The EUMETSAT
Network of
Satellite Application
Facilities

OSI SAF
Ocean and Sea Ice

Atlantic High Latitude L3 Sea Surface Temperature Product User Manual

OSI-203

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Document Change Record

Version	Date	Change	Description	Responsible
1.0	12.05.2002		First published version	Steinar Eastwood
1.1	30.08.2002	Minor	Upgrades after review.	SE
1.2	10.10.2002	Minor	Change in NOAA-16 SST algorithm coefficients.	SE
2.0	25.03.2011	Major	MAP product superseded by separate LML and HL products. Changed product resolution from 10 to 5km.	SE
2.1	28.11.11	Minor	Some clarifications after product review and operationalization.	SE

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1 Introduction

1.1 Scope

This product user manual presents the Atlantic High Latitude (AHL) Level 3 Sea Surface Temperature (SST) product from the EUMETSAT Ocean and Sea Ice Satellite Application Facility (OSI SAF). The focus of the manual is to present an overview of how this product is produced and describe technical details about the product format to enable users to understand and use the product.

1.2 Overview

The EUMETSAT OSI SAF is producing a range of operational air-sea interface products, namely: wind, sea ice characteristics, Sea Surface Temperatures (SST) and radiative fluxes, Surface Solar Irradiance (SSI) and Downward Longwave Irradiance (DLI). More details on the products and OSI SAF project are available at http://www.osi-saf.org.

SST, SSI and DLI products from the OSI SAF are produced using geostationary and polar orbiting satellites and are available in level 2 and level 3 formats, with different timeliness depending on the production setup.

A specific L3 Atlantic High Latitude SST product is produced at METNO covering the North Atlantic High Latitudes north of 50N. This product used to be a part of the the MAP SST products, but the MAP product is superseded by a Low and Mid Latitude (LML) product based on geostationary data and an Atlantic High Latitude product based on AVHRR polar orbiting data. The new LML product cover the Atlantic Ocean between 60S and 60N (more details in [RD.1]).

The HL SST products are derived from AVHRR polar orbiter data received at the local receiving station at METNO together with data received through the EUMETCast ATOVS Retransmission Service (EARS). Intermediate L2 SST products for each pass are input to the HL L3 SST product that are delivered every 12 hours. These 12-hourly products are available in HDF5 and GRIB format through the OSI SAF High Latitude FTP server (ftp://osisaf.met.no/prod). See also http://osisaf.met.no for product monitoring, validation, news messages and other information.

Chapter 2 presents a brief description of the algorithms and chapter 3 gives an overview of the data processing. Chapter 4 provides detailed information on the file format and content.

1.3 Glossary

Acronym	Description
AVHRR	Advanced Very High Resolution Radiometer
CMS	Centre de Méteorologie Spatiale
DLI	Downward Longwave Irradiance

Acronym	Description
DMI	Danish Meteorological Institute
GRIB	Gridded Binary Format
HDF	Hierarchical Data Format
HL	High Latitudes
HIRLAM	High Resolution Limited Area Model
LML	Low and Mid Latitudes
METNO	Norwegian Meteorological Institute
MODTRAN	Moderate Resolution Transmittance model
MSG	Advanced Very High Resolution Radiometer
NOAA	National Oceanic and Atmospheric Administration
NAR	Near Atlantic Regional
NWC	Nowcasting
RMDCN	Regional Meteorological Data Communication Network
SAF	Satellite Application Facility
SMHI	Swedish Meteorological and Hydrological Institute
SSI	Surface Solar Irradiance
SST	Sea Surface Temperature
TIGR	Tovs Initial Guess Retrieval database

1.4 Applicable documents

[RD.1] GEO SST Product Users Manual.

[RD.2] OSI SAF CDOP Product Requirement Document, v1.2.

[RD.3] Algorithm Theoretical Basis Document for the OSI SAF AVHRR Regional Ice Edge Product, v0.1.

[RD.4] HL SST Validation Report, v1.0.

[RD.5] HL SST matchup database format, v1.1.

[RD.6] Description of the osihdf5 format, v1.1.

[RD.7] WMO publication No 306, Manual on Codes, available at http://www.wmo.ch/web/www/WMOCodes/ManualCodes/WMO306vol-I-2PartB.pdf.

[RD.8] The recommended GHRSST Data Specification (GDS), v2.0.

Several of these documents are available at (http://osisaf.met.no/docs).

2 Algorithms

2.1 Development method

The developments of the OSI SAF SST algorithms have been presented in Andersen et al. (1998). It follows the same principals as presented in Brisson et al. (1998). The main principles of these developments are briefly presented here.

First, a cloud free radio-sounding database for high latitudes has been built using radio soundings available through GTS from maritime and coastal radio sounding stations. Several tests were applied to these radio-soundings to select only the cloud free cases. These radio soundings have been supplied by high latitude radio soundings from the NCEP/NCAR Arctic Marine Rawinsonde Archive received from NSIDC to have a geographically balanced dataset. Then, these radio soundings have been used in the radiative transfer model MODTRAN (Bernstein et al., 1996) to simulate radiances and brightness temperatures for high latitude Atlantic atmospheric conditions. These simulated brightness temperatures have been used to calculate coefficients for different SST algorithms by regression analysis. Different SST algorithm formalisms have been chosen from literature. The simulated radiances can be used to calculate coefficients for all satellites with known spectral response functions. For validating the different algorithm formalisms NOAA-14 was chosen. With the calculated coefficients the different algorithm formalisms have been applied on the Pathfinder Match-up Data Base (Podesta et al. 1997) to compare the performance of the different algorithm formalisms at high latitudes. From these studies a non-linear split window algorithm (NL) was chosen, with the same coefficients for daytime and nighttime conditions.

2.2 SST definition

Algorithms derived from simulations may show a few tenths of K biases when applied on real data, due to the approximations of the radiative transfer modeling. Correcting for these biases is possible after a few months of data have been processed. The correction terms have been provided in Table 1 for AVHRR on different satellites. This correction rises however the question of the definition of the satellite derived SST.

Satellites actually observe the skin brightness temperature (the temperature of the first few μm of the ocean surface). This quantity may be measured by radiometers mounted on ships etc., but such data are only available from occasional cruises and seldom at high latitudes. Significant validation data can only be obtained from buoy measurements, which usually measures at 0.2 - 1 meter depth. The skin-bulk difference is about 0.2 K by night on average (skin cooler than bulk), but this difference may reach several K by day under favorable diurnal heating conditions (skin warmer than bulk). The most appropriate way to evaluate an algorithm derived through simulations is thus through validation against nighttime buoy measurements. This comparison may reveal a bias. Correcting for this bias at night allows the retrieval of nighttime bulk SST, or sub-skin SST, since in the absence of diurnal thermocline, it is the temperature that would be recorded immediately beneath the skin layer. Applying the same bias by day allows similarly the retrieval of the daytime sub-skin SST, since the skin effect (i.e. the skin minus sub-skin difference) is similar by day and by night. The disadvantage of this definition is that the daytime bias correction has a statistical meaning depending in particular of the characteristics of the validation set. Furthermore the bulk SST derived this way does not resolve the local variability of the diurnal heating, so that large differences with buoy measurements may still be found. The sub-skin SST definition has thus been adopted in the operational stage, since it allows a representative validation by night, and preserves the evaluation of skin SST by day.

2.3 AVHRR algorithms

The AVHRR instrument on NOAA POES and EUMETSAT Metop satellites has two or three visible (VIS) and near infrared (NIR) channels and three infrared (IR) channels. The IR channels can be used for “split window” and “triple window” algorithms, using respectively two and three channels. The validation of different algorithm formalisms for NOAA-14 showed that the “split window” approach using channel 4 (10.3-11.3 μm) and channel 5 (11.5-12.5 μm) gave the best results at high latitudes, both day and night. The filter functions are slightly different for each instrument, which makes in necessary to use distinct coefficients for the SST algorithms for each instrument/satellite.

The algorithms coefficients derived from regression analysis on the simulation radiances are provided in Table 1. A bias correction (corr) should be applied to the calculated SST in order to retrieve the subskin SST. This correction term is available for the existing satellites, and will be derived after a few months of validation for the future satellites. The number of available in situ observations at high latitudes varies and the length of the period before a consistent correction term can be estimated might vary. The NL algorithm has the following form:

$$Ts = A_0 T4 + (B_1 S + B_2 T_{guess}) (T4-T5) + C_0 + C_1 S + corr , \qquad \textbf{Eq. 1}$$

where A_0, B_1, B_2, C_0, C_1 and corr are constants given in Table 1, Ts is the calculated SST, T4 and T5 are the brightness temperatures in channel 4 and 5, respectively. A mean climatological SST is used as T_{guess}. S = sec(θ) - 1 where θ is the satellite zenith angle. All temperatures are in Celsius.

	A_0	B_1	B_2	C_0	C_1	corr
NOAA-18	0,97588	0,95641	0,05905	1,49379	0,28288	0,00000
NOAA-19	0,96832	0,81105	0,05513	1,56730	0,30200	0,00000
Metop-A	0,99052	1,16321	0,06641	1,26512	0,16400	0,23000

Table 1: Coefficients of the Non-Linear SST algorithms for different AVHRR instruments used for the Atlantic High Latitude SST product.

Two sets of AVHRR coefficients are calculated in the OSI SAF, one set for the Atlantic High Latitude product and one set for the North Atlantic (NAR) product. The two sets of algorithms have shown to perform very similar at high latitudes. therefore the NAR derived coefficients are a present use in the HL SST product also, so that the two products are as consistent as possible.

The correction term is calculated after a few months of processing, based on the SST matchup data base. The correction term is defined by calculating the bias of all high quality SST (confidence level 4 and 5).

2.3.1 Coefficient files

The coefficients used are kept in a dedicated coefficient file. These coefficient files are labeled with a version number to keep track of all updates that are made. The format of the version number is:

nX.YpZ.W (e.g. n1.1p2.0),

where an increasing X,Y,Z or W indicates that there has been a change to the coefficient file. For each upgrade of the coefficient file one or more of the version numbers are increased by 1. The four version number indicates the following changes:

X	Coefficients for new satellite from new satellite mission have been included (e.g. METOP in 2007).
Y	Coefficients for new satellite from existing satellite mission have been included (e.g. new NOAA satellite).
Z	Coefficients of existing algorithm have been changed (e.g. bias correction).
W	Other minor changes.

Updated information about the currently and previously used coefficient files can be found on the HL OSI SAF web-page: http://osisaf.met.no/p/sst/algo/sst_algo.shtml.

2.3.2 Target accuracy:

The target accuracy is defined as the bias and standard deviation of the SST calculations when comparing with drifting buoy measurements, determined on a monthly basis using night time data (see [RD.2] for details):

- Bias: the biases should remain within +/-0.5 C by night on a monthly basis. By day at summer local biases of 1-2 K are possible.
- Standard deviation: the standard deviation should be lower than 0.8 C by night on a monthly basis.

The number of available drifting buoys at Atlantic high latitudes vary. The number of deployments at high latitudes have been very few for periods, the area is often cloudy and at summer there night is very short or none existent north of the polar circle for periods. For these reasons it can be difficult to determine representative night time validation results to assess the target accuracy. therefore both night time, twilight and daytime validation results are monitored and reported.

3 Processing scheme

3.1 Overview

The delivered products are 12-hourly means centered on 0 UTC and 12 UTC. The HL products are derived from AVHRR data from the NOAA POES and EUMETSAT METOP satellites. A combination of locally received data and data received through the EARS distribution system is used.

This chapter describes the processing of the AVHRR data for the HL SST products. Chapter 3.2 describes the primary processing of each satellite pass. The 12-hourly merging is presented in chapter 3.3. Procedures for validating the products are presented in 3.4 and the extraction of quality control parameters in 3.5.

Various parameters in capital letters are used throughout the processing. Their present values can be found in the configuration file and are presented in the chapter 9 .

3.2 L2 satellite pass processing

The primary SST calculations are at present made from each AVHRR pass received at METNO from NOAA-18, NOAA-19 and METOP-2. The main L2 processing steps are shown the left part of Figure 1. The main components of the L2 processing are briefly described below.

3.2.1 Preprocessing

At METNO the AVHRR HRPT data are received through the local receiving station and through the EARS system. Files from the different sources for the same orbits are then stitched together. These orbit files are then preprocessed using the AAPP software to L1B format. Each L1B file is the gridded and projected to fixed tiles in 1.5km polar stereographic projecting covering the North Atlantic area. This preprocessing step is not part of the OSI SAF processing chain, but a part of the basic AVHRR processing at METNO.

3.2.2 Cloud masking

Each of the AVHRR tiles generated in the preprocessing step this then cloud masked using the PPS software developed by SMHI in the Nowcasting SAF. More details about the PPS software is given in Dybbroe et al., 1999 and Dybbroe et al., 2001. This processing step is also done outside the OSI SAF processing chain, as a part of the basic AVHRR processing at METNO.

3.2.3 SST calculation, first step

The SST calculation is performed for all pixels that are not masked as clouds by the PPS cloud mask, and which are marked as sea by the land mask. Also major lakes are marked as sea and therefore processed for SST. As land mask is used the physiography file provided as a part of the PPS software for each product tile that are processed. The SST calculation uses the channel 4 and channel 5 brightness temperatures (T4 and T5) at both day and night, using the algorithm described in chapter 2.

The AVHRR SST algorithm uses the difference in brightness temperature between channel 4 and 5 (T4-T5) to estimate the radiative attenuation of the surface emitted radiance, the atmospheric correction. These differences are small over cloud free sea, typically 1-2K at high latitudes. This atmospheric correction is sensitive to radiometric noise in the two channels.

Over cloud free sea the atmospheric correction should not change much from pixel to pixel since the atmospheric conditions are similar within a few kilometers. A smoothing is therefore applied to reduce the effect of radiometric noise in the atmospheric correction term. This is done by averaging the T4-T5 value in a n*n pixel box centered on the actual pixel, where n=SFT45. Only cloud free pixels are used in this averaging.

As input to the SST algorithm is used a first guess SST. For this purpose a 10-day 9 km resolution climatology of mean SST is used. This climatology has been derived at CMS, Meteo-France from the Pathfinder archive (AVHRR data from 1985 till 1995, see Faugère et al, 2001 for details).

A quality index is calculated for each pass product, which includes confidence levels and information concerning the processing conditions (see chapter 6).

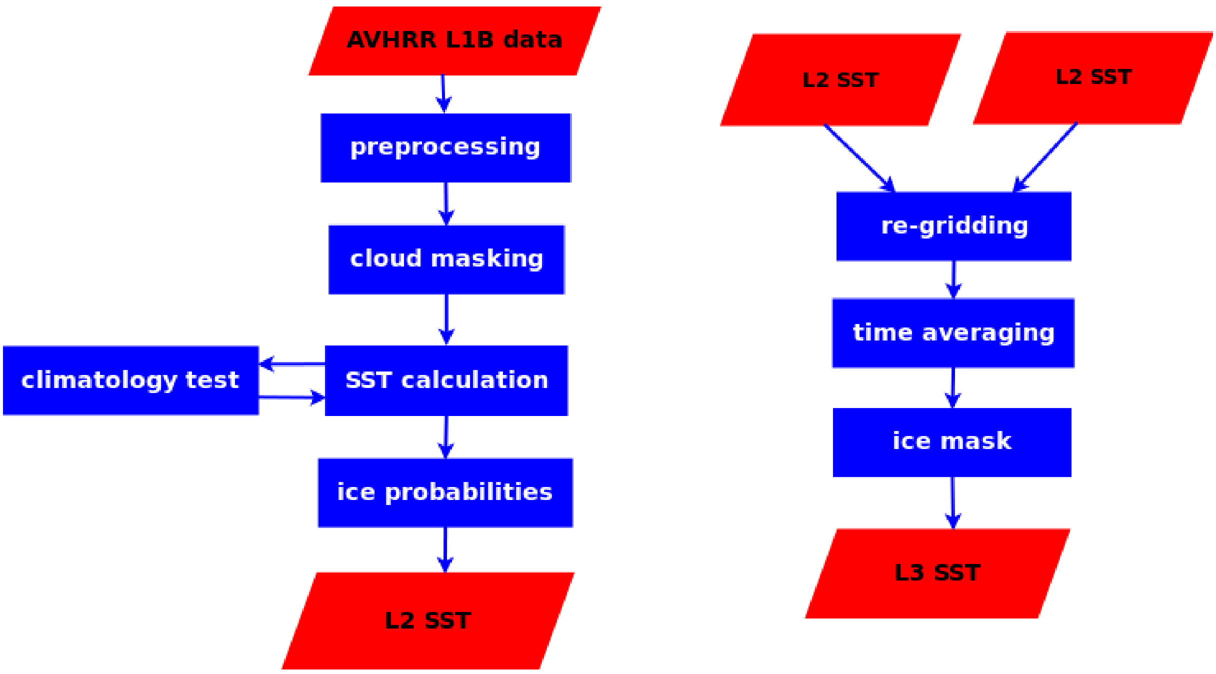

Figure 1: HL OSI SAF Sea Surface Temperature (SST) calculation scheme.

3.2.4 Climatology test

As a part of the OSI SAF L2 SST chain, a separate test is applied in addition to the PPS cloud mask to refine the cloud masking over sea. This test is based on a 10-days 9 km resolution minimum SST climatology, which has been derived at CMS, Meteo-France similarly as the mean climatology (see Faugère et al, 2001 for details).

In this climatology test each calculated SST value (Ts) is compared to the climatological minimum temperature (Tsmin) for the corresponding position and time (closest 10-day field). A Ts lower than Tsmin is indicative of cloud contamination. The minimum climatology test compares Ts with Tsmin and if the difference is lower than a certain threshold, the value is masked as cloudy. This threshold depends on the distance of the considered pixel to the closest cloud pixel in the PPS cloud mask and the location of the pixel with respect to the coast. The rationale for using distinct thresholds is the following: near a cloud, too cold temperatures are more suspect and the control of the calculated SST against climatology should be more severe. On the contrary, coastal areas may show cold patches due to winter cooling and local upwelling that might not be described by the climatology. Temperatures may thus be significantly lower than the climatology and still valid.

The processing scheme works as follows:

$$if \quad (Ts - Ts\,\mathrm{min}) < \Delta T \quad .$$

The pixel is considered as cloudy, with a variable ΔT threshold:

Variable name	**ΔT**	**Description**
MINCLIMDIFFOCL	-1.0	Open sea, not close to cloud
MINCLIMDIFFCCL	-2.0	Coastal, not close to cloud
MINCLIMDIFFONC	0.0	Open sea, close to cloud
MINCLIMDIFFCNC	-1.0	Coastal, close to cloud

- “close to a cloud” means that a cloud is detected in a n*n pixel box centered on the processed pixel where n=1+2*NEARCLPIXELS.
- “coastal pixel” means that land is detected in a n*n pixel box centered on the processed pixel where n=1+2*NEARLANDPIX .

3.2.5 SST calculation, second iteration

After the climatological test has been applied, the SST calculation step is repeated. This is mainly to recalculate the smoothed T4-T5 values, excluding the newly cloud masked pixels, and hence get a more correct T4-T5 atmospheric correction for pixels which are neighbors to these pixels.

3.2.6 Ice and cloud probabilities

The last step in the L2 SST processing is to search for undetected sea ice and clouds. The PPS cloud mask do discover most sea ice and clouds, but not all. A set of additional daytime tests is applied that calculates the probability of a pixel being cloud and ice free, given the observed reflectances. The visible and near infrared channels at 0.6, 0.9 and 1.6um (if available) are used (called R06, R09 and R16) in a Bayesian approach to combine probabilities calculated using the fraction of the reflectance (R09/R06 and R16/R06). The method for calculating these probabilities are the same as used in the Regional Sea Ice Edge product (OSI-406) and the Global Metop SST product (OSI-201), and more details are available in the Regional Sea Ice Edge ATBD (RD-2).

The probabilities for ice and cloud is used in the following way:

- if the probabilities of ice or cloud is higher than THRICEPROBMASK, then mask pixel as ice or cloud covered,
- if the probabilities of ice or cloud is between THRICEPROBDEGR and THRICEPROBMASK, then the SST quality level is degraded by one level.

3.3 12-hourly merging

The final L3 12-hourly 5km HL SST product is produced by combining available L2 1.5km satellite pass SST products, following th processing steps are shown the left part of Figure 1. The main components of the L3 processing are briefly described below.

3.3.1 Re-mapping

The re-mapping and time averaging is in a way done at the same time. The re-mapping first sets up the 5km polar stereographic HL OSI SAF grid. All SST observations/pixels from the different satellite passes are interpolated to this grid by a nearest neighbor method.

For each grid box the fraction of land is calculated from the land-sea information that is given in the satellite pass SST file (taken from the land-sea atlas). If this fraction is larger than MAXLANDFRAC, the grid box is marked as land.

3.3.2 Time averaging

The input to the 12-hourly product merging is all the available AVHRR satellite passes within the 12-hour period. The two daily 12-hourly products are centered at 00UTC and 12UTC, so that the 00UTC product covers all satellite passes from 18:00UTC the previous day to 05:59UTC the present day, and the 12UTC product covers 06:00 to 17:59UTC.

The averaging within each 10km grid box is done using the confidence level of each observation. All the observations inside one grid box are compared and only the observations with the highest available confidence level are used. If one pixel has a confidence level higher than the rest, only that is pixel used. The SST value of the grid box is then the mean of all the observations with the highest confidence level. This confidence level is then assigned to this grid box. In this way no observations with different confidence level is mixed within one grid box.

Similarly to the SST fields, a time field is calculated by averaging the times of all satellite pass SSTs effectively used to calculate the final SST value.

3.3.3 Sea Ice masking

To screen sea ice in the final SST field, the Sea Ice Edge product from the OSI SAF is used. The closest product in time is used (usually from the day before). This sea ice field is interpolated to the SST 5km grid. All grid boxes that indicate sea ice in the Sea Ice Edge field are marked as sea ice.

3.4 Validation

At METNO a matchup database (MDB) is built routinely collocating in situ measurements (buoys and ships) and satellite estimates of SST for each satellite. There is one MDB for the 1.5km satellite pass product and one for the 5km 12-hourly product.

The in situ data are collected through GTS from drifting buoys, moored buoys and ships. These observations are quality controlled. Then the observations are collocated with satellite data and SST product. For the satellite pass MDB the satellite AVHRR data (brightness temperatures and reflectances) and SST product are collected in a 15x15 pixel box centered at the pixel corresponding to the observation point. The cloud mask is used to screen out all cloudy pixels and calculate the cloud cover in the pixel box. The matchup time window is +/- 2 hours. For the 12-hourly SST product the MDB is built similarly, except only the SST product is matched against the in situ and a matchup time window of +/- 6 hours to the central time is used.

From the matchup database various statistics are made to validate the accuracy and precision of the products, mainly by investigating the bias and standard deviation of the estimated SST compare to the in situ measurement. Initial validation results are presented in the HL SST validation report ([RD.4]) and in the quarterly reports from the OSI SAF, available at http://www.osi-saf.org.

3.5 Quality control

The quality of the delivered products is controlled through a visual examination of the products and the automatic production of control parameters.

The examination of the products is done by the OSI SAF R&D team (not on a regular basis).

The automatic control have a daily and a monthly part. The daily part consists in the calculation for each 12-hourly product of the rate of confidence levels calculated as the percentage of pixels having a particular confidence level with respect to the total number of pixels. On a monthly basis the standard deviation and bias of estimates satellite SST compared with observed in situ SST are compared. For both the daily and monthly quality control warnings are issued to the production team if the values reaches certain threshold levels.

All these statistics are are reported in the quarterly report.

4 Data description

4.1 Overview

Data users have access to the following data for each 12-hourly SST product:

- a SST field,
- a time field,
- a quality index field.

These fields are coded in both GRIB and HDF format.

This chapter includes the definition of the fields (chapter 4.2 and 4.3) and a description of the formats used and the names of the products (chapter 4.4). Additional information can be found in the appendixes.

4.2 SST products

4.2.1 Characteristics

4.2.1.1 Physical definition

subskin SST : Comparable to in situ (buoy) measurements at night.

Relation to bulk SST: equivalent to bulk SST by night. By day, a bias of 1-2 Kelvin may be found under favorable diurnal heating conditions.

Relation to skin SST: By day and by night the subskin SST is convertible on average to skin temperature by subtracting 0. 2K.

4.2.1.2 Units and range

GRIB files:

- Unit: Kelvin
- Precision: 1/100 K
- Range: 271.00K to 303.00 K
- Undefined values: -32767.0

HDF files:

- Unit: Celcius
- Precision: 1/100 C
- Range of the SST in the HL product is set to -2.00 to 30.00°C

Other surfaces have these values:

- Land: -99.00 (HLSST_LAND)
- Cloud: -199.00 (HLSST_CLOUD)
- Sea ice: -299.00 (HLSST_SEAICE)
- Undefined: -999.00 (HLSST_UNDEF)

4.2.1.3 Origin

SST calculated from the IR 10.8 and 12.0 um AVHRR channels at 1.5km resolution from AVHRR data received locally at METNO and through EARS. Re-mapping is made by space and time averaging to 12-hourly products. The averaging is made using the SSTs having the best confidence level.

4.2.1.4 Geographical definition

Below are given the details of the grid definitions and approximate maps of the grid extents, corner coordinates are referenced to pixel center. Projection definitions in the form of PROJ-4 initialization strings are also given (for details, see http://www.remotesensing.org/proj).

Geographical definition for Atlantic High Latitude Grid, AHL	
Projection	Polar stereographic projection true at 60°N
Resolution	5.0 km
Size	1260 columns, 900 lines
Central Meridian	0°
Upper left corner	54.63564°N –90.15118°E
Upper right corner	66.15635°N 90.22828°E
Lower left corner	37.39928°N –40.16765°E
Lower right corner	43.20522°N 29.20606°E
Radius of Earth	6371000 m
PROJ-4 string	+proj=stere +a=6371000 +b=6371000 +lat_0=90 +lat_ts=60 +lon_0=0

The product coverage is shown in Figure 2. Actual data coverage depends on EARS coverage.

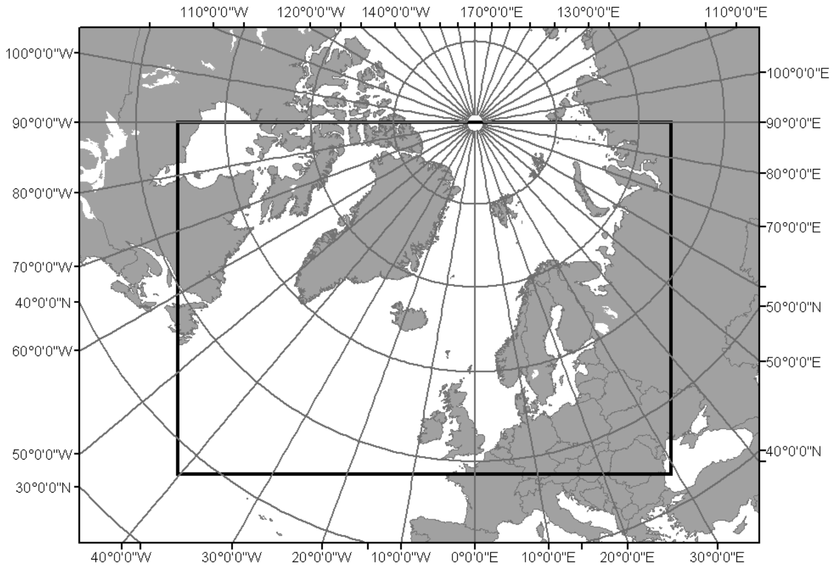

Figure 2: Coverage of HL OSI SAF 12-hourly SST products (marked by the black rectangle).

4.3 Associated fields

4.3.1 Time

4.3.1.1 Definition

The mean time of the calculated SST expressed in minutes since start time of product time interval. This means that for 00UTC products, this time is minutes since 18:00UTC the previous day, and for the 12UTC products minutes since 06:00UTC.

4.3.1.2 Origin

The production of the 12-hourly data is made by averaging over time the SSTs having the best confidence level. To each used SST value is associated a time, which is averaged in the same way as the SST to produce a mean time value.

4.3.1.3 Geographical definition

Same as that of the main product (see the preceding section)

4.3.1.4 Units and range

Unit: minutes after the product start time, which is 6 hours less than the reference time provided in the header of the files (see chapter 4.4). The reference times are the nominal mean time of the product. For the 12-hourly SST fields the reference times are 00:00 and 12:00UTC.

Range: 0 – 720 minutes.

4.3.2 Quality indexes

Each SST field (satellite pass and 12-hourly) is associated with a quality index field, coded in 16-bit words. This index includes a confidence level corresponding to the quality of the calculated SSI and information on the processing conditions, which may have some interest to the user, the OSI SAF team or both.

The confidence level scale is the same for all SST products. The pixels where the calculation has been attempted are labeled on a five level scale: 5 = “excellent”, 4= “good”, 3=”acceptable”, 2=“bad”, 1=“erroneous”, whereas the pixels where the calculation has not been attempted for normal reasons (out of the processed area) have a distinct confidence level 0=“unprocessed”. The “erroneous” confidence level may be attributed to a parameter missing due to a failure of the algorithm, cloudy, ice covered or land areas. This chapter explains the information included in the SST quality indexes, but not the coding of the 16-bit word, which is described in chapter 6.

The satellite pass SST quality index is calculated in for each satellite pass SST product in the same resolution and grid (see chapter 3). These data are not distributed, but is presented here since it directly contributes to the 12-hourly indexes. It includes confidence levels defined as follows:

- Excellent: no flagged cloud nearby and calculated SST reasonably above the climatic minimum.
- Good: close to the minimum climatological value.
- Acceptable: close to a cloudy pixel.
- Bad: close to the minimum climatological value and close to a cloudy pixel.
- Erroneous: cloud, ice or land.
- Unprocessed: out of area, missing data.

“close to minimum climatology”: SST - Tsmin < (MINCLIMDIFF + NEARMINCLIM)

“close to cloud”: there is at least 1 cloudy pixel in a n*n pixel box centered on the processed pixel (n=1+2*NEARCLPIXELS).

The values of MINCLIMDIFF, NEARMINCLIM and NEARCLPIXELS can be found in chapter 9.

In addition, the sea ice and cloud probability flags that are described in chapter 3.2.6 might also influence the confidence level. The confidence level is degraded one level if the sea ice or cloud probability flags indicates that the probability for sea ice or clouds is between THRICEPROBDEGR and THRICEPROBMASK.

The satellite pass SST quality index records the sea ice cases (for which SST values are not calculated). It also records information on the processing conditions and cloud cover identification. See chapter 6 for a full description of this quality index content.

The 12-hourly data are calculated by averaging satellite pass SSTs over time and over space. This process defines a set of pixels that may contribute to the final value. The averaging is done for pixels showing the best quality index. This quality index is that of the 12-hourly product. The coverage of the pixels contributing to the final value is recorded as a percentage of potential total pixels, as well as the number of satellite passes used. The presence of sea ice cases in the pixels is also recorded.

As part of the future upgrade of the AHL SST product to GDS v2.0 L3 format (see [RD.8]), the observation uncertainties will be provided in the product (spring 2012).

4.4 File formats

The products are available in both the WMO GRIB format and in the HDF5 format.

A complete description of the GRIB format can be found in WMO publication No 306, Manual on Codes ([RD.7]). A few parameters are encoded in the GRIB header. The header sections of the GRIB files, specific to the HL OSI SAF products, are described in chapter 7. A tool for reading GRIB files can be found at ECMWF under:

http://www.ecmwf.int/products/data/software/download/gribex.html

The HDF5 format has been defined by NCSA, and documentation is available here: http://www.hdfgroup.org/HDF5/doc

At METNO HDF5 has been used to define a common format for all the HL OSI SAF products, the OSIHDF5 format. This format uses standard features in HDF5. This format is further described in chapter 8.

4.5 Data distribution

There are two main sources for collecting the OSI SAF HL SST product; by FTP or through EUMETCast. In addition the products can be delivered through the Regional Meteorological Data Communication Network (RMDCN) on request.

At the OSI SAF High Latitude FTP server ftp://osisaf.met.no/prod/sst, the products are available on GRIB and HDF5 format. Here products from the last month can be collected. In addition there is a separate directory with archive of all previous products: ftp://saf.met.no/archive/sst. The file name convention for these products is given in the table below.

Through the EUMETSAT EUMETCast service the OSI SAF HL SST product is available on the GRIB format. The distributed files have been compressed with `gzip`. Different file name conventions have been chosen for the HL SST products at EUMETCast since many different products are disseminated through EUMETCast. More information about the EUMETCast service can be found at: http://www.eumetsat.int.

Table 2 gives the file name convention for the HL SST product.

Filename convention for HL SST files	
Through FTP	
SST HDF	sst_12h_hl_polstere-050_multi_<date12>.hdf
SST GRIB	sst_12h_hl_polstere-050_multi_<date12>.grb
QSST GRIB	qsst_12h_hl_polstere-050_multi_<date12>.grb
TSST GRIB	tsst_12h_hl_polstere-050_multi_<date12>.grb
Through EUMETCast	
SST GRIB	S-OSI_-NOR_-MULT-AHLSST_FIELD-<date12>Z.grb.gz
QSST GRIB	S-OSI_-NOR_-MULT-AHLSST_QUAL_-<date12>Z.grb.gz
TSST GRIB	S-OSI_-NOR_-MULT-AHLSST_TIME_-<date12>Z.grb.gz

Table 2: File name convention for HL SST files. <date12>: Date and time of the product on format YYYYMMDDHOMI, e.g. 201103221200.

4.6 Validation results

The accuracy of the HL OSI SAF SST products is monitored for both L2 and L3 files using two matchup databases (MDB) (see chapter 3.4 for details). The format of the MDB is shortly described in [RD.5] .

5 References

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6 Appendix A: Quality index content

Primary SST quality index	
Bit	Signification
0-2	Confidence level 5 = excellent, 4 = good, 3 =acceptable, 2 = bad, 1 = erroneous, 0 = unprocessed excellent: no flagged cloud nearby and calculated SST reasonably above the climatic minimum good: close to the minimum climatological value acceptable: close to a cloudy pixel bad: close to the minimum climatological value and close to a cloud erroneous: no cloud classification or failure in SSI calculations unprocessed: out of area, land, no satellite data
3 - 4	Satellite code 0=GOES, 1=Meteosat (MTP or MSG), 2 = Polar (NOAA or EPS), 3=unused.
5	Unused.
6	Sea ice case (if bit 6=1, then bit 15=1 and bit 9 = 1).
7	Unused.
8	Unused.
9-14	Bit 15 dependant.
15	No SST value (0=false, 1=true).
If bit 15 = 0	
Bit	Signification
9	Daytime algorithm (0=false, 1=true).
10	Nighttime algorithm (bits 9 and 10 may be both equal to 1: day-night transition)
11	All day algorithm.
If bit 15 = 1	
Bit	Signification
9	Sea ice case (0=false, 1=true).
10	Cloud case.
11-12	Cloud detection origin 0: SAFNWC cloud mask 1: SST climatology
13	No satellite data.
14	Out of the processed area.

Table 3: Description of quality index for intermediate satellite pass SST product.

12-h SST quality index	
Bit	Signification
0-2	Confidence level 5 = excellent, 4 = good, 3 =acceptable, 2 = bad, 1 = erroneous, 0 = unprocessed. They correspond to the best confidence level primary SSTs used to compute the 12-h average (primary SSTs having distinct confidence levels are not averaged together).
3 - 4	Satellite code 0=GOES, 1=Meteosat (MTP or MSG), 2 = Polar (NOAA or EPS), 3=unused
5	Unused.
6	Sea ice presence (in at least one of the primary pixels, not used, of the original set).
7	Unused.
8	Unused.
9-14	Bit 15 dependant.
15	No SST value (0=false, 1=true).
	If bit 15 = 0
Bit	Signification
9-10	Mean coverage of the pixel, i.e. average of the coverages of the primary SSTs used to calculate the 12-h SST. Coded on 4 levels: 0: <0,25%] 1: <25%,50%] 2: <50%,75%] 3: <75%,100%]
11-14	Number of primary SST values used to calculate the 12-h SST. Value: 1 to 14, 15 indicates more than 14 values are used.
	If bit 15 = 1
Bit	Signification
9	All pixels were ice covered.
10	All pixels were cloudy.
11	Unused.
12	Unused.
13	No satellite data.
14	Out of the processed area.

Table 4: Description of quality index for 12 hourly HL SST product.

7 Appendix B: Limited description of the GRIB file header

The header sections of the GRIB files, specific to the OSI SAF products, are given in the following table. The parameter names or values with a star * refer to the GRIB manual, in WMO publication No 306 - Manual on Codes.

octet	Content	value
Section 1		
1-3	Length in octets of Section 1	
4	Version number	3
5	Center identifier	88 for METNO Oslo
6	Process identifier	1 for METNO Oslo
7	grid definition	255 (grid defined in Section 2)
8	flag section 2 and 3	128* for the quality index fields (TBC) 192* for the other fields (TBC)
9	Parameter	11* for sst 210 for sst quality index 211 for sst time
10	type of level	1*
11-12	Level	0*
13-17 and 25	Reference time	
18	time unit indicator	1*
19	P1*	0
20	P2*	0
21	time range indicator	0
22-23	Number of products included	number of hourly fields (or orbits) actually included in the product
24	Number of products missing	number of missing hourly fields (or orbits)
27-28	Decimal scale factor	0*
29	Local use flag	0* (no local use)
Section 2		
1-3	Length in octets of Section 2	
4	Number of vertical coordinate parameters	0
5	Location of the list of vertical coordinate parameters	255* (not present)
6	data representation type	5 (Polar stereographic projection grid)
7-8	Number of points along x-	630

	axis	
9-10	Number of points along y-axis	450
11-13	Latitude of first grid point	37399
14-16	Longitude of first grid point	-40168
17	Resolution and component flags	00000000*
18-20	Longitude of the meridian parallel to y-axis	0
21-23	x-direction grid length	10000
24-26	y-direction grid length	10000
27	Projection centre flag	0* (North pole on the projection plane)
28	Scanning mode flags	01000000*
Section 3		
1-3	Length in octets of Section 3	
4	Number of unused bits at the end of Section 3	
06.05.11	Bitmap flag	1* for the quality index field 0* for the other fields

8 Appendix C: The OSIHDF5 format

The SST products are stored in a local implementation of the HDF5 format, which is called the OSIHDF5 format. This format is presented in a separate document, [RD.6] .

The objects and attributes of the OSI HDF5 files are given in Table 5, while the values applicable for the HL SST product is given in Table 6.

Object	Attribute	Contents
Header	source	Source of product, "OSI_SAF_HL" for all products.
	product	Type of product.
	area	Name of product grid area.
	projstr	PROJ-4 string for product projection.
	iw	Image width.
	ih	Image height.
	z	Number of fields in file, "1" for all products.
	Ax	Pixel size in x and y-direction.
	Ay	
	Bx	x and y-position of upper left corner of upper left pixel in UCS coordinates.
	By	
	year	Date and time of product.
	month	
	day	
	hour	
	minute	
data[00..nn]	description	Description of data field.
	osi_dtype	Data value type.

Table 5: Objects and elements in OSI SAF HDF5 products.

Attribute	Value
source	“OSI_SAF_HL”
product	“SST_HL”
area	“OSI SAF HL”
projstr	+proj=stere +a=6371000 +lon_0=0 +lat_ts=60 +b=6371000 +lat_0=90
iw	1260
ih	900
z	3
Ax	5,00
Ay	5,00
Bx	-3797,50
By	2,50
description[00]	“SST”
osi_dtype[00]	OSI_FLOAT
description[01]	“Qual flag SST”
osi_dtype[01]	OSI_UCHAR
description[02]	“Time flag SST”
osi_dtype[02]	OSI_USHORT

Table 6: Values for fixed attributes in Header and data fields for HL SST product.

9 Appendix D: Atlantic High Latitude SST configuration files

```
#define NUMSAT          5  /* Max number of NOAA satellites  */
#define MAXSATPROD      8  /* Number of satellite product areas used */
#define SFT45           5  /* Smoothing factor (pixels) for T4-T5  */
#define SFSA            9  /* Smoothing factor (pixels) for satellite angles */
#define NOICEFIELDS     1  /* Number of fields to be read from ice FELT file */
#define THRSZA          60.0  /* Optional threshold on satellite zenith angle when
merging */

#define THRICEPROBDEGR  25.0  /* Threshold on ice prob to degrade SST when merging */
#define THRCLDPROBDEGR  25.0  /* Threshold on cloud prob to degrade SST when merging
*/
#define THRICEPROBMASK  50.0  /* Threshold on ice prob to mask SST when merging */
#define THRCLDPROBMASK  50.0  /* Threshold on cloud prob to mask SST when merging */

#define NUMCONF 6     /* Number of confidence levels in SST quality flags */
#define CONFEX 5      /* Confidence level excellent */
#define CONFGO 4      /* Confidence level good */
#define CONFAC 3      /* Confidence level acceptable */
#define CONFBA 2      /* Confidence level bad */
#define CONFER 1      /* Confidence level erroneous */
#define CONFUN 0      /* Confidence level unprocessed */

/* Quality flag array positions for high latitude 5km SST product */
#define NUMQFLAGSHL 12  /* Number of quality flags for SSTHL products */
#define QFHLCL 0        /* Confidence level */
#define QFHLSC 1        /* Satellite code */
#define QFHLSO 2        /* Sun glint occurrence */
#define QFHLIO 3        /* Sea ice occurrence */
#define QFHLCA 4        /* Coastal area */
#define QFHLMC 5        /* Mean coverage */
#define QFHLNP 6        /* Number of passages used */
#define QFHLSI 7        /* Sea ice occurrence */
#define QFHLCO 8        /* Cloud occurrence */
#define QFHLND 9        /* No satellite data */
#define QFHLOA 10       /* Out of area */
#define QFHLNS 11       /* No SST value */

/* Quality flag array positions for high resolution SST product */
#define NUMQFLAGSHR 14  /* Number of quality flags for SSTHR products */
#define QFHRCL 0        /* Confidence level */
#define QFHRSC 1        /* Satellite code */
#define QFHRSO 2        /* Sun glint occurrence */
#define QFHRIO 3        /* Sea ice occurrence */
```

```
#define QFHRCA 4        /* Coastal area */
#define QFHRDA 5        /* Daytime SST algorithm */
#define QFHRNA 6        /* Nighttime SST algorithm */
#define QFHRAA 7        /* All day SST algorithm */
#define QFHRSI 8        /* Sea ice occurrence */
#define QFHRCO 9        /* Cloud occurrence */
#define QFHRCD 10       /* Cloud detection origin */
#define QFHRND 11       /* No satellite data */
#define QFHROA 12       /* Out of area */
#define QFHRNS 13       /* No SST value */

#define MINHLSST -2.0        /* Minimum SST value at high latitudes */
#define MAXHLSST 30.0        /* Maximum SST value at high latitudes */
#define OFFSHIGHSSTVAL 10.0  /* Offset added to mean clim for upper gross error check
*/
#define MINHLSSTGRAD 0.0     /* Minimum SST gradient value at high latitudes */
#define MAXHLSSTGRAD 3.0     /* Maximum SST gradient value at high latitudes */

/* Lowest allowed difference between calc and clim min SST */
#define MINCLIMDIFFOCL -1.0   /* Open sea, clear areas */
#define MINCLIMDIFFCCL -2.0   /* Costal, clear areas */
#define MINCLIMDIFFONC  0.0   /* Open sea, near cloud */
#define MINCLIMDIFFCNC -1.0   /* Coastal, near cloud */

#define NEARCLPIXELS 2       /* Radius of pixels box to define "near cloud" */
#define NEARLANDPIX  50      /* Radius of pixels box to define "near land" */
#define NEARMINCLIM  1.0     /* Temperature diff defining near clim minimum */

#define MAXLANDFRAC 0.5      /* Maximum land fraction for calculating SST */
#define MINSSTAVR 3          /* Minimum number of SST calculations within
                                one grid box for averaging SST */
#define MAXEXPRAD 10         /* Maximum radius for extrapolation of sea ice edge
                                info into unclassified pixels */

/* Ice and cloud post processing flags */
#define ICEFLCOEFF_NPDF 3
#define ICEFLCOEFF_NCLS 3
#define ICECLFL_UNDEF 255
/* High Latitude SAF SST field values */
#define HLSST_LAND -99.0
#define HLSST_CLOUD -199.0
#define HLSST_SEAICE -299.0
#define HLSST_UNDEF -999.0

/* Cloud mask pixel values */
```

```
#define MASK_UNPROC   0
#define MASK_CLFREE   1
#define MASK_CLOUD    2
#define MASK_LAND     3
#define MASK_SEA      4
#define MASK_SNOWICE  5
#define MASK_UNCLASS  6

/* Parameters for HDF5 SST files */
#define  HLSSTH5P_PROJSTR  "+proj=stere  +a=6371000  +lon_0=0  +lat_ts=60  +b=6371000
+lat_0=90"
```