EUMETSAT OSI SAF
OCEAN AND SEA ICE

Product User Manual for Geostationary Sea Surface Temperature

Meteosat (0°) SST (OSI-206-a)

GOES-East SST (OSI-207-b)

Meteosat over Indian Ocean SST (demo)

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1.0	10/04/2011		First version.
1.1	02/05/2011		Minor correction : Table of content updated.
1.2	26/11/2011		Appendix A.1. updated
1.3	30/09/2013		Information concerning Surface Temperature over selected lakes added in the section 1.1. Other minor corrections and changes.
1.4	07/04/2016		Coefficients of Meteosat 10 SST algorithm and minor corrections
1.5	04/07/2016		Update of output formats and dissemination means
1.6	13/07/2017		Addition of the demo product : METEOSAT over Indian Ocean SST Removal of information on GRIB (stopped since 12/01/2017)
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1.8	08/02/2018	CH SSP	From 20/02/2018, Meteosat-11 (also Meteosat Second Generation) replaces Meteosat-10 : OSI-206 becomes OSI-206-a
1.9	22/02/2018	CH SSP	First tuning of coefficients (f and g) in GOES-16 SST algorithm, using collocation with drifting buoys measurements. The tuned algorithm is used since product dated 2018-02-22T14:00:00Z.
2.0	8/11/2019	SSP	Remove information on methods and algorithms that are now in the ATBD.
2.1	04/12/20	SSP	OSI-207-a becomes OSI-207-b (GOES-16)

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1. Introduction

1.1. Overview

The EUMETSAT Ocean and Sea Ice Satellite Application Facility (OSI SAF) is a consortium constituted of Météo-France as leading entity, and MET Norway, DMI, KNMI and Ifremer as co-operating entities.

The OSI SAF is routinely producing on a pre-operational or operational basis a range of air-sea interface products, namely: wind, sea ice characteristics, Sea Surface Temperatures (SST) and radiative fluxes : Downward Longwave Irradiance (DLI) and Surface Solar Irradiance (SSI).

OSI SAF commitments for a 5-years phase are described in the Product Requirement Document (PRD) [AD.1]. Operational and pre-operational OSI SAF products are described in the Service Specification Document (SeSp) [AD.2]. Validations statistics are provided in the Half-yearly Operations Reports and on the web site http://osi-saf.eumetsat.int.

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.

The main content of this manual are a description of the processing methods, an introduction to the algorithms used, some validation results and the product content and format.

The present manual describes the geostationary derived SST products.
The OSI SAF is committed to produce hourly SST products on distinct 0.05° resolution grids for GOES-East (longitude around 75° W) and Meteosat (longitude around 0°).
OSI SAF has no commitment on the hourly SST product with Meteosat-8 over Indian Ocean (IO) data which is available in a demo mode : these data are produced in "best effort" mode, and are not delivered under operational constraints. The production may be temporarily interrupted without any notice.

These three products include surface temperature over selected lakes, using the standard SST algorithms with no commitment on the accuracy and validation.

Table 1 describes the characteristics of the OSI SAF derived geostationary SST.

Name (reference)	Coverage	Resolution	Time characteristics	Formats	Timeliness	Volume per unit (NetCDF4)
Meteosat SST (OSI-206-a)	60S-60N 60W-60E	0.05°	hourly	NetCDF4 L3C (GHRSST)	4h	11-12 MB
GOES-East SST (OSI-207-b)	60S-60N 135W-15W	0.05°	hourly	NetCDF4 L3C (GHRSST)	4h	3-11 MB
Meteosat Indian Ocean SST (demo)	60S-60N 19.5W-101.5E	0.05°	hourly	NetCDF4 L3C (GHRSST)	4h	11-12 MB

Table 1: Characteristics of the OSI SAF geostationary derived SST products

L3C is the NetCDF format recommended by the Group for High Resolution Sea Surface Temperature (GHRSST). The L3C content is identical to L2P GHRSST products, “3” refers to gridded products and

“C” to the fact that hourly products result from compositing 15 minutes (Meteosat) or 10 minutes (GOES-East) data.
The products are not available in GRIB format any more since 12/01/2017.
Scientific validation results for the three GEO SST products are available in the following reports :

- Scientific validation report for the Geostationary Satellites sea surface temperature [RD.1]

1.2. Ownership and copyright of data

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.

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.

1.3. Glossary

AOD	Aerosol Optical Depth
Auxiliary data	Dynamic data that are used in the preparation of GHRSST L2P or L3 data products including wind speed, aerosol optical depth and sea ice.
AVHRR	Advanced Very High Resolution Radiometer
BT	Brightness temperature
CMS	Centre de Météorologie Spatiale (Météo-France)
DMI	Danish Meteorological Institute
ECMWF	European Centre for Medium-range Weather Forecasting
GDS	In situ and satellite data integration processing model
GHRSST	Group for High Resolution Sea Surface Temperature
GOES	Geostationary operational environmental satellite (US)
GRIB	GRIdded Binary format
L2	Levels from 0 to 4 have been defined by the remote sensing community to describe the processing level of products. Level 0 represents raw data, while Level 4 data have had the greatest amount of processing applied. Level 2 products are retrieved environmental variables at the same resolution and location as the level 1 source data.
L2P	Level 2 Pre-processed : On top of levels from L0 to L4 defined by the remote sensing community to describe the processing level of products, the SST community has developed a set of SST definitions in the context of the GHRSST. L2P products are satellite SST observations together with a measure of uncertainty for each observation in a common GHRSST netCDF format. Auxiliary fields are also provided for each pixel as dynamic flags to filter and help interpret the SST data. This family of data products provides the highest quality data obtained from a single sensor for a given processing window. In satellite projection.
L3C	Level 3 Collated : Gridding a single L2P file produces an "uncollated" L3 file (L3U). Multiple L2P files are gridded to produce either a "collated" L3 file (L3C) from a single sensor or a "super-collated" L3 file from multiple sensors (L3S). L3C products are gridded and resulting from compositing several orbits or slots from a single sensor.
MDB	Match up database
MET Norway	Norwegian Meteorological Institute
MF	Météo-France
MSG	Meteosat second Generation
NAAPS	Navy Aerosol Analysis Prediction System
NetCDF	Network Common Data Form

NWP	Numerical Weather Prediction
SDI	Saharan Dust Index
SEVIRI	Spinning Enhanced Visible and Infrared Imager
SSES	Single Sensor Error Statistics
SST	Sea Surface Temperature

1.4. Applicable and reference documents

1.4.1. Applicable documents

[AD.1] OSI SAF
CDOP 3 Product Requirement Document (PRD)
SAF/OSI/CDOP3/MF/MGT/PL/2-001, Version 1.1, 20/11/2017

[AD.2] OSI SAF
Service Specification (SeSp)
SAF/OSI/CDOP3/MF/MGT/PL/003, Version 1.3, 14/12/2017

Reference to an Applicable Document within the body of this document is indicated as reference in the list above, e.g. [AD.1].

1.4.2. Reference documents

[RD.1] OSI SAF
Scientific validation report for the Geostationnary Satellites sea surface temperature
SAF/OSI/CDOP3/MF/SCI/RP/371
Version 1.0

[RD.2] GHRSST Science Team (2010)
The Recommended GHRSST Data Specification (GDS) 2.0
document revision 5 available from the GHRSST International Project Office, 2011, pp 123.
https://www.ghrsst.org/documents/q/category/ghrsst-data-processing-specification-gds/operational/

[RD.3] Algorithm Theoretical Basis Document for Geostationary Satellite Sea Surface Temperature.
SAF/OSI/CDOP3/SCI/MA/342
Version 1.1

Reference to a Reference Document within the body of this document is indicated as reference in the list above, e.g. [RD.1].

2. Overview of the processing Chain

The OSI SAF geostationary SST chain compute SST fields at full space view resolution for every slots (see figure 1), and an hourly synthesis is produced.

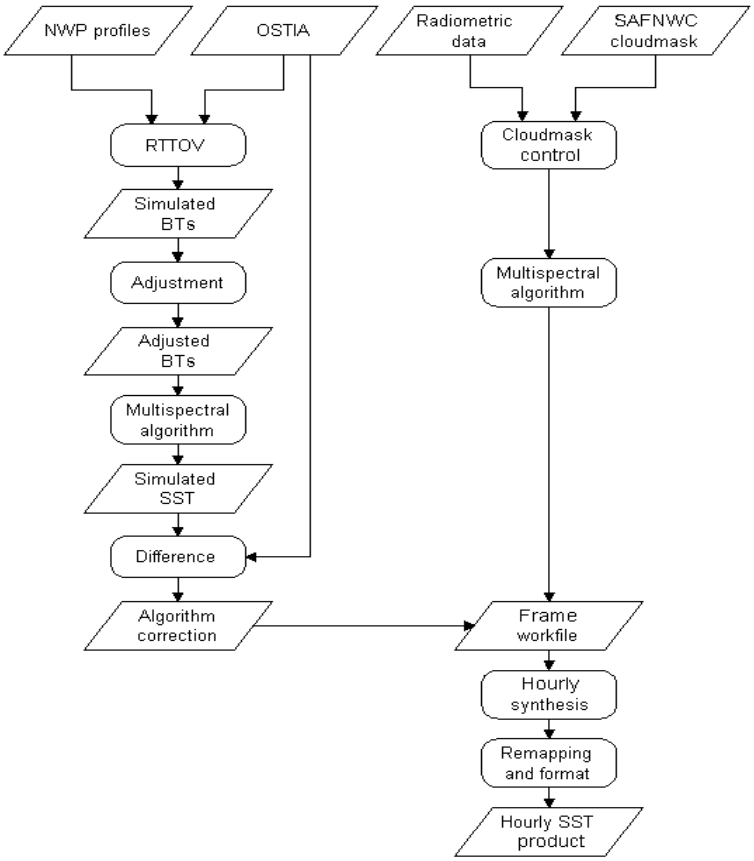

Figure 1: Overview of the geostationary chain. Radiometric data are used every 15' (Meteosat) or 30' (GOES-East). The algorithm correction is calculated every 3 hours and applied to the SST calculation the nearest in time.

The chain and methodologies are described in details in the Algorithms Theoretical Basis Document for the Geostationary Satellites Sea Surface Temperature Processing Chain [RD.3].

The retrieval methodologies include a non-linear algorithm using split window channels of each respective instruments. A bias correction methodology is implemented: it uses radiative transfer simulation and atmospheric profiles from a Numerical Weather Prediction (NWP) model in order to estimate the regional and seasonal biases of the SST algorithm.

2.1. Quality level

Each pixel of any product is associated with a quality level which is an indication of the quality of the retrieval process. The definition of the quality levels adopts the recommendations of the GHRSST formalised through the GDS v2 document. For infrared derived SST six quality levels are defined. 0: unprocessed; 1: cloudy, 2: bad, 3: suspect, 4 acceptable, 5 excellent.
During the elaboration of SST products, many considerations are looked at in the making of the quality level:

- Difference of SST to SST climatology
- Difference of local value of SST gradient to climatology
- Distance to cloud
- Presence of dust aerosols

- Risk of having sea ice
- Satellite zenith angle
- Value of the algorithm correction

Each of these considerations is synthesized into an indicator which is tested against a threshold for the computation of the per-pixel quality level. If every test is passed successfully the quality level will be set to the highest value.
For more details about the test indicators and quality levels, see [RD.3].

The most common source of degraded quality level is undetected clouds. Quality level 2 certainly contain cloudy pixels; quality level 3 may contain cloudy pixels whereas quality levels 4 and 5 are unlikely to contain remaining clouds.

Important notice:
It is very important to filter the data according to the user objectives. For instance, if a user wants to compare different sources of data (in situ, climatologies, other products,...) it is recommended to only select quality level greater or equal to 2. On the other hand quality level 2 to 5 may be used for qualitative purposes such as visually detecting surface structure (thermal fronts, eddies,...)

2.2. Product processing

Each slot is processed separately at full resolution. For each slot a workfile is produced along the processing and contains all input data and intermediate data required such as:

- location and illumination conditions
- reflectances and brightness temperatures
- NWC SAF cloud mask original information
- static data (landmask, climatology values,..)
- dynamic data (SEVIRI SDI, NAAPS AOD,..)
- intermediate calculation values (gradients, indicators..)
- final results (SST, quality level, ,..)

These workfiles are produced and archived at CMS for validation, control and further use.

SST fields derived from each slots are aggregated within [- 30;+20] minutes around a round hour to produce the hourly fields. Data are not averaged but selected at pixel level according to the following criteria (in this priority order):

- time within 30 minutes from the nominal time,
- highest quality level,
- lowest mask indicator,
- time closest to the nominal time.

Hourly fields are then remapped to the nearest neighbour on the 0.05° grid covering a 120°x 120° square centred on the satellite sub-point.

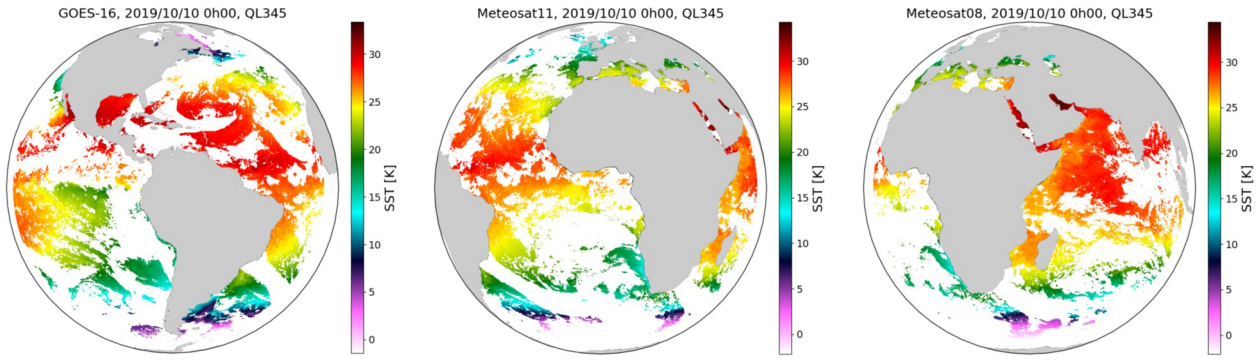

Figure 2: Geostationary SST product on the 10th of October 2019 at 00:00 UTC for GOES-E, Meteosat 0° and Meteosat-IO

3. Product description

Operational products are then produced by remapping over a 0.05° regular grid SST fields obtained by aggregating all SST data available in one hour time, the priority being given to the value the closest in time to the product nominal hour. Figure 2 shows an example of hourly GOES-East, Meteosat-0° and Meteosat-IO derived SST products. The final products result from collecting data from various slots within one hour. Consequently they are considered as “L3C” (remapped collated) in the GHRSST product definition.

Projection:	Cylindrical equidistant (linear scaling in latitude and longitude)	
Resolution:	0.05 degree in latitude and longitude	
Size:	2400 columns, 2400 lines	
Longitude and latitude limits :	GOES-East SST:	60S-60N; 135W- 15W
	Meteosat SST:	60S-60N; 60 W- 60E
	Meteosat IO SST :	60S-60N; 19.5W-101.5E

In summary the files include the following variables:

Time and location information:

time, lat and lon that enable dating and locating each pixel
or_latitude and **or_longitude** are the original latitude and longitude values prior to remapping
L2P_flags: Flags describing the nature of the earth target

Angles:

satellite_zenith_angle: The satellite zenith angle at time of observation (varies in function of the platform position)
solar_zenith_angle: Solar zenith angle at time of observation

SST information (L2Pcore):

sea_surface_temperature: SST at pixel, this value contains all corrections applied throughout the processing

sst_dtime: Time differences of SST measurements from a reference time
sses_bias and **sses_standard_deviation**: estimate of the error characteristics at pixel level, derived from exploiting the validation results against drifting buoys measurements.
l2p_flags: Flags specific to each L2P data set that help users interpret data
quality_level: Quality level on a 0 to 5 scale 0: unprocessed; 1 cloudy, 2: qualitative use only: 3, 4, 5: usable data of increasing quality

Ancillary information (L2Paux):

dt_analysis: Difference between the delivered SST and the last available SST analysis. In the nominal chain configuration, this analysis is the met. Office OSTIA analysis.
wind_speed: 10 meter wind speed derived from ECMWF forecast
sea_ice_fraction: Fractional ice cover from OSI SAF ice concentration product
aerosol_dynamic_indicator: Information regarding the aerosol loading of the atmosphere. In our case, it can be either the SEVIRI derived Saharan Dust Index (SDI, see section 2.2) or the NAAPS derived Aerosol Optical Depth.
adi_dtime_from_sst: age of the aerosol information relative to the time of SST observation.
sources_of_adi: nature of the aerosol indicator. This information is essential for using this indicator, since they are distinct in nature (and units) depending on their origin.

For more details on the content of these products, the reader is recommended to refer to the following document : GHRSST Data Processing Specification 2.0 revision 5 [RD.2].

Information on the NetCDF4 files volume (per unit) is indicated in Table 1 : Characteristics of the OSI SAF geostationary derived SST products.

4. Access to the products

The Meteosat and GOES-East hourly SST products are available in near-real time in GHRSST compliant L3C NetCDF4 format on Ifremer FTP server and via EUMETCast. L3C is the NetCDF format recommended by the Group for High Resolution Sea Surface Temperature (GHRSST).
The archived L3C NetCDF4 files are also available on Ifremer FTP server and in EUMETSAT Data Center (EDC).

Access to the products is indicated in the following table :

Name (reference)	Format*	Near real time access	Off line access
MET SST (OSI-206) GOES-E SST (OSI-207-b)	L3C NetCDF	EUMETCast Ifremer FTP server	Ifremer FTP server EUMETSAT data centre (EDC)
MET IO SST (demo)	L3C NetCDF	Ifremer FTP server	Ifremer FTP server

Table 2: Access to the products

* The products are not available in GRIB format any more since 12/01/2017.

Ifremer FTP server, ftp://eftp.ifremer.fr/cersat-rt/project/osi-saf/, is accessible to users registered on the OSI SAF web site http://osi-saf.eumetsat.int (Users rights are provided on request in the registration process).

5. Appendices

5.1. L2P and L3C format description

The GHRSST data files have been chosen to follow the Climate and Forecast NetCDF conventions because these conventions provide a practical standard for storing oceanographic data. The NetCDF data format is extremely flexible, self describing and has been adopted as a de-facto standard for many operational oceanography systems. **The GDS version 2.0 products are NetCDF4 classic model files using internal compression feature**.

The table below gives an overview of the GHRSST data products specified by the version 2.0 of the GDS.

Table 6-1 GHRSST data products specified by the GDS 2.0.

SST Product	L2 Pre-Processed [Section 8]	L3 Uncollated [Section 1010]	L3 Collated [Section 10]	L3 Super-collated [Section 10]	Analyzed SST [Section 11]	GHRSST Multi-Product Ensemble SST [Section 12]
Acronym	L2P	L3U	L3C	L3S	L4	GMPE
Description	Geophysical variables derived from Level 1 source data at the same resolution and location as the Level 1 data, typically in a satellite projection with geographic information. These data form the fundamental basis for higher-level GHRSST products and require ancillary data and uncertainty estimates. No adjustments to input SST have been made.	L2 data granules remapped to a space grid without combining any observations from overlapping orbits. L3 GHRSST products do not use analysis or interpolation procedures to fill gaps where no observations are available	SST measurements combined from a single instrument into a space-time grid. Multiple passes/scenes of data can be combined. Adjustments may be made to input SST data.	SST measurements combined from multiple instruments into a space-time grid. Multiple passes/scenes of data are combined. Adjustments may be made to input SST data.	Data sets created from the analysis of lower level data that results in gridded, gap-free products. SST data generated from multiple sources of satellite data using optimal interpolation are an example of L4 GHRSST products	GMPE provides ensemble information about various L4 data products. It provides gridded, gap-free SST information as well as information about the spread in the various L4 products.
Grid specification	Native to SST data format	Defined by data provider	Defined by data provider	Defined by data provider	Defined by data provider	Defined by data provider
Temporal resolution	Native to SST data stream	Native to data stream	Defined by data provider	Defined by data provider	Defined by data provider	Defined by data provider
Delivery timescale	As available, Ideally within 3 hours from acquisition at satellite	As available, Ideally within 3 hours from acquisition at satellite	As available, Ideally within 3 hours from acquisition at satellite	As available, Ideally within 3 hours from acquisition at satellite	Analyzed product processing window as defined by data provider.	As available, ideally within 24 hours of the input L4 products being available.
Target accuracy	Native to data stream	Native to data stream	<0.4 K	<0.4 K	< 0.4 K absolute, 0.1 K relative	< 0.4 K
Error statistics	Native to data stream if available, sensor specific error statistics otherwise	Native to data stream if available, sensor specific error statistics otherwise	Derived from input data for each output grid point.	Derived from input data for each output grid point.	Analysis error defined by data provider for each output grid point (no input data statistics are retained)	The standard deviation of the input L4 analyses is provided. This is not an error estimate, but provides some idea of uncertainty.
Coverage	Native to data stream	Native to data stream	Defined by data provider	Defined by data provider	Defined by data provider	Defined by data provider