EUMETSAT

OSI SAF

OCEAN AND SEA ICE

Product User Manual for the Geostationary Satellites Radiative Fluxes

GOES-East	OSI-305-b	OSI-306-b
Meteosat 0°	OSI-303-a	OSI-304-a
Meteosat-8	OSI-IO-DLI	OSI-IO-SSI

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Document Change record

Document version	Software version	Date	Author	Change description
1.0		10/04/2011		First version.
1.1		14/06/2011		Updated version with Appendix A.4: ncdump of a METEOSAT-9 hourly flux
1.2		28/11/2011		Appendix A.2. and A.3. updated
1.3		15/04/2013		4.5 updated
1.4		16/08/2016		Timeliness correction
1.5	a1.0p1.0	13/07/2017		Addition of the demo products : METEOSAT over Indian Ocean DLI and SSI Addition of information on output formats : GRIB (planned to be stopped at the end of 2017), switch from NetCDF3 to NetCDF4.
1.6	a1.0p1.0	13/12/2017		From 14/12/2017, GOES-16 (new generation) replaces GOES-13 : OSI-305 becomes OSI-305-a OSI-306 becomes OSI-306-a From 14/12/2017, GRIB and NetCDF3 are discontinued. NetCDF4 is the only format available.
1.7	a1.0p1.0	08/02/2018	CH	From 20/02/2018, Meteosat-11 (also Meteosat Second Generation) replaces Meteosat-10: OSI-303 becomes OSI-303-a, OSI-304 becomes OSI-304-a
1.8	a1.0p1.1	26/02/2018	CH	Tuning of coefficient: 0.94 is now applied to the calibrated visible channel (ABI channel 2), which is the main input of the Surface Solar Irradiance (SSI). This factor has been estimated mainly from the comparison between GOES-16 and Meteosat-10 SSI over the area common to both satellites. The tuned algorithm is used since hourly file dated 20180226T10:00:00Z and daily file dated 20180227T12:00:00Z
2.0		31/10/2019	AM	Major change. Algorithms and processing method are now described in [RD.1], they are summarized in section 2 of the document. Sections 1, 3, 4 have been re-written for consistency with other OSI SAF documents.

Table of contents

1. Introduction

The EUMETSAT Satellite Application Facilities (SAFs) are dedicated centres of excellence for processing satellite data. They form an integral part of the distributed EUMETSAT Application Ground Segment. The Ocean and Sea Ice SAF, led by Météo-France/Centre de Météorologie Spatiale (M-F/CMS), has the responsibility of developing, validating and distributing products of near real time products of Sea Surface Temperature (SST), radiative fluxes, wind and Sea Ice parameters for a variety of platorms/sensors. More information can be found at http://www.osi-saf.org.

As part of the Third Continuous Development and Operations Phase (CDOP-3) OSI SAF (more specifically M-F/CMS) has committed to provide user community with operational product of Sea Surface Temperature (SST) and Radiative Fluxes from the American Geostationary Operational Environment Satellite (GOES) in East position and the Meteosat Second Generation (MSG) in position 0°. OSI SAF is also providing SST and radiative fluxes for MSG Indian Ocean on a best effort basis. Currently OSI SAF is processing data from:

- GOES-16 which was launch on the 19th of November 2017 and was declared operational in East position (75.2 W) on the 18th of December 2017.
- Metosat-11 which was launched on the 15th of July 2015 and operationally replaced Meteosat-10 on the 20th of February 2018.
- Meteosat-8 which was relocated to the position 41.5 E on the 15th of September 2016.

1.1. Purpose and scope of the document

The present document describes the radiative fluxes products derived from geostationary satellites. A brief overview of the processing is given in section 2 and a description of the products characteristics is given in section 3.

This document is completed by the Algorithm Theoretical Basis Document [RD.1], which describes the algorithms and the processing scheme in more details.

1.2. Reference documents

[RD.1] Algorithm Theoretical Basis Document for the Geostationary Satellite Radiative Fluxes Version 1.0, 6 May 2019, SAF/OSI/CDOP3/MF/SCI/MA/343

[RD.2] METEOSAT and GOES-E Radiative fluxes validation report SAF/OSI/CDOP/M-F/TEC/MA/184. Version 1.2, June 2011

[RD.3] Radiative fluxes over Indian Ocean from METEOSAT-8 data, validation report SAF/OSI/CDOP3/MF/SCI/RP/305. Version 1.0, 3 July 2017

[RD.4] Radiative Fluxes Validation Report – OSI-305a / OSI-306a / OSI-303 / OSI-304 / OSI-IO-DL I/ OSI-IO-SSI. SAF/OSI/CDOP3/MF/SCI/RP/328. Version 1.0, 6 November 2018.

[RD.5] Geostationary Satellite Radiative fluxes Scientific Validation Report. OSI-305b / OSI-306b / OSI-303 / OSI-304 / OSI-IO-DL I/ OSI-IO-SSI. Version 0.1, 31 October 2019

1.3. Applicable documents

[AD.1] OSI SAF, Product Requirements Document, version 1.4, 20/12/2019 SAF/OSI/CDOP3/MF/MGT/PL/2-001

[AD.2] Service Specification (SeSp) SAF/OSI/CDOP3/MF/MGT/PL/003, Version 1.2, 20/11/2017

1.4. Acronyms and definitions

The Surface Solar Irradiance (SSI) is the solar irradiance reaching the Earth surface in the 0.3-4 μm band. The Downward Longwave Irradiance (DLI) is the irradiance reaching the Earth surface in the 4-100 μm band. The irradiance is the radiant energy received per unit time and per unit area, it is expressed in Wm^{-2}.

ABI	Advanced Baseline Imager
CMS	Centre de Météorologie Spatiale
DLI	Downward Longwave Irradiance
ECMWF	European Center for Medium range Weather Forecast
GOES	Geostationary Operational Environmental Satellite
MSG	Meteosat Second Generation
NWP	Numerical Weather Prediction
NWC SAF	Nowcasting and very short range forecasting SAF
OSI SAF	Ocean and Sea Ice SAF
SAF	Satellite Application Facility
SEVIRI	Spinning Enhanced Visible and Infrared Imager
SSI	Surface Solar Irradiance
SST	Sea Surface Temperature
TOA	Top of atmosphere
UT	Universal Time

1.5. Disclaimer

All intellectual property rights of the OSI 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 © <YYYY> EUMETSAT" on each of the products used.

1.6. Helpdesk

Users are highly recommended to register on the OSI SAF Web Site : http://osi-saf.eumetsat.int , in order to get access to useful information, documentation and links, service messages, and to the helpdesk.

User feedback to the OSI SAF project team is highly valued. The comments we get from our users is important argumentation when defining development activities and updates. We welcome anyone to use the data and provide feedback.

2. Processing overview

This section summarizes the radiative fluxes processing, which is described in more details in the Algorithm Theoretical Basis Document [RD.1].

2.1. Radiometers characteristics

The SEVIRI instrument on board MSG satellites is a multi-channel passive imaging radiometer operating in twelve channels. Infrared channels have a spatial resolution of 3 km at nadir. The full disk is scanned with a repeat cycle of 15 minutes.

The ABI instrument on board GOES-16 is a multi-channel passive imaging radiometer operating in sixteen channels. Infrared channels have a spatial resolution of 2 km at nadir. The full disk is scanned with a basic repeat cycle of 15 minutes, but a cycle at 10 minutes has been used occasionally

2.2. Radiative fluxes calculation

The SSI algorithm is based on a physical parametrization using the radiometer 0.6 mm visible channel as main input. The visible channel is converted into a Top Of Atmosphere (TOA) albedo. The parametrization relates the SSI, the TOA albedo, the atmospheric transmittance (out of cloud) and the surface albedo. The atmospheric transmittance is obtained by analytical formulas depending on the viewing angles, water content of the atmosphere and ozone content. The surface albedo is calculated theoretically over sea and derived from an atlas, over land. Finally, the SSI is derived from the TOA albedo.

The DLI algorithm,is based on a bulk parameterization. The clear sky contribution is a function of near surface air temperature and humidity. The cloudy sky contribution is obtained differently by day and night. By day, it is directly deduced from the actual to clear sky SSI ratio. By night, it uses the cloud classification of the NWC SAF cloud classification and empirical coefficients (one per cloud type), previously obtained on a 1-year data set.

The atmospheric parameters (water content, temperature and humidity) needed for SSI and DLI calculations are predicted by a ECMWF NWP model.

The radiative fluxes are firstly calculated on satellite images, in space view at Infra-red resolution, every 30 minutes. The satellite images are not homogeneous in time, because of the radiometer scanning. Secondly, a pseudo instantaneous product at rounded UT hour is obtained by a pixel dependant temporal interpolation between two consecutive satellite images.

The daily product is the integration of all the hourly products in the UT day. The DLI daily integration is straightforward. The SSI daily integration accounts for the calculated sunrise and sun set times, independently for every pixel. The solar day may be fully included in the UT day or corresponds to two uncompleted solar days: day 1 / night / day 2.

The final step is a remapping of the space view products (hourly or daily) onto a regular 0.05° grid. This remapping simply re-distributes, at the nearest neighbour, the radiative fluxes and quality level values without changing them.

The processing chain responsible for producing SST and radiative fluxes products has been upgraded in 2019. The upgrade mostly consisted in technical updates: the code is now using Python3 as the primary language, it is adapted to the new version of the dispatcher system used at Météo-France.

2.3. Validation

The radiative fluxes products are routinely validated against in situ measurements following the method described in [RD.1]. Validation statistics are provided monthly on EUMETSAT web site and in the Half-yearly Operations Reports.

Validation reports (available on EUMETSAT web site) present specific studies:

- [RD.2] shows Meteosat-9 and GOES-13 results from August 2010 to January 2011,
- [RD.3] shows Meteosat-8 results from February to May 2017,
- [RD.4] shows GOES-16 and Meteosat-11 results from March to May 2018 and Meteosat-8 results from June 2017 to 31 May 2018.
- [RD.5] shows GOES-16, Meteosat-11 and Meteosat-8 results from 1 May to 30 September 2019, obtained with the upgraded processing chain.

3. Product description

This section describes the present version of the products, which started on 7 September 2011. for GOES-East and Meteosat at 0° and on 27 April 2018 for Meteosat-8. Before 7 September 2011, the products, available at Ifremer, have slightly different characteristics, the user is invited to contact OSI SAF for more information.

3.1. Data

As defined in 1.2, SSI and DLI correspond to the energy received per unit time and per unit area, and are expressed in Wm^{-2}. A hourly flux, SSI or DLI, is a pseudo instantaneous irradiance at a rounded UT hour. A daily flux is the mean irradiance over the UT day. In other words, the total energy received during the day per unit area is equal to the daily flux multiplied by 24 x 3600 (day duration in seconds).

All products have a spatial sampling of 0.05° in latitude and longitude and two temporal frequencies, hourly (every rounded TU hour) and daily. The satellite and product characteristics are summarized in table 1.

Product id	Product name	Satellite	Information	Spatial coverage
OSI-305-b	GOES-East DLI	GOES-16	1st satellite of GOES Third Generation	135W -15W-60S-60N
OSI-306-b	GOES-East SSI			
OSI-303-a	Meteosat DLI	Meteosat-11	4th satellite of Meteosat Second Generation	60W-60E-60S-60N
OSI-304-a	Meteosat SSI			
OSI-IO-DLI	Meteosat IO DLI	Meteosat-8	1st satellite of Meteosat Second Generation	19.5W-101.5E-60S-60N
OSI-IO-SSI	Meteosat IO SSI			

Table 1: satellites and products summary (input data being at the time of the document)

3.2. Quality levels

Each pixel DLI or SSI value, is associated to a quality level expressed on a scale showing 6 values : 0 : unprocessed, 1 : erroneous, 2: bad, 3: acceptable, 4: good, 5 : excellent.

The 0 value corresponds mostly to space, the 1 value correspond to an error in the software logic and should not occur. The 2 to 5 values are related to the processing itself, the quality level being decreased when the flux calculation appears less reliable. The hourly and daily quality level meanings are explained in [RD.1].

Users are recommended to use data having a quality level equal or higher than 3 .

3.3. Format

The products are in NetCDF4 classic format. There are separate files for each satellite and for each hourly or daily product, with DLI and SSI being in the same file. The appendix shows the variables of a hourly file, the daily file variables are the same. The quality level variable is named confidence level, by consistency with the first files produced by OSI SAF. Daily files are about 11 MB and hourly files are from 3 to 12 MB.

4. Access to the products

The products are available on:

- on EUMETCast
- on IFREMER FTP server ftp://eftp.ifremer.fr/cersat-rt/project/osi-saf/. This server is accessible to users registered on the OSI SAF web site, access rights are provided on request in the registration process.
- from the EUMETSAT Data Center (EDC) (http://navigator.eumetsat.int/).

as indicated in the following table :

Product id	Product name	Near real time access	Off line access
OSI-305-b OSI-306-b OSI-303-a OSI-304-a	GOES-East DLI GOES-East SSI Meteosat DLI Meteosat SSI	EUMETCast Ifremer FTP server	Ifremer FTP server EUMETSAT data centre (from 2017)

OSI-IO-DLI OSI-IO-SSI	Meteosat IO DLI Meteosat IO SSI	Ifremer FTP server	Ifremer FTP server

Table 2: Access to the products

5. Appendix: ncdump of a METEOSAT-11 hourly flux

```
dimensions:
        lat = 2400 ;
        lon = 2400 ;
variables:
        double time ;
                time:_FillValue = -9999999. ;
                time:long_name = "reference time" ;
                time:standard_name = "time" ;
                time:units = "seconds since 1981-01-01 00:00:00" ;
                time:comment = "" ;
        float lat(lat) ;
                lat:long_name = "latitude" ;
                lat:units = "degrees_north" ;
                lat:valid_min = -90. ;
                lat:valid_max = 90. ;
        float lon(lon) ;
                lon:long_name = "longitude" ;
                lon:units = "degrees_east" ;
                lon:valid_min = -180. ;
                lon:valid_max = 180. ;
        byte landmask(lat, lon) ;
                landmask:_FillValue = -128b ;
                landmask:long_name = "auxiliary land mask" ;
                landmask:valid_min = 0b ;
                landmask:valid_max = 2b ;
                landmask:flag_values = 0b, 1b, 2b ;
                landmask:flag_meanings = "sea land lake" ;
                landmask:comment = "from GMT" ;
                landmask:coordinates = "lon lat" ;
        short ssi(lat, lon) ;
                ssi:_FillValue = -32768s ;
                ssi:long_name = "surface solar irradiance" ;
                ssi:standard_name = "surface_downwelling_shortwave_flux_in_air" ;
                ssi:units = "W m-2" ;
                ssi:add_offset = 0. ;
                ssi:scale_factor = 0.1 ;
                ssi:comment = "" ;
                ssi:coordinates = "lon lat" ;
        byte ssi_confidence_level(lat, lon) ;
                ssi_confidence_level:_FillValue = -128b ;
                ssi_confidence_level:long_name = "ssi confidence level" ;
                ssi_confidence_level:valid_min = 0b ;
                ssi_confidence_level:valid_max = 5b ;
                ssi_confidence_level:flag_values = 0b, 1b, 2b, 3b, 4b, 5b ;
                ssi_confidence_level:flag_meanings = "unprocessed erroneous bad
acceptable good excellent" ;
                ssi_confidence_level:comment = "" ;
                ssi_confidence_level:coordinates = "lon lat" ;
        short dli(lat, lon) ;
                dli:_FillValue = -32768s ;
```

```
                dli:long_name = "downward longwave irradiance" ;
                dli:standard_name = "surface_downwelling_longwave_flux_in_air" ;
                dli:units = "W m-2" ;
                dli:add_offset = 0. ;
                dli:scale_factor = 0.1 ;
                dli:comment = "" ;
                dli:coordinates = "lon lat" ;
        byte dli_confidence_level(lat, lon) ;
                dli_confidence_level:_FillValue = -128b ;
                dli_confidence_level:long_name = "dli confidence level" ;
                dli_confidence_level:valid_min = 0b ;
                dli_confidence_level:valid_max = 5b ;
                dli_confidence_level:flag_values = 0b, 1b, 2b, 3b, 4b, 5b ;
                dli_confidence_level:flag_meanings = "unprocessed erroneous bad
acceptable good excellent" ;
                dli_confidence_level:comment = "" ;
                dli_confidence_level:coordinates = "lon lat" ;

// global attributes:
                :Conventions = "CF-1.0" ;
                :title = "Surface radiative fluxes" ;
                :institution = "OSISAF" ;
                :history = "METEO-FRANCE/CMS GEOSAFO processor" ;
                :comment = "" ;
                :license = "All intellectual property rights of the Ocean & Sea Ice SAF
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products. EUMETSAT neither commits to nor guarantees the continuity, availability, or
quality or suitability for any purpose of, the Ocean & Sea Ice SAF products." ;
                :acknowledgment = "In case SAF data (pre-operational or operational)
has been used for the study described in a paper the following sentence would be an
appropriate reference to the funding coming from EUMETSAT: The data from the EUMETSAT
Satellite Application Facility on Ocean & Sea Ice  used in this study are accessible
through the SAF\'s homepage http://www.osi-saf.org" ;
                :creator_name = "O&SI SAF" ;
                :creator_email = "osi-saf.helpdesk@meteo.fr" ;
                :creator_url = "http://www.osi-saf.org" ;
                :file_quality_index = 0 ;
                :platform = "MSG4" ;
                :reference_time = "20191028T120000Z" ;
                :start_time = "20191028T113000Z" ;
                :stop_time = "20191028T123000Z" ;
                :file_quality_level = 3L ;
                :_NCProperties = "version=2,netcdf=4.6.3,hdf5=1.10.5" ;
```