DF01, DF03, DF04, IT_CB_04, IT_CB_05, IT_CB_06, IT_CB_07, IT_CB_08, IT_CB_09, IT_CB_10, IT_CB_11, IT_CB_12)

Applicable documents

Reference	Title	Code
AD 1	CM SAF CDOP 2 Product Requirements Document	SAF/CM/DWD/PRD/2.4

Reference Documents

Reference	Title	Code
RD 1	Validation Report SEVIRI cloud mask data set	SAF/CM/DWD/VAL/SEV/CLM/1.1
RD 2	Product User Manual for “Cloud Products” (CMa-PGE01 v3.2, CT-PGE02 v2.2 & CTTH-PGE03 v2.2)	SAF/NWC/CDOP/MFL/SCI/PUM/01, Issue 3, Rev. 2
RD 3	Validation Report SEVIRI Cloud Products Edition 1 (CLAAS)	SAF/CM/DWD/VAL/SEV/CLD/1.2
RD 4	Algorithm Theoretical Basis Document SEVIRI Cloud products Edition 1	SAF/CM/DWD/ATBD/SEV/CLD/1.1
RD 5	Algorithm Theoretical Basis Document SAFNWC/MSG “Cloud mask, Cloud Type, Cloud Top Temperature, Pressure, Height”	SAF/NWC/CDOP/MFL/SCI/ATBD/01, Issue 3, Rev. 0
RD 1	SAF NWC / MSG Output Products Format Definition	SAF/NWC/CDOP/INM/SW/ICD/013, Issue 4

Table of Contents

List of Tables

List of Figures

1 Introduction

This CM SAF Product User Manual provides information on the 15 minutes Cloud Mask dataset derived from Spinning Enhanced Visible and InfraRed Imager (SEVIRI) observations onboard the EUMETSAT METEOSAT Second Generation (MSG) satellites. The covered time period ranges from 2004 to 2012, thus includes MSG 1 and MSG 2, for which the transition took place in April 2007.

This manual briefly describes the Cloud Mask data set including application examples and an overview about the validation. A technical description of the data set including information on the file format and on the data access is provided. The cloud mask algorithm msgv2012 is provided by NWC SAF (SAF to support to Nowcasting and Very Short Range Forecasting). Hence, details on the cloud mask itself can be found in the respective product user manual [RD 2]. Further information on the implementation of the retrieval processing chain, and individual algorithm descriptions are available in the algorithm theoretical basis document [RD 4]. Basic accuracy requirements are defined in the product requirements document [AD 1]. A detailed validation of the SEVIRI based cloud mask parameters is available in the validation report [RD 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 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. CM SAF also assists other SAFs in producing SAF-specific geophysical variables via the delivery of ECV time series. 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 support 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 (World Climate Research Program). 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.

3 Compilation of the Cloud Mask dataset

The Cloud Mask data set is based on 9 years of SEVIRI measurements. SEVIRI is a passive visible and infrared imager mounted on the Meteosat Second Generation satellites (MSG) 1 and 2. MSG 1 and MSG 2 are geostationary satellites which, by their rotation, support an SEVIRI imaging repeat cycle of 15 minutes. SEVIRI itself is an optical imaging radiometer with 12 spectral channels ranging from the visible (approx. 0.6 µm) to the infrared of about 13.4 µm. The respective MSGs in operational mode are centred near 0°/0° latitude/longitude, where a full earth disk image includes Europe, Africa, the Middle East and the Atlantic Ocean.

For this CM SAF cloud mask dataset the original 15 minutes resolution was used to enable research with the highest possible temporal resolution. The horizontal resolution of a SEVIRI image is 3 x 3 km² at nadir. The dataset covers the time-span 2004-2012, where MSG 1 measurements were processed from 01/2004 – 04/2007 and MSG 2 from 04/2007 – 12/2012. Gaps of more than 24 hours in the MSG 2 time-series were filled with MSG 1 measurements (Figure 3-1).

For the derivation of the CM SAF cloud mask data set the Level 1.5 SEVIRI data provided by EUMETSAT have been used. Level 1.5 data are an extension of Level 1 data which are image data that were directly transferred to the EUMETSAT's ground segment. i.e. raw data before any modification has taken place. The Level 1.5 data record comprises image data that has already undergone certain modifications by the EUMETSAT ground segment. All images have been corrected for all unwanted radiometric and geometric effects, have been geolocated using a standardised projection, and have been calibrated and radiance-linearised.

Due to the introduction of a new radiance definition by EUMETSAT on 5.5.2008, reprocessed Level 1.5 data prior this date (EUM base algorithm version 0201) have been used, while the near real time (EUM base algorithm version 0100) have been used afterwards to ensure homogeneity of the time series.

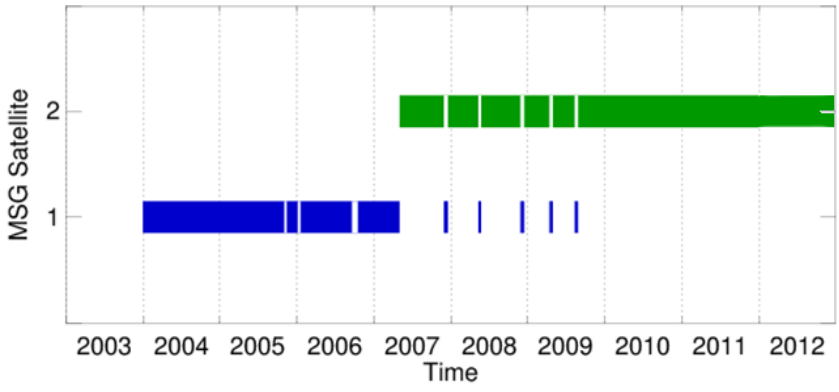

Figure 3-1: Overview of SEVIRI measurements record at CM SAF used as basis for cloud products. Short-term data gaps are shown enlarged due to better visibility.

The Level 1.5 radiance data record was processed with the MSG v2012 software package by the NWC SAF used to derive cloud fraction and cloud top properties (Derrien and Le Gléau, 2005). The time-series of SEVIRI reflectances were carefully

calibrated against MODIS, which improves especially the retrieval of microphysical parameters but also the cloud mask. For the two satellites static coefficients were derived, but no temporal dependence was included. Bhatt *et al*. (2010) found SEVIRI to be stable over time with a degradation of 5 – 8 ‰ over 3 years. With the calibration also homogenisation was performed because the same MODIS instrument was used for both, MSG 1 and MSG 2. The IR radiances of SEVIRI were left unchanged, relying on the on-board black-body calibration as the radiances definition as provided by EUMETSAT.

For a more detailed instrument specification and description of the calibration the reader is referred to the SEVIRI Cloud Products Algorithm Theoretical Baseline Document [RD 4].

4 Product definitions

The 15 minutes cloud data set from SEVIRI provides one parameter, the cloud mask which is introduced in Table 4-1 with associated acronym and unit.

The cloud mask can be accessed on Level 2 basis, which is the native SEVIRI pixel size (3 x 3 km² at sub-satellite point) and native temporal resolution. For this data set no averaging has been performed.

Table 4-1: The product suite of the CM SAF SEVIRI cloud mask data set.

Product identifier	Acronym	Product title	Unit
CM-21012	CMa	Cloud Mask.	*dimensionless*

The temporal coverage of the data set ranges from January 2004 to December 2012.

For each CM SAF cloud parameter, also various metadata and information about selected statistical parameter distributions in each grid point is available in addition to the main product content described above. Details on how to access this information is given in Section 6.

A complete description of the retrieval methods for the cloud mask is given in the Algorithm Theoretical Basis Documents [RD 4, RD 5]. The general methods for SEVIRI calibration and calculation of Level 3 products are described in [RD 4].

In the following section 4.1, the cloud mask is shortly described regarding retrieval methods, information content and limitations. Section 4.1.2 summarizes the obtained validation results. A summary of all validation results can also be found at the end of this document. More details on achieved validation results are given (e.g., more detailed information on accuracy and precision studies) in [RD 1]. At the end of the product description a short statement on recommended applications areas is also given.

4.1 Description of Cloud Mask

4.1.1 Overview of retrieval

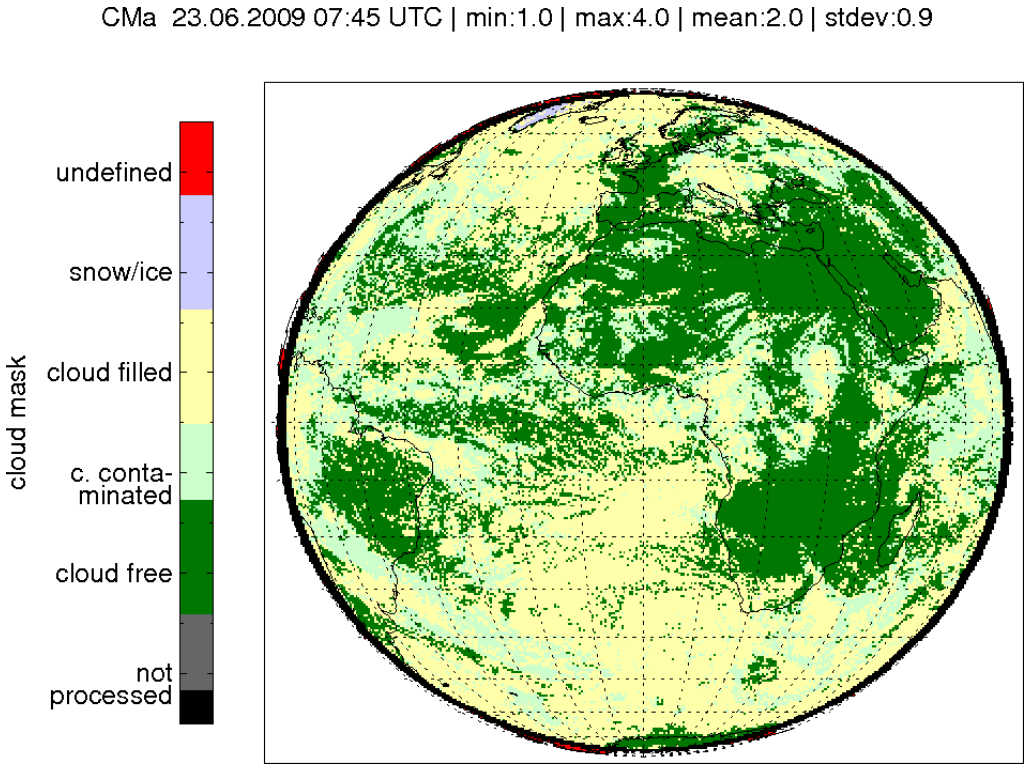

Figure 4-1: Cloud mask as seen by SEVIRI, 23.06.2009 at 7:45 UTC, not processed pixel are coloured in black.

This product is derived directly from results of a cloud screening or cloud masking method. The cloud mask (Level 2) comprises 6 categories: Cloud filled, cloud-free, cloud contaminated and non-processed, snow/ice contaminated, undefined. An example, here the cloud mask of 23. June 2009, 7:45 UTC, is shown in Figure 4-1.

Short Algorithm description

The cloud screening and cloud masking is performed using the NWC SAF MSG v2012 algorithm, which is described in more detail in [RD]. See http://NWCSAF.org for details on the NWC-SAF project. The algorithm is based on a multi-spectral thresholding technique applied to every pixel of the satellite scene (Derrien and Le Gléeau, 2005 and 2010). Several threshold tests may be applied and must be passed before a pixel is assigned to be cloudy or cloud-free.

Thresholds are determined from present viewing and illumination conditions and from the current atmospheric state (prescribed by data assimilation products from numerical weather prediction models – here, the ERA-Interim dataset, see Dee et al, 2011, http://www.ecmwf.int/research/era/do/get/era-interim). On the influence of the numerical weather prediction data on the cloud mask see Fuchs *et al.* (2012) and Trolez *et al.* (2008).

The six cloud categories that result from the screening procedure are defined as described in the product user manual of NWC SAF [RD 2] and given here for convenience:

The main product output consists in the following six categories coded on 3 bits as given in Table 4-2.

Table 4-2: Cloud_mask coding in 3 bits.

Bit	Category	Description
0	Non-processed	containing no data or corrupted data
1	Cloud-free	no contamination by snow/ice covered surface, no contamination by clouds but contamination by thin dust/volcanic clouds not checked
2	Cloud contaminated	partly cloudy or semitransparent. May also include dust clouds or volcanic plumes.
3	Cloud filled	opaque clouds completely filling the FOV. May also include thick dust clouds or volcanic plumes.
4	Snow/Ice contaminated	
5	Undefined	has been processed but not classified due to known separability problems

16 bits to describe which test was successful

For each cloudy pixel, the bits corresponding to the successful tests are activated. More than one bit may be activated, if tests were not really successful (measurement too close to thresholds)). Table 4-3 lists the bits for the successful tests.

Table 4-3: Bit coding for successful tests.

Bit	Successful test
0	T10.8µm or SST
1	R0.6µm (land) or R0.8µm (sea)
2	Sunglint test using 3.9µm
3	Local Spatial Texture
4	T10.8 µm - T12.0µm
5	T10.8 µm - T3.9µm or T12.0µm - T3.9µm
6	T3.9 µm - T10.8µm
7	Spatial smoothing (reclassify isolated cloud-free pixels)
8	T8.7 µm - T3.9µm
9	R1.6 µm (sea)
10	T8.7 µm –T10.8µm or T10.8µm –T8.7µm
11	Snow using R1.6µm or T3.9µm
12	HRV-based test
13	Stationary cloud in twilight
14	Spatial expansion of stationary cloud in twilight
15	Temporal-differencing

Quality bits

11 bits are defined for quality information on pixel level as defined in Table 4-4.

Table 4-4: Definition of quality bits.

3 bits to define illumination and viewing conditions	
0	Undefined (space)
1	Night
2	Twilight
3	Day
4	Sunglint
2 bits to describe NWP input data	
0	Undefined (space)
1	All NWP parameters available (no low level inversion)
2	All NWP parameters available (low level inversion)
3	At least one NWP parameter missing
2 bits to describe SEVIRI input data	
0	Undefined (space)
1	All useful SEVIRI channels available
2	At least one useful SEVIRI channel missing
3	At least one mandatory SEVIRI channel missing
2 bits to describe the quality of the processing itself:	
0	Non processed (containing no data or corrupted data)
1	Good quality (high confidence)
2	Poor quality (low confidence)
3	Reclassified after spatial smoothing (very low confidence)
1 bit for temporal processing indicator (significant for cloud-free pixels)	
0	Not performed
1	Performed
1 bit for HRV processing indicator (significant for cloud-free pixels)	
0	Not performed
1	performed

Dust detection

2 bits are defined for dust detection as given in Table 4-5.

Table 4-5: Definition of dust detection bits.

Bit setting	Description
0	Non processed (containing no data or corrupted data)
1	Dust
2	non dust
3	undefined (due to known separability problems)

Volcanic Plume detection

2 bits are defined for volcanic plume detection as detailed in Table 4-6.

Table 4-6: Definition of Volcanic plume detection bits.

Bit Setting	Description
0	Non processed (containing no data or corrupted data)
1	volcanic plume
2	non volcanic plume
3	undefined (due to known separability problems)

The NWC SAF cloud retrieval software msgv2012 was run with settings common to all PGE's (see Table 4-7) and specific settings for PGE01 (Table 4-9) and PGE02 (Table 4-10). Results from PGE02 are needed for the temporal correction of cloud mask. The list of NWP-fields from ERA interim reanalysis is given in Table 4-8.

Table 4-7: Common settings for NWC SAF msgv2012 used in all PGE's.

Parameter	Setting	Intent
REGION	MSGdisc	MSG region processed, here complete disc
REGION_CENTRE_P	1857, 1857	Centre of the processing region relative to complete disc
REGION_SIZE	3712, 3712	In number of pixels
AV_PRESSURE_LEVELS	1000,950,925,900,850,700,500, 400,300,250,200,150,100,70,50, 30,10	Available pressure levels from NWP data

Table 4-8: List of used ERA Interim fields used in processing.

PGE	ERA Interim fields
PGE01	surface temperatures total water vapour content surface geopotential on the NWP model grid air temperature at 950hPa
PGE02	surface temperature air temperature at 950hPa, 850hPa, 700hPa, 500hPa and at tropopause level total water vapour content of the atmosphere surface geopotential of the NWP model grid

Table 4-9: Settings used for NWC SAF msgv2012 for PGE01 (cloud mask).

Parameter	Setting	Intent
NWP_PARAM01	NWP_ST NWP_ST_TYPE NWP_ST_LEVEL 4 BILIN_MASKED	Interpolation method surface temperature with segment size
NWP_PARAM02	NWP_PT NWP_PT_TYPE 950 4 BILIN	Interpolation method pressure at level 950 hPa with segment size
NWP_PARAM03	NWP_PT NWP_PT_TYPE 925 4 BILIN	Interpolation method pressure at level 925 hPa with segment size
NWP_PARAM04	NWP_TCWV NWP_TCWV_TYPE NWP_TCWV_LEVEL 4 MAX	Interpolation method total column water vapour with segment size
NWP_PARAM05	NWP_ALTM NWP_ALTM_TYPE NWP_ALTM_LEVEL 4 BILIN	Interpolation method altitude with segment size
NWP_PARAM06	NWP_SGEOP NWP_SGEOP_TYPE NWP_SGEOP_LEVEL 4 BILIN	Interpolation method geopotential with segment size
SEV_BANDS	HRVIS, VIS06, VIS08, IR16, IR39, WV73, IR87, IR108, IR120, IR134	SEVIRI channels used
CMA_SZSEG	4	Segment size, # of SEVIRI pixels to which NWP data are mapped
HRV_NEED	FALSE	Use of HRV-channel
TEMPORAL_USE	TRUE	Use of temporal correction (twilight + fast moving clouds)

Table 4-10: Settings used for NWC SAF msgv2012 for PGE02 (cloud type).

Parameter	Setting	Intent
SEV_BANDS	HRVIS, VIS06, IR16, IR39, WV73, IR87, IR108, IR120, IR134	SEVIRI channels used
CT_SZSEG	4	Segment size, # of SEVIRI pixels to which NWP data are mapped
HRV_NEED	FALSE	Use of HRV-channel
PHASE_COMPUTATION	TRUE	Computation of cloud phase flag
CT_PHASE_SZSEG	8	Segment size for cloud phase flag
NWP_PARAM01	NWP_ST NWP_ST_TYPE NWP_ST_LEVEL 4 BILIN_MASKED	Interpolation method surface temperature with segment size
NWP_PARAM02	NWP_PT NWP_PT_TYPE 950 4 BILIN	Interpolation method pressure at level 950 hPa with segment size
NWP_PARAM03	NWP_PT NWP_PT_TYPE 925 4 BILIN	Interpolation method pressure at level 925 hPa with segment size
NWP_PARAM04	NWP_PT NWP_PT_TYPE 850 4 BILIN	Interpolation method pressure at level 850 hPa with segment size
NWP_PARAM05	NWP_PT NWP_PT_TYPE 700 4 BILIN	Interpolation method pressure at level 700 hPa with segment size
NWP_PARAM06	NWP_PT NWP_PT_TYPE 500 4 BILIN	Interpolation method pressure at level 500 hPa with segment size
NWP_PARAM07	NWP_TT NWP_TT_TYPE NWP_TT_LEVEL 4 BILIN	Interpolation method tropopause temperature with segment size
NWP_PARAM08	NWP_TCWV NWP_TCWV_TYPE NWP_TCWV_LEVEL 4 MAX	Interpolation method total column water vapour with segment size
NWP_PARAM09	NWP_ALTM NWP_ALTM_TYPE NWP_ALTM_LEVEL 4 BILIN	Interpolation method altitude with segment size
NWP_PARAM10	NWP_SGEOP NWP_SGEOP_TYPE NWP_SGEOP_LEVEL 4 BILIN	Interpolation method geopotential with segment size

Highlights of the cloud mask retrieval

- Cloud screening is based on information from SEVIRI channels R0.6µm, R0.8µm, R1.6µm, T3.9µm, T8.7µm, T10.8µm, T12.0µm, T13.4µm
- The cloud masking algorithm delineates all cloud-free pixels in a satellite scene with a high confidence, see [RD 4].
- Different tests are applied, where it is distinguished between land or sea pixels, subsequently the solar illumination (daytime, night-time, twilight, sunglint) and the viewing angles are criteria for the application of a certain test.
- Daytime conditions with good illumination (i.e., conditions enabling access to information in all spectral channels) provide best cloud screening results
- Transition between day- and night-time is smoothed with the temporal dependence twilight test (Derrien and Le Gléau, 2010)
- The fast moving clouds are represented more accurately due to the 15 minutes temporal dependence test (Derrien and Le Gléau, 2010)

Limitations

- Not all clouds will be detected due to inherent limitations of the SEVIRI imager as being a passive radiometer with a rather coarse field of view (here 3 x 3 km² at sub-satellite point). This can be compared to actively probing instruments (like cloud lidars and radars) with a much higher cloud detection sensitivity. Better agreement between Calipso and SEVIRI was found when clouds with an optical depth smaller than 0.3 were removed from the Calipso dataset.
- Some thin clouds (particularly, ice clouds) over cold ground surfaces may remain undetected even if having cloud optical thicknesses higher than the above mentioned detection limit
- The cloud detection algorithm changes from VIS/IR to an infrared only version at the transition from day to night. Even though the SAF NWC msgv2012 package is applied using a special twilight transition procedure, the switch from day- to night-time algorithm remains present. Irregularities can occur as spikes in the diurnal cycle.
- Since SEVIRIs are mounted on geostationary satellites, a distinct dependency on viewing zenith angle occurs that leads to an overestimating of cloudiness at high VZA.
- An underestimation for small VZA is found for CLAAS (CM SAF cLoud property dAtAset using SEVIRI, Stengel *et al*., 2014) by comparing with SYNOP and MODIS which also applies to this dataset

More details on the product retrieval are given in [RD 4] and [RD 5].

4.1.2 Validation of the CM SAF cloud mask data set

The cloud mask was validated in detail with independent satellite measurements from CALIPSO and CloudSat from the A-train, see [RD 1] for a complete analysis. The results can be summed up as follows. The cloud mask was compared with A-train measurements acquired with active sensors, the cloud profiling radar CPR and the lidar CALIOP. The probability of detecting a cloud was found to be 0.91 for CPR

and 0.94 in case of CALIOP, when clouds with an optical depth smaller than 0.3 were removed from the CALIOP data, the probability of detection increased to 0.96. The figures are based on the complete SEVIRI field of view, which also includes the pixel towards the rims of the disc that are due to the viewing geometry more erroneous than the centre pixel. An investigation of the viewing angle dependency can be found in the validation report of the dataset CLAAS, which also applies to the present dataset, see [RD 3].
The cloud mask fulfils threshold and target requirements (probability of detection is 0.902 or 0.946 respectively see [RD 1]) in all cases.
From the SYNOP data which are considered to be stable over time, it was demonstrated that no artificial trends occur when changing from MSG 1 to MSG 2.
Since SEVIRI is mounted on geostationary satellites, a distinct dependency on viewing zenith angle (VZA) occurs that leads to an overestimating of cloudiness at high VZA.
Information on the achieved accuracy and precision of the product is found in the CM SAF SEVIRI cloud mask validation report [RD 1].

4.1.3 Recommended applications

The product can be used everywhere except at the rims of the disk, Cloud mask values at viewing zenith angles larger than 75° become unreliable. This can be decided by users themselves with the help of the validation report [RD 3].

Possible applications of the cloud mask dataset are all those which require a multi annual, stable and spatiotemporally highly resolved cloud mask. Tracking of convective cloud systems like thunderstorm fields (Goyens *et al*., 2011) or monitoring convective initiation in middle Europe (Siewert *et al*., 2010) shall serve as an example here.

5 Outlook

The present cloud mask dataset is the first processing of the cloud mask SEVIRI time-series from 2004 – 2012 by CM SAF in full temporal and spatial resolution. Prior to this, a processing of the time-series in hourly resolution but with a complete set of cloud properties including cloud fractional cover, cloud-top parameters as well as optical properties was compiled to form the dataset CLAAS (Stengel *et al.*, 2014). In CDOP 2 (the current phase of the CM SAF project) a new edition of the SEVIRI data set CLAAS will be processed. The experience gained while creating and evaluating the first edition of CLAAS and the present temporally full resolved cloud mask dataset will be incorporated into the next version of CLAAS.

Some new features will be:

- The applied algorithms will be updated after a careful testing of performance and quality
- The possibility of including error characteristics of the processed variables will be explored

- The temporal resolution of the next dataset will be increased to 15 minutes, so the full dataset of SEVIRI will be utilized. This will further improve the accuracy of the diurnal cycle of the processed variables. Especially in case of CFC, fast moving clouds will be visible which also enables to use the NWC SAF cloud masking algorithm to its full capacity
- The length of the dataset will be increased
- A new temporally variable version of the VIS/NIR calibration will be applied, also an infrared calibration will be explored and eventually integrated

.

The Calypso and CloudSat datasets were found to deliver most valuable information for the analysis of the cloud mask. In the future this allows us to analyze extremely high resolved features and helps for example in the assessment of cloud top pressure and NWP profiles.

6 Data format description

Level 2 data are stored in hdf5-Format. Each hdf5 file has a predetermined structure and is composed of attributes, variables and nested structures. While the content of the cloud mask file is briefly described in the following to provide the user with an overview, a complete description of the data fields in the cloud mask product can be found in [RD 1].

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).

6.1 General attributes

On the main level, a cloud mask hdf5 file possesses general attributes that are valid for all variables contained in this file. These general attributes are described in Table 6-1.

Table 6-1: General attributes of a hdf5 cloud mask file.

Name	Description
Product_algorithm_version	Version of the Algorithm
Nominal_product_time	Date of creation of product
Image_aquisition_time	Date and time of measurement
Product_name	Name of the atmospheric variable
Gp_sc_id	Satellite identification number, 322=MSG2
projection	Geographic projection
NC	Number of columns
NL	Number of lines
Sgs_product_quality	General product reliability
Sgs_product_completeness	Number of successfully processed pixel relative to possible pixel
GEOTRANSFORM_GDAL_TABLE	6 coefficients for the gdal georeferencing
XGEO_LOW_RIGHT_	Lower right corner of gdal georeference, x value
XGEO_UP_LEFT	Top left corner x value
YGEO_LOW_RIGHT	Lower right corner of gdal georeference, y value
YGEO_UP_LEFT	Top left corner y value

6.2 Data fields

The variables contained in each cloud mask file are listed and described in Table 6-2. Please note that apart from the variables themselves also colour tables (called ‘palettes’) are provided to facilitate the graphical presentation.

Table 6-2: Data fields contained in a cloud mask file.

Name	Description
CMa	Cloud Mask
CMa_DUST	Dust Mask
CMa_QUALITY	Quality flag of the cloud mask
CMa_TEST	Describes which test was used and successful
CMa_VOLCANIC	Volcanic plume mask
01-palette	Additional colour table cloud mask
02-palette	Additional colour table dust flag
03-palette	Additional colour table volcanic ash flag

6.3 . Attributes

All data fields possess general attributes as well, which are listed and described in Table 6-3. Again, note that apart from the variables reference to colour tables (called ‘palettes’) are provided to facilitate the graphical presentation.

The absolute value of the respective variable y is composed of the value in the data field x together with gain and intercept:

$$Y = \text{gain} * x + \text{intercept}$$

Table 6-3: Attributes of each variable in a cloud mask hdf5 file. An example for the data field ‘CMa’ is shown.

Name	Description
N_COLS	Number of columns
N_LINES	Number of lines
Palette	Reference to the colour table, see Table 6-2
Product	Product name, such as CMa
Scaling factor	gain
Offset	intercept

7 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. The user is referred 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.

7.1 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.

7.2 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 (http://www.cmsaf.eu) or the main page of the Web User Interface.

7.3 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 7.2) 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.

7.4 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.

8 Copyright and Disclaimer

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

Copyright

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

Acknowledgement and Identification

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

Re-distribution of CM SAF data

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

Feedback

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

9 References

Bhatt, R., D. R. Doelling, D. Morstad, and A. Gopalan: 2010: The CERES geostationary calibration methodology with emphasis on the desert calibration, AMS 13th Conference on Atmospheric Radiation, Portland, OR, USA.

Dee et al. (35 named authors), 2011: The ERA-Interim reanalysis: configuration and performance of the data assimilation system, Quart. J. Royal Met. Soc., **137** (656), 553 - 597. Online version: http://onlinelibrary.wiley.com/doi/10.1002/qj.828/abstract.

Derrien, M. and H. Le Gléau, 2005, MSG/SEVIRI cloud mask and type from SAFNWC, International Journal of Remote Sensing, **26**, No. 21, 4707–4732.

Derrien, M. and H. Le Gléau, 2010: Improvement of cloud detection near sunrise and sunset by temporal differencing and region-growing techniques with real-time SEVIRI, International Journal of Remote Sensing, **31**, No. 7, 1765-1780.

Fuchs, P., 2012: Satellite Application Facility on Climate Monitoring Evaluation Report Change of NWP Input – SEVIRI, SAF/CM/DWD/ER/SEVIRI/1.

Goyens, C., D. Lauwaet, M. Schröder, M. Demuzere, N. van Lipzig, 2011: Tracking Mesoscale Convective Systems in the Sahel: relation between cloud parameters and precipitation, Int. J. Clim., doi: 10.1002/joc.2407.

Trolez, M., K.-G. Karlsson, S. Johnston and P. Albert, 2008: The impact of varying NWP background information on CM-SAF cloud products, CM SAF Visiting Scientist Report, SMHI Reports Meteorology, 128, 41 pp.

Siewert, C. W., M. Koenig and J. R. Mecikalski, 2010: Application of Meteosat second generation data towards improving the nowcasting of convective initiation, Meteorol. Applications, **17**, 442-451, DOI: 10.1002/met.176

Stengel, M., Kniffka, A., Meirink, J. F., Lockhoff, M., Tan, J., and Hollmann, R., 2013: CLAAS: the CM SAF cloud property dataset using SEVIRI, Atm. Chem. Phys., 14 /8 , 4297-4311, 2014.

10 Glossary

ATBD	Algorithm Theoretical Baseline Document
AVHRR	Advanced Very High Resolution Radiometer
CALIPSO	Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations
CALIOP	Cloud-Aerosol Lidar with Orthogonal Polarisation
CDO	Climate Data Operators
CDOP	Continuous Development and Operations Phase
CFC	Fractional Cloud Cover
CLAAS	CM SAF CLoud property dAtaset Using SEVIRI
CM SAF	Satellite Application Facility on Climate Monitoring
CPR	Cloud Profiling Radar
DRI	Delivery Readiness Inspection
DWD	Deutscher Wetterdienst (German MetService)
ECMWF	European Centre for Medium Range Forecast
ECV	Essential Climate Variable
ERA-Interim	Second ECMWF Re-Analysis dataset
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
FCDR	Fundamental Climate Data Record
GCOS	Global Climate Observing System
MODIS	Moderate Resolution Imaging Spectroradiometer
MSG	Meteosat Second Generation
KNMI	Koninklijk Nederlands Meteorologisch Institut
NWC SAF	SAF on Nowcasting and Very Short Range Forecasting
NWP	Numerical Weather Prediction
POD	Probability of Detection
PRD	Product Requirement Document
PUM	Product User Manual
SEVIRI	Spinning Enhanced Visible and InfraRed Imager
SAF	Satellite Application Facility
SMHI	Swedish Meteorological and Hydrological Institute
SYNOP	Synoptic observations

11 Summary table of validation results regarding product accuracy

Table 11-1 shows the achieved accuracies of the cloud products as discussed in [RD 1]. The acronyms used are: CALIPSO = Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation, CPR = Cloud Profiling Radar, the reference data base is described in detail in [RD 1].

Table 11-1: Summary table of validation results as given in [RD 1]. The entire SEVIRI field of view was basis for the validation.

Product	**Precision requirement** (POD)	**Achieved precisions**
Cloud Mask (CMa)	0.90	0.946 ± 0.008 CALIOP 0.902 ± 0.011 CPR