

Ocean&SeaIceSAF

HighLatitudeSeaSurfaceTemperature

ProductManual

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1 Introduction

1.1 Purpose-Scope

This manual presents the High Latitude (HL) Sea Surface Temperature (SST) product from the Ocean & Sea Ice Satellite Application Facility (O&SISAF). The intended readers are users of the Merged Atlantic SST product (see below) and others interested in the production of the HLSST products.

1.2 Overview

The O&SISAF is producing on a preoperational basis a range of fair-weather sea interface products, namely: wind, sea ice characteristics, Sea Surface Temperatures (SST) and radiative fluxes, Surface Solar Irradiance (SSI) and Downward Longwave Irradiance (DLI).

SST, SSI and DLI products are available within 2 hours after the last satellite data acquisition over the following grids:

- NAR: Near Atlantic Regional, six areas at 2 km resolution
- LML: Low and Mid Latitudes, 100W -45E and 60N -60S, at 0.1 degree resolution
- MAP: Merged Atlantic Products, 100W -45E and 89.9N -60S, at 0.1 degree resolution.

These products are described in more details in Brisson et al. (2001).

The High Latitude (HL) SST products are input to the MAP SST products. HLSST products are derived from NOAA polar-orbiting data. Intermediate SST products for each pass are input to the HLSST products that are delivered every 12 hours. These 12-hourly products are delivered to Meteor-France through FTP. These products are available in HDF5 and GRIB format through the DNMI server (<ftp://ftp.dnmi.no/saf/prod>). See also <http://saf.dnmi.no> for real-time examples of the products and updated information.

This document is one of the product manuals dedicated to the O&SISAF product users. It describes the High Latitude part of the MAP SST products, covering the intermediate single satellite pass products and the 12-hourly HLSST products. At present these products are based on NOAA/AVHRR data north of 50N over the West Atlantic. METOP/AVHRR data will be used when they are available. This document only presents information about the NOAA/AVHRR processing. Information concerning the processing of METOP/AVHRR will be added to the present document when available.

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

1.3 Glossary

AVHRR	Advanced Very High Resolution Radiometer
CMS	Centre de Météorologie Spatiale
DLI	Downward Longwave Irradiance
O&SISAF	High Latitude SST Product Manual version 1.2 October 2002

DMI	Danish Meteorological Institute
DNMI	Det Norske Meteorologiske Institutt
GOES	Geostationary Operational Environmental Satellite
GRIB	Gridded Binary Format
HDF	Hierarchical Data Format
HL	High Latitudes
LML	Low and Mid Latitudes
LMD	Laboratoire de Météorologie Dynamique
MAP	Merged Atlantic Products
MODTRAN	Moderate Resolution Transmittance Model
MSG	Meteosat Second Generation
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

2 Algorithms

2.1 Development method

The developments of the O&SISAF 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 (or with very few clouds) 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 differential algorithm formalisms NOAA-14 was chosen. With the calculated coefficients the differential algorithm formalisms have been applied on the Pathfinder Match-up Data Base (Podesta et al. 1997) to compare the performance of the differential algorithm formalisms at high latitudes. From these studies an on-line split window algorithm 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 the NOAA satellites. This correction rises however the question of the definition of the satellite derived SST.

Satellites actually measure the skin temperature (the temperature of the first few microns of the ocean surface), a quantity that may be measured by radiometers mounted on ships on the experimental scale, but not yet to a scale representative of all ocean conditions. Significant validation data can only be obtained by buoy measurements at depths 0.5 to 1 meter beneath the skin layer. The skin-bulk difference is about 0.2 K by night (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 a simulation derived algorithm 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 subsurface 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 subsurface skin SST, since the skin effect (i.e. the skin minus subsurface 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 subskin SST definition has thus been adopted in the operational stage, since it allows representative validation by night, and preserves the evaluation of skin SST by day.

2.3 NOAA-14 and NOAA -16 algorithms

NOAA-14 carries the AVHRR/2 instrument that has one visible, one near-infrared and three infrared (IR) channels. The three IR channels can be used for “split window” and “triple window” algorithms. The validation of differential algorithms for NOAA -14 shows 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, both day and night.

NOAA-16 carries the AVHRR/3 instrument that has an additional near-infrared channel compared to NOAA -14, but the other five channels have similar characteristics. The filter functions are also slightly different, which makes it necessary to use distinct coefficients for the SST algorithms.

The algorithm 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. At high latitudes there are not so many in situ observations available, and the correction term will be monitored over a long time period to check the consistency.

The selected nonlinear (NL) algorithm has the following form:

$$T_s = (A_0 + A_1 S) T_4 + (B_0 + B_1 S + B_2 T_{guess}) (T_4 - T_5) + C_0 + C_1 S, \quad \text{Eq. 1}$$

where $A_0, A_1, B_0, B_1, B_2, C_0$ and C_1 are constants given in Table 1, T_s is the calculated SST, T_4 and T_5 are the brightness temperatures in channel 4 and 5, respectively. The climatologic SST is used as T_{guess} . $S = \sec(\theta) - 1$ with θ : satellite zenith angle; all temperatures are in Celsius.

	A_0	A_1	B_0	B_1	B_2	C_0	C_1	Corr.
NOAA-14	0.9879	0.0041	1.1067	0.4892	0.0305	0.4216	0.5270	0.0
NOAA-16	0.95576	0.00	0.00	0.92937	0.07955	0.97607	0.00	0.00

Table 1: Coefficients of the Non-Linear SST algorithms for NOAA -14 and 16.

The coefficients used for NOAA -16 are the same as for the NAR -products. The differences in performance between the mid latitudes and high latitudes for the differential algorithms were small for NOAA -14 and for NOAA -16 the NAR -algorithm is slightly better.

Coefficient files

The coefficients used are replaced in a 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. n1.1 p2.0),

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 numbers indicate the following changes:

X	Coefficients for newsatellite from newsatellite mission have been included (e.g. METOP in 2006).
Y	Coefficients for newsatellite 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 changes.

Updated information about the current and previously used coefficient files can be found on the HLOSISAF web page: http://saf.met.no/p/sst/algo/sst_algo.shtml.

Expected accuracy:

The expected accuracy is defined as the expected bias and standard deviation of the primary calculations against drifting buoy measurements determined on a monthly or yearly basis.

Bias: Apart from the first 2 months after the launch of a newsatellite, the monthly biases should remain within ± 0.4 C by night. By day at summer local biases of ± 2 K are possible.

Standard deviation: The standard deviation is expected to be lower than 0.5 C on a yearly basis, while the monthly values can be higher.

A critical point for the validation is the number of available observations. At high latitudes there are few in situ observations and often cloudy conditions over seas, which give few validation points. Therefore for some months it can be difficult to determine representative validation results.

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 the polar satellite data (NOAA and METOP). At present only NOAA-16 data received locally at DNMI is used. NOAA-14 experienced a sensor failure in 2001 and is therefore not used. The postponement of METOP launch implicates that the NOAA satellites will be the only data source at high latitudes during the intermediate operational phase of the OSISAF.

This chapter describes the processing of the polar satellite 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 represented in APPENDIX E.

3.2 Satellite pass processing

The primary SST calculations are at present made from each NOAA 16 pass received at DNMI. The processing steps are presented in Figure 1. This scheme should also be valid for METOP.

Four main components of the processing are briefly described in this section: the preprocessing, the cloud mask, the SST calculations and the atlas used in the processing.

Preprocessing

At DNMI the AVHRR data are preprocessed and the calibrated and rectified data are redivided into 4 product tiles. These product tiles are in a 1.5 km polar stereographic projection, each covering 1200x1200 pixels, that is 1800x1800 km². They are covered by these tiles as shown in Figure 2.

Cloudmasking

The cloud mask in use is the cloud mask developed for high latitudes by SMHI in the NWC SAF¹ (Dybbroe et al., 1999, Dybbroe et al., 2001). Some additional tests have been added to this cloud mask to refine the cloudmasking over sea. These tests are based on a fine scale minimum SST climatology.

The local calculated SST value (T_s) is compared to the climatology minimum temperature at the time of year in question (T_{smin}). A ten-day climatology is used for this purpose. A too low SST is indicative of cloud contamination and the "too low" threshold depends on the distance of the considered pixel to the pre-calculated 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.

¹ see <http://www.smhi.se/saf>

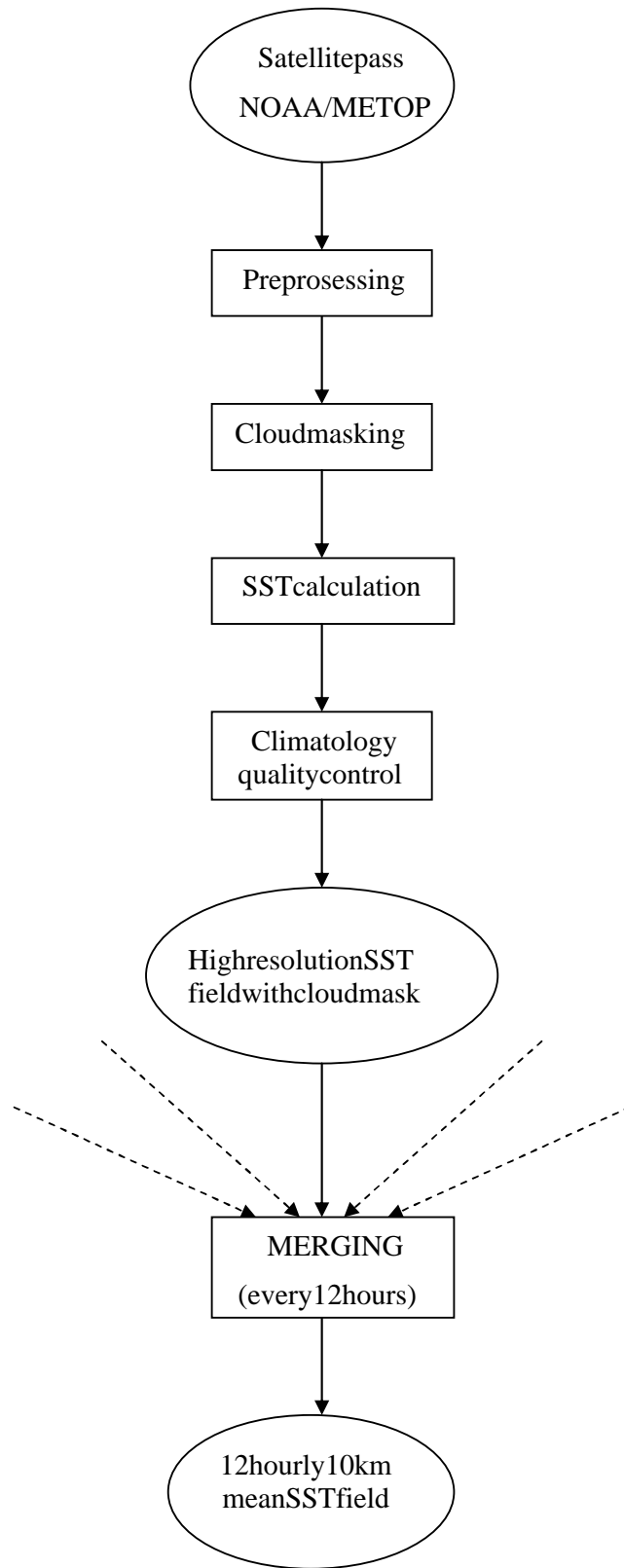


Figure 1: HLOSISAF Sea Surface Temperature (SST) calculation scheme.

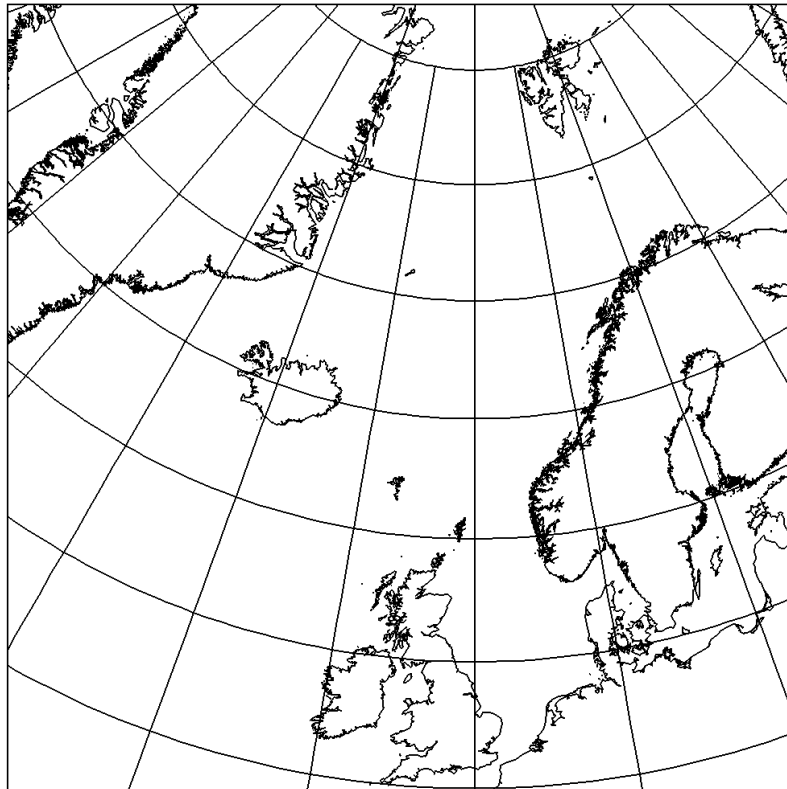


Figure 2: Area covered by the four product tiles for the AVHRR data at DNMI.

should be more severe. On the contrary coastal areas may show very cold patches due to winter cooling that could have not been described by the climatology. Temperatures may thus be significantly lower than the climatology.

The processing scheme works as follows:

$$\text{if } (T_s - T_{s \text{ min}}) < \Delta T,$$

the pixel is considered as cloudy, with four ΔT threshold:

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 an n pixel box centered on the processed pixel where $n = 1 + 2 * \text{NEAR_CL_PIXELS}$.
- “coastal pixel” means that land is detected in an n pixel box centered on the processed pixel where $n = 1 + 2 * \text{NEAR_LAND_PIX}$.

In other words the calculated SST must be warmer than the minimum climatology by 1 K near a cloud in the open ocean, whereas it can be colder by 2 K far from a cloud in the coastal area. The “close to a cloud” and “coastal pixel” criteria are given in the quality index (APPENDIX A).

SST Calculations

SST are derived from each NOAA 16 pass (will be extended with future NOAA and METOP satellites) from the channel 4 and channel 5 brightness temperatures (T_4 and T_5) at both day and night (see chapter 2 for algorithm description).

The AVHRR SST algorithm uses the difference in brightness temperature between channel 4 and 5 ($T_4 - T_5$) to estimate the radiative attenuation of the surface emitted radiance, the atmospheric correction. These differences are small over cloud free sea, typically 1 - 2 K at high latitudes. This atmospheric correction is sensitive to radiometric noise in the two channels. Over cloud free sea the atmospheric corrections 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 $T_4 - T_5$ value in an n pixel box centered on the actual pixel, where $n = \text{SFT}45$. Only cloud free pixels are used in this averaging.

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

Atlas

Land-sea: contains land, sea and lake. The same land-sea atlas used in the cloud masking is used. This land-sea atlas has been derived from GTOPO30², using PROJ4³. The atlas includes 2 types of pixels, “land” and “sea”. “sea” includes sea and lakes. The fraction of each type inside a pixel is used to choose between the two types. SST calculations are done over the “sea” pixels.

SST minimum: A fine scale (about 9 km) climatology of minimum temperatures has been derived at CMS from the Pathfinder archive (AVHRR data from 1985 till 1995, see Faugère et al, 2001). This climatology has been made on 10-day basis and includes minimum values re-mapped over the High Latitude OSISAF grid. Minimum values are used in the cloud masking.

SST mean: A fine scale (about 9 km) climatology of mean temperatures has been derived at CMS from the Pathfinder archive (AVHRR data from 1985 till 1995, see Faugère et al, 2001). This climatology has been made on 10-day basis and includes mean values re-mapped over the High Latitude OSISAF grid. Mean values are used in the daytime non-linear algorithms.

² see <http://edc.usgs.gov/products/elevation/gtopo30.html>

³ see <http://www.remotesensing.org/proj>

3.3 12-hourly merging

The input to the 12-hourly merging is the 1.5 km resolution satellite pass SST products. The output is a 10 km resolution product, so this merging consists of 2 steps: time averaging and re-mapping. These steps are described below.

Re-mapping

Re-mapping and time averaging is done in a way done at the same time. The re-mapping first sets up the 10 km polar stereographic HLOSISAF grid. All SST observations/pixels from the different satellite passes are refitted to this grid by position, so that each pixel is used in the grid box it is situated in.

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.

Time averaging

The input to the 12-hourly product merging is all the NOAA-16 satellite passes within the 12-hour period. The 2 daily 12-hourly products are centered at 00 UTC and 12 UTC, so that the 00 UTC product covers all satellite passes from 18 UTC the previous day to 06 UTC, and the 12 UTC product covers 06-18 UTC.

The averaging within each 10 km 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 pixel is 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 levels are mixed within one grid box.

To screen sea ice in the final SST field, the Sea Ice Edge product from the OSISAF is used. The closest product is used (usually from the day before). This field gives the sea ice edge in the same HLOSISAF grid as for the 12-hourly HLSSST product. All grid boxes that indicate sea ice in the Sea Ice Edge field are marked as sea ice.

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.

3.4 Validation

At DNMI a matchup database (MDB) is built routinely collocating in situ measurements (buoys and ships) and satellite estimates of SST for each satellite. The satellite pass SST products are used for this matchup database, and not the 12-hourly product. Therefore only the satellite pass SST products are validated directly.

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. 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.

From the match up database various graphs are made to validate the accuracy of the product and monitor the error. The error is plotted against several parameters to look for systematic errors, such as satellite zenith angle.

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 OSISAF R&D team (not on a regular basis).

The automatic control consists in the calculation for each 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. Those statistics are recorded in a quality control file for each 12 hourly product (APPENDIX D). From series of these files graphs are produced to monitor the confidence levels and their evolution with time.

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 GRIB and HDF format.

This section includes the definition of the fields (chapter 4.2 and 4.3), a description of the formats used and the names of the products (chapter 4.4) and chapter 4.5 and 4.6 describe the validation and quality control information, respectively. Additional information can be found in APPENDIX A to APPENDIX E.

4.2 SST products

Characteristics

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 to skin temperature by subtracting 0.2 K.

Units and range, GRIB files

Unit: Kelvin

Precision: 1/100 K

The range of the SST in the HL product is set to 273.15 K to 303.15 K.

Undefined values: -32767.0

Units and range, HDF files

Unit: Celsius

Precision: 1/100 C

The range of the SST in the HL product is set to -2.0 to 30.0 C

Other surfaces have these values:

- Land: -99.00 (HLSST_LAND)
- Cloud: -199.00 (HLSST_CLOUD)

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- Seaiice: -299.00(HLSST_SEAICE)
- Undefined: -999.00(HLSST_UNDEF)

Origin

SSTcalculatedfromtheIRchannel4and5ofAVHRRatfullresolutionforeachNOAA -16 pass(atpresentonlyNOAA -16isused).Re -mappingismadebyspaceandtimeaveragingto 12-hourlyproducts.TheaveragingismadeusingtheSSTshavingthebestconfidencelevel.

Geographicaldefinition

Projection: Polarstereographic,trueat60N,notrotated.

Resolution: 10kmat60N

Size: 630*450

Productcoverage: See Figure 3.

Actualdatacoverage:see Figure 1.

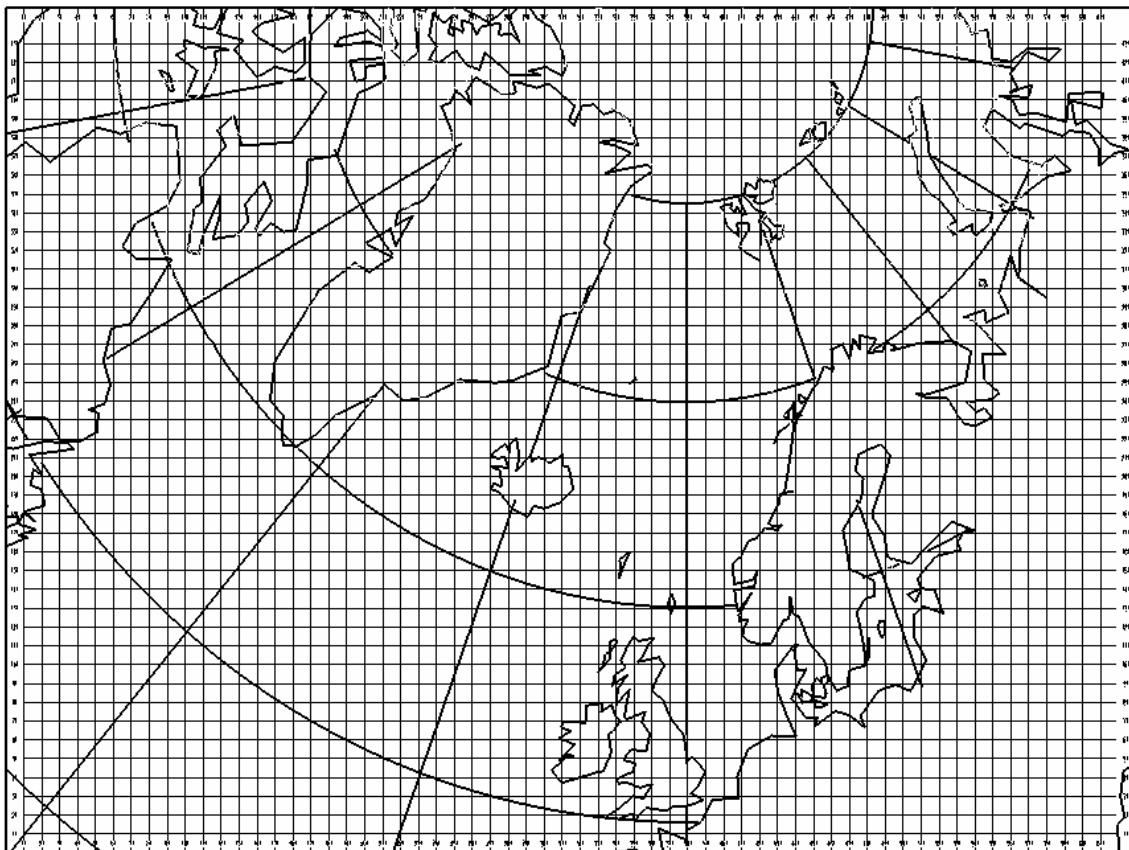


Figure 3:CoverageofHLOSISAF12 -hourlySSTproducts.Each10.gridpointisshown.

4.3 Associated fields

Time

Definition

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

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.

Geographical definition

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

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.

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 O&SISAF 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”, where as 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 section explains the information included in the SST quality indexes, but not the coding of the 16-bit word, which is described in APPENDIX A.

The satellite pass SST quality index is calculated in fore 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 climatologic 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 - T_{min} < (MINCLIMDIFF + NEARMINCLIM)

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

The values of MINCLIMDIFF, NEARMINCLIM and NEARCLPIXELS can be found in APPENDIX E.

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

The 12-hourly data are recalculated 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.

4.4 File formats

The products are available in 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. A few parameters are encoded in the GRIB header. The header sections of the GRIB files, specific to the HLOSISAF products, are described in APPENDIX B.

The HDF5 format has been defined by NCSA, see <http://hdf.ncsa.uiuc.edu/HDF5> for documentation. At DNM, HDF5 has been used to define a common format for all the HLOSISAF products, the OSIHDF5 format. This format uses standard features in HDF5. This format is further described in APPENDIX C.

4.5 Validation results

The accuracy of the HLOSISAF SST products is monitored at the satellite pass level through statistics applied on a match-up database (MDB) (see chapter 3.4 for details). The MDB itself is available on request. Validation results will be presented on the website. Validation results are presented in Table 2. NOAA-14 shows good validation results, but the high bias of NOAA-16 is unexpected and will be further investigated. The validation of NOAA-16 is further described in Eastwood (2002). More validation results will be presented on our website (<http://saf.met.no>) as the validation goes on.

	num.obs.	std.dev.	bias	meanSST
NOAA14,night,03.2001 -07.2001	37	0.27	0.20	8.88
NOAA-14,day,03.2001 -07.2001	224	0.36	0.06	9.37
NOAA-16,night,01.2002 -07.2002	315	0.63	-0.55	7.87
NOAA-16,day,01.2002 -07.2002	437	0.52	-0.59	8.73

Table 2: Validation result of HLOSISAF SST data against drifting buoys.

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4.6 Quality control results

The processing conditions are evaluated through the calculation of confidence levels (described in APPENDIX A) made in real time in the processing chain. The automatic quality control calculates the confidence level distribution and stores the results in the quality control file of the field (described in APPENDIX D). These files can be concatenated and presented in graphics. An example of this is shown in Figure 4. This figure shows that a large part of the processed area is covered by clouds, sea ice and land.

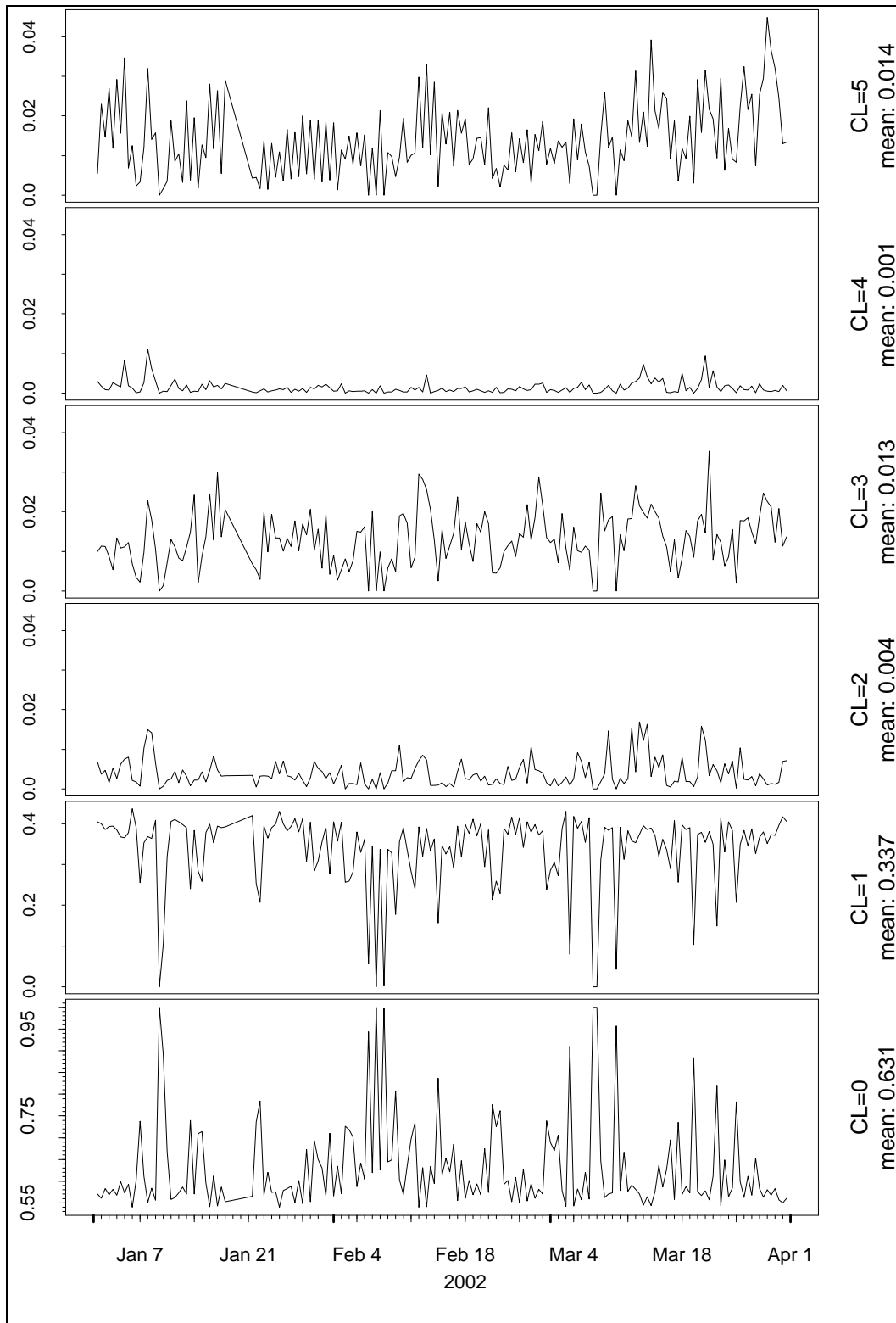


Figure 4: Distribution of the 12-hourly derived SST confidence levels in January, February and March 2002. CL=0,1,2,3,4 and 5 represent unprocessed, erroneous, bad, acceptable, good and excellent, respectively. Erroneous represents clouds, land and ice, while unprocessed represents areas with no data.

5 References

- Andersen, S., A. Brisson, S. Eastwood, P. Le Borgne, A. Marsouin, 1998, Developments on SST retrieval over the Atlantic using geostationary and polar orbiters satellite data in the frame of Eumetsat Ocean and Sea Ice Satellite Application Facility. Proceedings of the 9th conference on satellite meteorology and oceanography, Paris, 246 -249.
- Bernstein L.S., A. Berk., P.K. Acharya, D.C. Robertson, G.P. Anderson, J.H. Chetwynd, L.M. Kimball, 1996, Very Narrow Band Model Calculations of Atmospheric Fluxes and Cooling Rates Using the MODTRAN Code, *J. Atmos. Sci.*, **53**, 2887 -2904.
- Brisson A., P. Le Borgne and A. Marsouin, 2001: OSISAF Atlantic Sea Surface Temperature Product manual, v1.1. CMS/Meteo -France, Lannion, France.
- Brisson, A., P. Le Borgne, A. Marsouin, 1998, Development of algorithms for SST retrieval at O&SISAF Low and Mid Latitudes. CMS report to EUMETSAT, Météo -France/CMS 22302 Lannion, France.
- Dybbroe, A., K.G. Karlsson and A. Thoss, 1999: The AVHRR cloud mask scheme of the SAFNWC. Proceedings of the 1999 EUMETSAT Meteorological Satellite Data Users' conference, Copenhagen, Denmark.
- Dybbroe, A., Thoss, A. and Karlsson, K. -G., 2001: Validation of Nowcasting SAF Polar platform products. Proceedings of the 2001 Eumetsat Meteorological Satellite Data Users Conference, October 1 -5, Antalya, Turkey, pp. 344 -451. ISBN: 92 -9110-044-7.
- Eastwood, S., 2002: Validation of the High Latitude SST product for NOAA 16 from the OSISAF. O&SISAF report. Available at <http://saf.met.no>.
- Faugère, Y., P. Le Borgne, and H. Rouquet, 2001, Réalisation d'une climatologie mondiale de température de surface à échelle fine, to appear in *La Météorologie*.
- Godøy, Ø., 2002: Description of the osihdff format. OSISAF document, Norwegian Meteorological Institute. Available at <http://saf.met.no>.
- Podesta G.P., S. Shenoi, J.W. Brown and R.H. Evans, 1997, AVHRR Pathfinder Oceans Matchup database 1985 -1995 version 19.0, <http://www.rsmas.miami.edu/~gui/matchups.html>.

APPENDIXA Qualityindex content

PrimarySSTqualityindex	
Bit	Signification
0-2	Confidencelevel 5=excellent, 4=good, 3=acceptable,2=bad,1=erroneous,0=unprocessed excellent:noflaggedcloudnearbyandcalculatedSSTreasonablyabovethe climaticminimum good: close tothemimum climatologicvalue acceptable:closetoacloudypixel bad: closetotheminimumclimatologicvalueandclosetoacloud erroneous: nocloudclassificationorfailureinSSlcalculations unproc essed:outofarea,land,nosatellitedata
3 -4	Satellitecode 0=GOES,1=Meteosat(MTPorMSG),2=Polar(NOAAorEPS),3=unused.
5	Unused.
6	Seaicecase(ifbit6=1,thenbit15=1andbit9=1).
7	Unused.
8	Unused.
9-14	Bit15dependant.
15	NoSSTvalue(0=false,1=true).
Ifbit15=0	
Bit	Signification
9	Daytimealgorithm(0=false,1=true).
10	Nighttimealgorithm(bits9and10maybebothequalto1:day -nighttransition)
11	Alldayalgorithm.
Ifbit15 =1	
Bit	Signification
9	Seaicecase(0=false,1=true).
10	Cloudcase.
11-12	Clouddetectionorigin 0:SAFNWCcloudmask 1:SSTclimatology
13	Nosatellitedata.
14	Outoftheprocessedarea.

12-hSSTqualityindex	
Bit	Signification
0-2	Confidencelevel 5=excellent,4=good,3=acceptable,2=bad,1=erroneous,0=unprocessed. TheycorrespondtothebestconfidencelevelprimarySSTsusedtocomputethe 12-haverage(primarySSTshavingdistinctconfidencelevelsarenotaveraged together).
3 -4	Satellitecode 0=GOES,1=Meteosat(MTPorMSG),2=Polar(NOAAorEPS),3=unused
5	Unused.
6	Seaicepresence(inatleastoneoftheprimarypixels,notused,oftheoriginal set).
7	Unused.
8	Unused.
9-14	Bit1 5dependant.
15	NoSSTvalue(0=false,1=true).
Ifbit15=0	
Bit	Signification
9-10	Meancoverageofthepixel,i.e.averageofthecoveragesoftheprimarySSTs usedto calculatethe12 -hSST. Codedon4levels:0:<0,25%]1:<25%,50%]2:<50%, 75%]3:<75%,100%]
11-14	NumberofprimarySSTvaluesusedto calculatethe12 -hSST.Value:1to14,15 indicatesmorethan14valuesareused.
Ifbit15=1	
Bit	Signification
9	Allpixelswereicecovered.
10	Allpixelswerecloudy.
11	Unused.
12	Unused.
13	Nosatellitedata.
14	Outoftheprocessedarea.

APPENDIX B Limited description of the GRIB file header

The header sections of the GRIB files, specific to the OSISAF 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 octet of Section 1	
4	Version number	3
5	Center identifier	88 for DNMIOslo
6	Process identifier	1 for DNMIOslo
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 octet of Section 2	
4	Number of vertical coordinate parameters	0

5	Locationofthelistof verticalcoordinate parameters	255*(notp resent)
6	datarepresentationtype	5(Polarstereographicprojectiongrid)
7-8	Numberofpointsalongx axis	- 630
9-10	Numberofpointsalongy axis	- 450
11-13	Latitudeoffirstgridpoint	37399
14-16	Longitudeoffirstgridpoint	-40168
17	Resolutionandcomponent flags	00000000*
18-20	Longitudeofthemeridian paralleltoy -axis	0
21-23	x-directiongridlength	10000
24-26	y-directiongridlength	10000
27	Projectioncentreflag	0*(Northpoleontheprojectionplane)
28	Scanningmodeflags	01000000*
Section3		
1-3	LengthinoctetsofSection3	
4	Numberofunusedbitsatthe endofSection3	
5-6	Bitmapflag	1*forthequalityindexfield 0*fortheotherfields

APPENDIX C The OSIHDF5 format

The SST products are stored in a local implementation of the eHDF5 format, which is called the OSIHDF5 format. This format is presented in a separate document, Godøy (2002), available through our web-server (<http://saf.met.no>).

In Table 3 the parameters that are distinct for the HLSST product are represented. The other parameters are given in Godøy (2002).

HLOSISAF12 -hourlySSTproductHDF5format		
Object	Element	Contents
Header	source	“OSI_SAF_HL”
	product	“SST_12H”
	area	<empty>
data[00]	Description	“SST_12H”
	osi_dtype	OSI_FLOAT

HLOSISAF12 -hourlyQSSTproductHDF5format		
Object	Element	Contents
Header	source	“OSI_SAF_HL”
	product	“QualflagSST”
	area	<empty>
data[00]	Description	“QualflagSST”
	osi_dtype	OSI_USHORT

Table 3: Description of some of the parameters in the OSIHDF format for the SST product and QSST (quality flag) product.

APPENDIX D Description of the quality control file

A quality control file is associated to each 12-hourly SST product, including information about the distribution of confidence level in each product. The file is an ASCII file where the separator between each field is the blank character.

Example:

2002050700002835000.57670.34600.00210.02220.00310.0498

fieldname	purpose
ref_date	referenced date and time of the product in UTC
ref_time	format: YYYYMMDD (date) and HHMMN (time)
num_pix	total number of pixels in product
cl0_frac	fraction of pixels with confidence level 0, 0 to 1
cl1_frac	fraction of pixels with confidence level 1, 0 to 1
cl2_frac	fraction of pixels with confidence level 2, 0 to 1
cl3_frac	fraction of pixels with confidence level 3, 0 to 1
cl4_frac	fraction of pixels with confidence level 4, 0 to 1
cl5_frac	fraction of pixels with confidence level 5, 0 to 1

APPENDIXE HighLatitudeSSTconfigurationfiles

```
/*
 * NAME: saf_sst.h
 *
 * PURPOSE: Header file for High Latitude O&SI SAF SST
 *          software.
 *
 * AUTHOR: Steinar Eastwood, DNMI/FOU, 21.08.2000
 * MODIFIED: SE, DNMI, 23.01.2001, 11.06.2001
 *           SE, DNMI, 11.09.2001    Changed names on BIAS variables
 *           SE, DNMI, 17.12.2001    NUMSAT = 5
 */

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

#define NUMQFLAGSHL 12 /* Number of quality flags for SSTHL products */
/* Quality flag array positions for high latitude 10km SST product */
#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 */

#define NUMQFLAGSHR 14 /* Number of quality flags for SSTHR products */
/* Quality flag array positions for high resolution SST product */
#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 T4BIASN14 0.99 /* Bias in T4 for NOAA14 */
#define T5BIASN14 1.29 /* Bias in T5 for NOAA14 */

#define MINHLSST -2.0 /* Minimum SST value at high latitudes */
#define MAXHLSST 30.0 /* Maximum SST value at high latitudes */
#define MINHLSSTGRAD 0.0 /* Min SST gradient value at high latitudes */
#define MAXHLSSTGRAD 3.0 /* Max 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 /* Coastal, 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 /* Max land fraction for calculating SST */
#define MINSSTAVR 3 /* Minimum number of SST calculations within

```

one grid box for averaging SST */

/* 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 SSTH5P_LEVELS 1 /* Number of levels of data on HDF5 file */
#define SSTH5P_DESC "SST" /* Product description passage product */
#define SSTH5P_DESC_12H "SST_12H" /* Product desc 12 hour product */
#define SSTH5P_SOUR "NOAA" /* Product source passage product */
#define SSTH5P_SOUR_12H "OSI_SAF_HL" /* Product source 12 hour product */
#define SSTH5P_AREA "DNMI" /* Product area passage product, not used */
#define SSTH5P_AREA_12H "OSI_SAF_HL" /* Product area 12 hour product */
#define SSTH5P_DT OSI_FLOAT /* Data type */
```

/* Parameters for HDF5 QSST files (quality flags) */

```
#define QSSTH5P_LEVELS 1 /* Number of levels of data on HDF5 file */
#define QSSTH5P_DESC "Qual flag SST" /* Product description */
#define QSSTH5P_DT OSI_USHORT /* Data type */
```