Low Earth Orbiter
Sea Surface Temperature
Product User Manual

GBL SST (OSI-201-b)

NAR SST (OSI-202-b)

MGR SST (OSI-204-b)

IASI SST (OSI-208-b)

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Document Change record

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1.0		22/10/2007		First version.
1.1		30/10/2007		Version taking into account EUMETSAT comments on version 1.0 : from Dominique Faucher on 23/10/07, Peter Schluess on 24/10/07 and Hans Bonekamp on 25/10/07.
1.2		12/02/2008		Description of the GRIB ed 2 included in appendix A.2
1.3		31/07/2008		• Section 5 presents the validation results (in place of Preliminary validation results) • Appendix A1 : A1.1 accounts for the modifications of the NetCDF global attributes that were suggested by EUMETSAT. A1.2 describes the final names adopted when the products became demonstrational.
1.4		26/08/2008		Section 5, access to data added.
1.5		09/01/2009		in the introduction data volume updated and explanation given on product confidence levels
2.0		20/05/2009		The Metop/AVHRR Sea Surface Temperature Product User MANUAL is replaced by the Low Earth Orbiter Sea Surface Temperature Product User Manual, addressing the products derived from NOAA and MetOp AVHRR data, an in the future from NPP/VIIRS data. The NAR SST over one unique area, replacing the NAR SST over 7 areas, is addressed in the current PUM, while the old NAR SST over 7 sub-areas is addressed in the NOAA NAR PUM.
2.1		04/11/2009		Version updated when NOAA-18 is replaced by NOAA-19. Introduction updated. Chapter on validation results removed (reference given to the Validation reports)
2.2		12/05/2010		Modification in GRIB2 NAR SST description (Appendix A.2)
2.3		05/06/2013		Modification in Appendix A.1
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2.5		30/09/2013		Updated version taking into account NAR SST VIIRS ORR RIDs. Information concerning Surface Temperature over selected lakes added in the section 1.1.
2.6		15/04/2014		Updated version to include IASI derived SST products. Few changes taking into account IASI SST OSI-208 ORR RIDs.
2.7		31/10/2014		IASI SST format updated : this product is available inL2P NetCDF only
3.0		20/11/2015		Updated version for the ORR of AVHRR derived products OSI-201-b / OSI-202-b / OSI-204-b Information on processing chain removed because given in the ATBD.

3.1		10/12/2015		Updated version taking into account the RIDs from reviewers of the Operational Readiness Review.
3.2		04/07/2016		Update of output formats and dissemination means
3.3		28/06/2018	SSP CH	Upcoming upgrade of GBL SST and MGR SST planned in July 2018

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1. Introduction

1.1. The EUMETSAT Ocean and Sea Ice SAF

The Satellite Application Facilities (SAFs) are dedicated centres of excellence for processing satellite data – hosted by a National Meteorological Service – which utilise specialist expertise from institutes based in Member States. EUMETSAT created Satellite Application Facilities (SAFs) to complement its Central Facilities capability in Darmstadt. The Ocean and Sea Ice Satellite Application Facility (OSI SAF) is one of eight EUMETSAT SAFs, which provide users with operational data and software products. More on SAFs can be read at www.eumetsat.int.

The objective of the OSI SAF is the operational near real-time production and distribution of a coherent set of information, derived from earth observation satellites, and characterising the ocean surface and the energy fluxes through it: sea surface temperature, radiative fluxes, wind vector and sea ice characteristics. For some variables, the OSI SAF is also aiming at providing long term data records for climate applications, based on reprocessing activities.

The sea surface temperature products include global and regional products, both from geostationary (GEO) and low orbit satellites (LEO).

The OSI SAF consortium is hosted by Météo-France.

The LEO global SST processing and the GEO SST processing are performed at the Low and Mid Latitudes processing facility (LML centre). The LML production subsytem is operated by Météo-France's Centre for Satellite Meteorology (MF/CMS) in Lannion, France; Ifremer centre in Brest, France, is in charge of near real-time distribution of OSI SAF Low and Mid Latitudes products via a FTP server.

The characteristics of the products currently produced by the OSI SAF under pre-operational or operational status are provided in the Service Specification Document (SeSp) [RD-1]). The quality assessment of the OSI SAF products is done first just before becoming an operational/pre-operational product distributed by the OSI SAF. This first assessment is explained in this scientific validation report [RD.1]. Then continuous monitoring of the product quality is done by the OSI SAF team and presented in the half-yearly operations reports available on the OSI SAF web site project documentation. The quality assessment of the OSI SAF products is done against the target accuracy requirement defined in the OSI SAF Service Specification [AD.6]. The target accuracy corresponds to the desired performance level (the breakthrough accuracy). If the values are not compliant to the target accuracy requirement, we consider that the product is still useful/useable as long as the values are compliant to the threshold requirement.

Users are highly recommended to register on the OSI SAF web Site in order to get access to useful information, documentation and links, news, service messages, and access to the help desk.

1.2. Disclaimer

All intellectual property rights of the OSI SAF products belong to EUMETSAT. The use of these products is granted to every interested user, free of charge. If you wish to use these products, EUMETSAT's copyright credit must be shown by displaying the words “Copyright © <YYYY> EUMETSAT” on each of the products used.

Note : The comments that we get from our users is an important input when defining development activities and updates, and user feedback to the OSI SAF project team is highly valued.

1.3. Overview

This document is the product user manual the committed products described below:

- The GHRSST L3C Global Metop/AVHRR sub-skin Sea Surface Temperature (GBL SST) is a 12 hourly synthesis on a 0.05° global grid, referenced OSI-201-b,
- The GHRSST L3C North Atlantic Regional (NAR) Sea Surface Temperature product consists in Metop/AVHRR and SNPP/VIIRS derived sub-skin Sea Surface Temperature over North Atlantic and European Seas at 2 km resolution four times a day, referenced OSI-202-b
- The GHRSST L2P full resolution Metop Sea Surface Temperature metagranules (MGR SST), referenced OSI-204-b, consist in Metop/AVHRR full resolution (1 km at nadir) sub-skin Sea Surface Temperature granules. Granules are disseminated every 3 minutes through EUMETCast.
- The GHRSST L2P Metop/IASI Sea Surface Temperature files (IASI SST), referenced OSI-208-b, is a full resolution skin SST product based on Metop IASI data, in satellite projection from a resolution of 12km at nadir to 40km.

These products format is compliant with the Data Specification (GDS) version 2 from the Group for High Resolution Sea Surface Temperatures (GHRSST).

These products will be referred to as GBL, NAR, MGR and IASI in this text, respectively. They include surface temperatures over selected lakes. They are derived using the standard SST algorithms with no commitment on the accuracy and validation.

Name	Coverage	Satelite	Reso-lution	Generation frequency	Formats	Timeli-ness	Volume per unit : NetCDF
GBL SST	Global	Metop	0.05°	2 per day	NetCDF4 L3C GRIB2*****	6h	40 MB
NAR SST	European Seas	Metop	2 km	2 per day	NetCDF4 L3C GRIB2*****	6h	20-25 MB
		NPP	2 km	2 per day	NetCDF4 L3C GRIB2*****	6h	20 MB
MGR SST	Global	Metop	Full res. (1 km)	Every granule	NetCDF4 L2P	4h	2-5 MB
IASI SST	Global	Metop	12 to 40km	Every granule	NetCDF4 L2P	4h	130 KB
*** only until 12/01/2017**							

Table 1: Characteristics of the OSI SAF SST products

L2P or L3C are in the NetCDF4 with internal compression format. In L2P and L3C, “2” refers to products in satellite projection and “3” to gridded products.
Products in NetCDF4 are compliant with the GHRSST recommendations GDS v2.0 for IR derived products. As such the normalized Proximity Confidence Value (or quality level) scale fixes 6 values : 0 : unprocessed, 1 : cloudy , 2: bad, 3: suspect, 4: acceptable, 5 : excellent. Those values are good predictors of the errors. **It is recommended not to use the confidence value 2 for quantitative use. Usable data are those with confidence values 3, 4 and 5.**

1.4. Glossary

Auxiliary data	Dynamic data that are used in the preparation of GHRSST L2P or L3C data products including wind speed, surface solar irradiance, aerosol optical depth and sea ice.
AVHRR	Advanced Very High Resolution Radiometer
AVH1B, AVH1C	Level-1 formats for AVHRR data. In AVH1B, calibration coefficients are included, and in AVH1C calibration coefficients are applied to provide reflectances and brightness temperatures
BT	Brightness temperature
CMS	Centre de Météorologie Spatiale (Météo-France)
DMI	Danish meteorological Institute
ECMWF	European Centre for Medium-range Weather Forecasting
GDS	GHRSST Data Specification
GEO	Geostationary Earth Orbit
GHRSST	Group for High Resolution Sea Surface Temperature
GBL	Global
GOES	USA Geostationary Operational Environmental Satellite
GRIB	GRIdded Binary format
GTS	Global Transmission System
IASI	Infrared Atmospheric Sounding Interferometer
Ifremer	Institut français de recherche pour l'exploitation de la mer : French Research Institute for Exploitation of the Sea
IR	Infra-Red
LEO	Low Earth Orbiter
L1B	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 1B are unprocessed instrument data alongside ancillary information (Level 1A data) that have been processed to sensor units.
L1C	L1B + cloud mask
L2	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.
L2Pcore	Level 2 Pre-processed Core: L2Pcore is defined like L2P but only with 6 mandatory fields that form the core data content of a GHRSST L2P data file.
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.
MDS	Match up dataset
MET Norway	Norwegian Meteorological Institute
MF	Météo France
MGR	Metagranule
MSG	Meteosat Second Generation

NAR	North Atlantic Regional
NetCDF	Network Common Data Form
NOAA	National Ocean and Atmosphere Administration
SNPP or NPP	Suomi National Polar-orbiting Partnership
NWP	Numerical Weather Prediction
Reference data	Pseudo static data and analysis products that are used by the GHRSST-PP (e.g., climatology maps, previous SST analysis (T-1))
SDI	Saharan Dust Index
SEVIRI	Spinning Enhanced Visible and Infrared Imager
SSI	Surface Solar Irradiance
SSES	Single Sensor Error Statistics
SST	Sea Surface Temperature
VIIRS	Visible Infrared Imaging Radiometer Suite
XML	Extensible Mark-up Language

1.5. Reference and applicable documents

1.5.1. Reference documents

[RD.1] OSI SAF
Validation report for OSI SAF Metop/AVHRR SST
SAF/OSI/CDOP2/M-F/SCI/TEC/234, http://osi-saf.eumetsat.int

[RD.2] OSI SAF
Algorithms Theoretical Basis Document for the Low Earth Orbiter Sea Surface Temperature Processing
SAF/OSI/CDOP3/MF/SCI/MA/216, http://osi-saf.eumetsat.int

1.5.2. Applicable documents

[AD.1] GHRSST
Data Processing Specification 2 release 5 (GDS_2.0r5)
SAF/OSI/CDOP3/MF/MGT/PL/003, http://osi-saf.eumetsat.int

[AD.2] EUMETSAT
IASI Level 2 product guide
EUM/OPS-EPS/MAN/04/0033, http://www.eumetsat.int/

[AD.3] EUMETSAT
IASI Level 2 Product Generation Specification
EPS.SYS.SPE.990013, http://www.eumetsat.int/

[AD.4] EUMETSAT
Single Sensor Error Statistic Scheme for IASI Level 2 Sea Surface Temperature
EUM/MET/DOC/11/0142, http://www.eumetsat.int/

[AD.5] OSI SAF
Product Requirement Document (PRD)
SAF/OSI/CDOP2/M-F/MGT/PL/2-001, http://osi-saf.eumetsat.int

[AD.6] OSI SAF
Service Specification Document (SeSp)
SAF/OSI/CDOP3/MF/MGT/PL/003, http://osi-saf.eumetsat.int

2. Metop/AVHRR and SNPP/VIIRS

This section presents a brief summary of the main features of the processing of the data.

2.1. Overview of the processing chain and methods

The Low Earth Orbiter (LEO) processing chain ingests Metop/AVHRR and SNPP/VIIRS granules. Each of these granules is processed and results in a workfile containing all intermediate information produced by the chain. The workfile are then used to elaborate the Matchup DataSet (MDS) and the OSI SAF products (Figure 1).

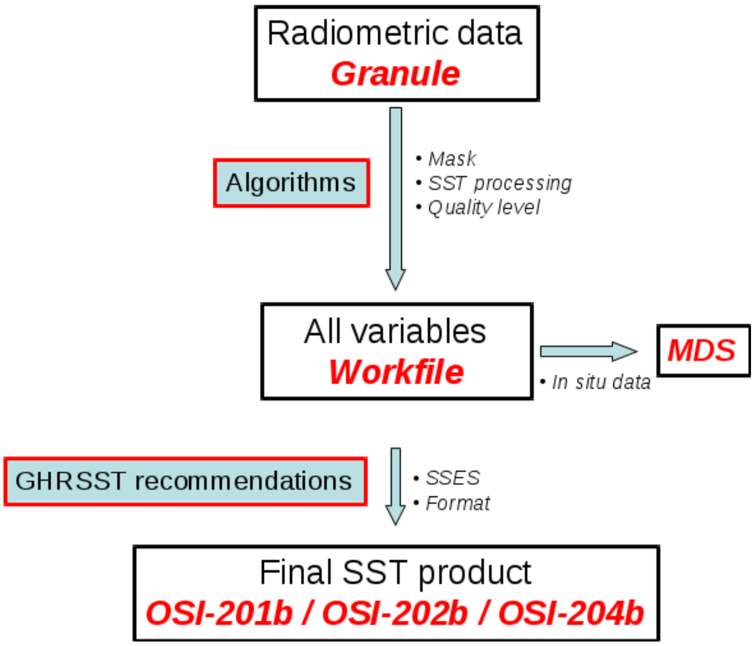

Figure 1: Schematic representation of the LEO processing chain

The chain and methodologies are described in details in the Algorithms Theoretical Basis Document for the Low Earth Orbiter Sea Surface Temperature Processing Chain [RD.2].

The retrieval methodologies include a non-linear algorithm using split window channels of each respective instruments. In the case of Metop/AVHRR data, 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. **This method is not used for NPP/VIIRS processing.**

2.2. Quality levels

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_2.0r5 document [AD.1]. 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 elaboration of the 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.2].

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,…).

2.3. Elements of validation

A detailed validation is presented in the Validation report for OSI SAF Metop/AVHRR SST [RD.2]. Only the global statics of the comparison of AVHRR SST against drifting buoys measurements for a limited period of time are presented in table 2. Results are presented per quality levels.

	Day			Night		
Quality level	**number of cases**	**Bias (K)**	**standard deviation (K)**	**number of cases**	**bias (K)**	**standard deviation (K)**
5	13717	-0.04	0.39	15407	-0.01	0.32
4	16817	-0.10	0.50	17952	-0.10	0.46
3	40433	-0.26	0.59	26637	-0.41	0.60
2	46722	-2.01	2.04	63958	-3.37	2.11

Table 2: Global statistics of the comparison of AVHRR SST against drifting buoys measurements for the period 19/04/2015 – 30/10/2015

3. Metop/IASI

This section presents the physical and statistical basis for the retrieval of Sea Surface Temperature (SST) from the Infrared Atmospheric Sounding Interferometer (IASI) on the Metop satellites, referencing applicable documents where appropriate. The IASI SST L2P is produced by the OSI SAF to be compliant with the specification from the Group for High Resolution Sea Surface Temperatures (GHRSST) [AD-1] based upon skin sea surface temperatures derived from IASI by EUMETSAT central facilities. These skin SSTs are produced from the EUMETSAT IASI L2 Product Processing Facility (PPF) and stored at EUMETSAT as IASI L2Pcore (reduced GHRSST format). Since the algorithm development is performed at EUMETSAT, this section references the algorithm description documents available from EUMETSAT, and gives an overview of the additions to the product given by the OSI SAF. The applicable documents are listed in section 1.4 of this Product User Manual.

3.1. Overview and background

Skin sea surface temperatures from IASI have been produced at EUMETSAT in GHRSST Data Specification 2.0 [AD-1] L2Pcore format since March 2011. The SSTs are the same as those available since April 2008 from the IASI L2 Product Processing Facility (PPF) at EUMETSAT [AD-2]. The IASI L2Pcore SSTs products contain skin SSTs, Sensor Specific Error Statistics [AD-4], quality levels, flags and collocated model surface winds. These IASI L2Pcore SSTs are augmented by the OSI SAF to produce full GHRSST-compliant L2P files, by the addition of other auxiliary data including sea-ice, aerosol and SST background fields.

Details of the IASI L2Pcore product, used as an input to the OSI SAF production of the full IASI L2P file can be found in [AD-3] with further details contained in the product guide [AD-2]. Previous validation results of the IASI skin sea surface temperatures are documented in August et al, 2012 and O'Carroll et al, 2012.

3.2. Algorithm overview

Details on the retrieval for Surface Temperature are given within section 5 of [AD.3].

An essential feature of the GHRSST L2P specification is the Sensor Specific Error Statistic (SSES) field. These are observational error estimates provided at pixel level as a bias and standard deviation, traditionally derived from comparisons with drifting buoys. Each observation is assigned a quality level from 0 to 5, where 0 is missing data, 1 is bad data (such as cloud), 2 is the worst useable data, and 5 is the best quality. The SSES bias and standard deviation are calculated for each quality level from analysing differences between satellite SSTs collocated with drifting buoys in a match-up database. Further details on the methodology and estimation of the SSES for IASI SSTs can be found in [AD.4].

3.3. Algorithm description

The theoretical description of the algorithm can be found in the EUMETSAT document "IASI Level 2 Product Generation Specification" [AD.3]. A description of the SSES can be found in the EUMETSAT document "Single Sensor Error Statistic Scheme for IASI Level 2 Sea Surface Temperatures" [AD.4].

3.4. Constraints, assumptions and limitations

The constraints, assumptions and limitations are included in the EUMETSAT document "IASI Level 2 Product Generation Specification" [AD.3] in section 5.

3.5. Implementation of IASI L2P at the EUMETSAT OSI SAF

Core IASI SST files are produced at the EUMETSAT central facility. They are pulled in near real time to CMS via FTP.

At CMS, they are complemented with the following variables: DT_analysis (source : OSTIA) ; Aerosol Dynamic Indicator (source : NAAPS Aerosol Optical Depth) ; Sea Ice Fraction (source : OSI SAF). These ancillary data are the nearest in space and time to the input SST pixel among available datasets at processing time. The maximum time offset between these ancillary data and the SST data are 36 h for the DT_analysis, 24h for the Aerosol Dynamic Indicator and 72 h for the Sea Ice Fraction. NB : The wind variable has been already filled up at EUMETSAT central facility.

They are formatted according to GDSV2.0 under product string : « IASI_SST_Metop_B ». This format is NetCDF4 with internal compression.

4. Products description

4.1. Format

All products are GDSv2 revision 5 [AD.1] compliant. This means that the products are delivered in NetCDF format and the following variables are available:

- time : reference time of the file
- lat/lon: latitude/longitude grid in degree North/East
- or_latitude/or_longitude: Original latitude/longitude of the satellite measurement as provided in the L2P
- l2p_mask: describes the land/ice/lake mask
- satellite_zenith_angle : The satellite zenith angle at the time of observation
- solar_zenith_angle : The solar zenith angle at the time of observation
- sea_surface_temperature : SST provided in Kelvin
- quality_level : pixel-wise quality level ranging from 0 to 5
- sses_bias/sses_standard_deviation :estimate of the error characteristics at pixel level, derived from exploiting the validation results against drifting buoys measurements.
- dt_analysis : Difference between the delivered SST and the last available OSTIA SST analysis (previous day).
- wind_speed : 10 meter wind speed derived from ECMWF forecast
- sea_ice_fraction : Fractional ice cover from OSTIA analysis
- aerosol_dynamic_indicator : Information regarding the aerosol loading of the atmosphere. In our case, it is the SEVIRI derived Saharan Dust Index or aerosol optical depth from NAAPS
- adi_dtime_from_sst :age of the aerosol information relative to the time of SST observation
- sources_of_adi :nature of the aerosol dynamic indicator. This information is essential for using this indicator, since they can be distinct in nature (and units) depending on their origin.

The L2P or L3C format description is provided in appendix A.1.
The GRIB format (provided only until 12/01/2017) description is provided in appendix A.2.

The SST match-up data set (containing collocated in-situ and satellite data) are available to interested users on request.

4.2. MGR SST and GBL SST (Metop/AVHRR)

The SST MGR (metagranules) are sent each 3 minutes to Ifremer in L2P format for further usages. The GBL SST product is a 12 hourly synthesis centered at 0000 and 1200 UTC. Please refer to [AD.6] for more information.

Geographical definitions MGR SST product (AVHRR L2 global)
Projection: satellite projection
Resolution: full AVHRR resolution (1 km)
Size: 2048 columns, 1080 lines corresponding to 3 minutes of data acquisition; note that the number of lines may vary.

Geographical definitions GBL SST product (AVHRR L3 global)
Projection: linear scaling in latitude and longitude
Resolution: 0.05 degree in latitude and longitude
Size: 7200 columns, 3600 lines
Longitude and latitude limits : 180° W, 180° E, 90° S, 90° N

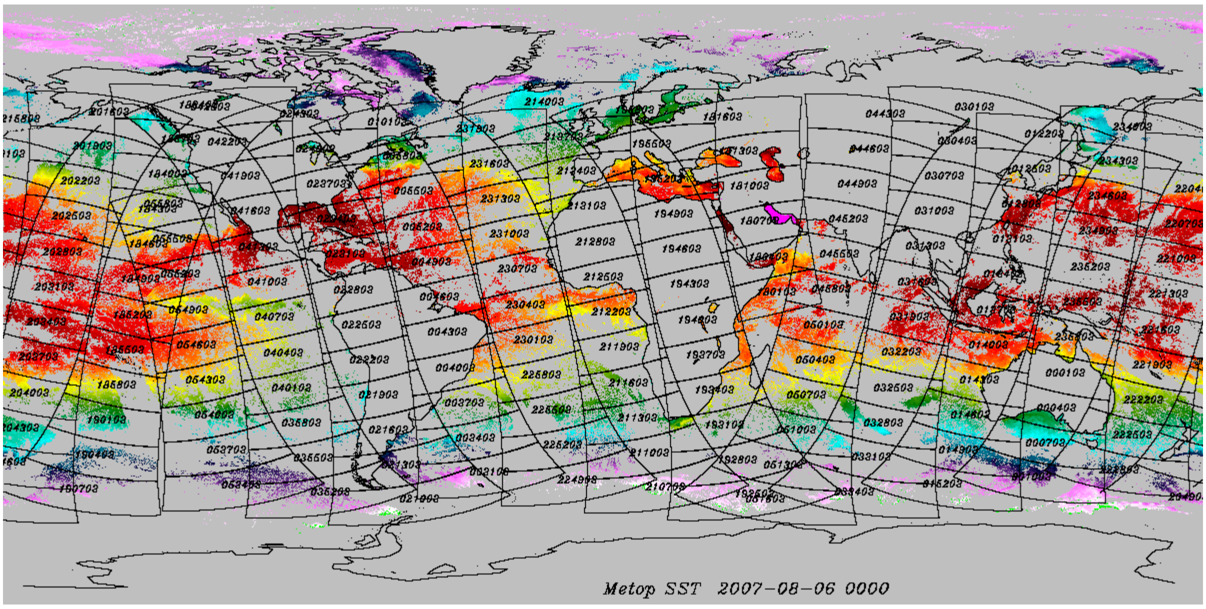

Figure 2: 0.05° resolution global product on the 6th of August at 0000 UTC, showing the contributing Metop metagranules superimposed

4.3. NAR SST derived from Metop AVHRR or NPP/VIIRS

The NAR 2 km resolution products (Figure 3) are made twice a day for each satellite over the European waters. Note the difference in coverage (on Figure 3) for Metop (data acquisition through EUMETCast) and NPP (data acquisition through Direct readout). Prior to entering the contribution scheme, the metagranules are filtered according to their time: they must be dated to within DT from the NAR reference times (1000 UTC and 2000 UTC for Metop; 0200 UTC and 1300 UTC for NPP). At present DT=4.5h.

Geographical definitions NAR SST product (AVHRR & NPP L3 NAR)

Projection: Polar stereographic projection defined with an elliptical earth (equatorial radius: 6378.388 km; polar radius: 6356.912 km), y axis is meridian 0.
Resolution: 2 km at 45 N
Size: 4096 columns, 3072 lines
Longitude and latitude limits (westernmost and easternmost longitudes; southernmost and northernmost latitudes): 76.02° W, 72.97° E, 13.59° N, 78.24° N

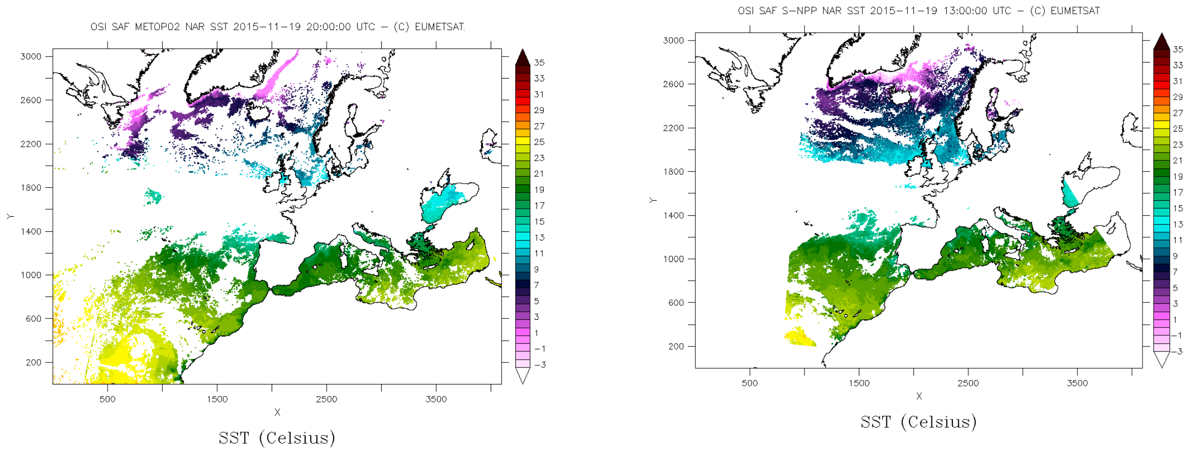

Figure 3: Example of 2 km resolution NAR product on 19th November 2015: left: Metop; right NPP

4.4. 5.3 IASI SST

Geographical definitions of the IASI SST product (IASI L2 global)

Projection: satellite projection
Resolution: full IASI resolution
Size: 120 columns, 23 lines corresponding to 3 minutes of data acquisition; note that the number of lines may vary.
Longitude and latitude limits : 180° W, 180° E, 90° S, 90° N

5. Access to the products

5.1. Access to products in near-real time

Access to the products in near-real time is described in the following table:

Name and ref. of the product	Format	Access
GBL SST (OSI-201-b)	L3C NetCDF	LML FTP server / EUMETCast
NAR SST (OSI-202-b)	L3C NetCDF	LML FTP server / EUMETCast
MGR SST (OSI-204-b)	L2P NetCDF	LML FTP server / EUMETCast
IASI SST (OSI-208-b)	L2P NetCDF	LML FTP server / EUMETCast

The LML FTP server (hosted by Ifremer) is accessible to users registered on the OSI SAF web site, (http://osi-saf.eumetsat.int) at the following address. Credentials are provided on request, after registration on OSI SAF web site.

EUMETCast is a multi-service dissemination system based on standard Digital Video Broadcast (DVB) technology. It uses commercial telecommunication geostationary satellites to multi-cast files (data and products) to a wide user community. More information on EUMETCast can be found on :
http://www.eumetsat.int/website/home/Data/DataDelivery/EUMETCast/index.html

5.2. Access to archived products

Name and ref. of the product	Format	Access
GBL SST (OSI-201, OSI-201-b)	L3C NetCDF	LML FTP server / EDC
GBL SST (OSI-201, OSI-201-b)	GRIB2*	EDC
NAR SST (OSI-202, OSI-202-b)	L3C NetCDF	LML FTP server / EDC
NAR SST (OSI-202, OSI-202-b)	GRIB2*	EDC
MGR SST (OSI-204, OSI-204-b)	L2P NetCDF	LML FTP server
IASI SST (OSI-208, OSI-208-b)	L2P NetCDF	LML FTP server / EDC

*** only until 12/01/2017**

The LML FTP server (hosted by Ifremer) is accessible to users registered on the OSI SAF web site, (http://osi-saf.eumetsat.int) at the following address. Credentials are provided on request, after registration on OSI SAF web site.

EDC is EUMETSAT Data Center (sometimes also called UMARF).
More information on EDC can be found on :
http://www.eumetsat.int/website/home/Data/DataDelivery/EUMETSATDataCentre/index.html

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7. Appendix A.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 L2P and L3C EUMETSAT OSI SAF LEO SST product format is compliant with the GHRSST Data Processing Specification (GDS) document. This document has evolved from version 1.7 to version 2.0. The OSI SAF LEO SST products have evolved accordingly. They were compliant with GDS version 1.7 till the 3rd of July 2013. Since then they have been compliant with GDS version 2.0. 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.	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.
		L3 GHRSST products do not use analysis or interpolation procedures to fill gaps where no observations are available				
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

The corresponding document is available through :
https://www.ghrsst.org/documents/q/category/ghrsst-data-processing-specification-gds/operational/

Any future update of the GDS format will be found under this directory.

Users must be aware that GDS version 1.7 compliant data were compressed using bzip2 compression. **The GDS version 2.0 products are NetCDF4 classic model files using internal compression feature**.

8. Appendix A.2: Format of the GRIB ed. 2 product

The GRIB products are encoded following the rules defined in FM 92 GRIB Edition 2 (version 3 02/11/2005).

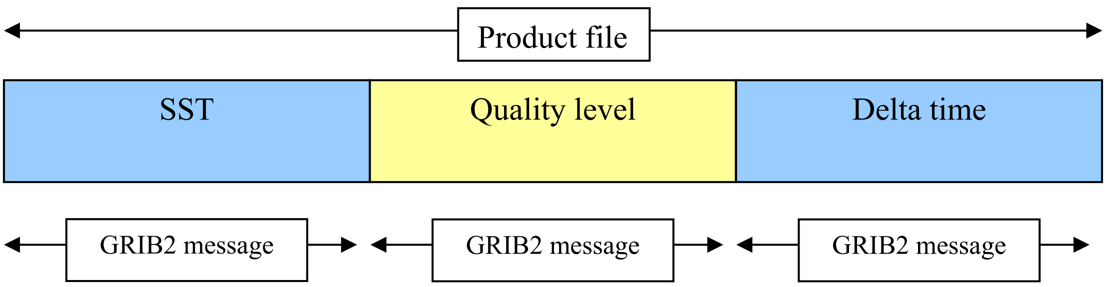
There are two types of GRIB ed. 2 products:

- GBL (Global) product
- NAR (Near Atlantic Regional) product

A2.1 File structure

A GRIB ed. 2 product is delivered as a single file in which three GRIB2 messages are concatenated.:

The first GRIB2 message provides the SST data, the second one provides the quality level data and the last one provides the delta time data.



Note : The multi-fields capability of the GRIB2 format has not been used for the sake of the simplicity and also because it would have mixed a standard parameter (SST) with non standard ones ("confidence level" and "delta time").

The Appendix A.3 gives some hints to access data by using the ECMWF GRIB API.

A2.2 Encoding characteristics

Hereafter are described the most relevant and specific information of each section of the GRIB2 messages. Unless otherwise specified the values are given for both types of product (GBL or NAR) or of data (SST, confidence level, delta time)

Section 0 (Indicator Section)

Octet. No.	Meaning	Value	Notes
7	Discipline	10	Oceanographics products (cf. Table 0.0)

All the three messages have the same Indicator Section.

Section 1 (Identification Section)

Octet. No.	Meaning	Value	Notes
6-7	Identification of originating/generating centre	211	Lannion (see Common Code Table C-1)
8-9	Identification of originating/generating sub-centre	0	
12	Significance of Reference Time	3	Observation time (see Code Table 1.2)
13-19	Reference time of data	variable and product specific	Individual pixels time can be derived from reference time by using the Delta Time message data. For GBL products the reference hour is either 00:00 or 12:00 UTC. For Metop02 NAR products the reference hour is either 10:00 or 20:00 UTC For NOAA-19 NAR products the reference hour is either 03:00 or 13:00 UTC For NPP NAR products the reference hour is either 02:00 or 13:00 UTC *In the past, for NOAA-18 NAR products the reference hour was either 02:00 or 12:00 UTC*

All the three messages have the same Identification Section.

Section 2 (Local Use Section)

There is no section 2 in either message.

Section 3 (Grid Identification Section)

The “Grid Definition Template Number” (Octets No. 13-14) depends on the product type :

- for GBL product it is coded 0 : Latitude/longitude (see Code Table 3.1)
- for NAR product it is coded 20 : Polar stereographic (see Code Table 3.1)

In both cases data have been organized such as the “scanning mode” flag is 0 (Points of first row scan in the +i direction, points of the first column scan in the –j direction).

For more details, see the “Grid characteristics” paragraph below.

All the three messages have the same Grid Identification Section.

Section 4 (Product Definition Section)

Octet. No.	Meaning	Value	Notes
8-9	Product definition template number	31	Satellite product (see Code Table 4.0) Since Ed. 2 version 3 product definition 4.30 is deprecated . Template 4.31 should used instead.
10	Parameter category	data specific	SST data : 3 (Surface properties) Confidence level data : 192 (Reserved for local use) Delta time data : 192 (Reserved for local use) (see Code Table 4.1 for Product Discipline 10)
11	Parameter number	data specific	SST data : 0 Water temperature (see Code Table 4.2 for Product Discipline 10 / Parameter category 3) Confidence level data : 1 (Since confidence level has no entry in the code table, a local category values is to be used) Delta time data : 2 (Since delta time has no entry in the code table, a local category values is to be used)
13	Observation generating processing identifier	220 or 229	220 : product from the operational processing chain 229 : product from the test processing chain
14	Number of contributing spectral bands	3	For NOAA and Metop products only
15-25	Definition of spectral band 1		IR3.7
26-36	Definition of spectral band 2		IR10.8
37-47	Definition of spectral band 3	591	IR12.0

Inside the definition of the contributing spectral bands, the satellite series, the satellite number and the instrument type are encoded as per BUFR code tables :

satellite series : (see BUFR code table 0 02 020)
EPS is coded 61
TIROS 2 is coded 3

satellite number : (see BUFR code table 0 01 007)
Metop02 is coded 4
Metop01 is coded 3
NOAA18 is coded 209
NOAA19 is coded 223
NPP is coded 224
instrument type : (see BUFR code table 0 02 019)
AVHRR/3 is coded 591
VIIRS is coded 616

Section 5 (Data Representation Section)

Octet. No.	Meaning	Value	Notes
10-11	Data Representation Template Number	0	Grid point data-simple packing (see Code Table 5.0)

The product are encoded so that the Decimal scale factor and the Numbers of bits are invariant for a given data type. The following table gives these values for each data type.

Octet No.		SST	Confidence level	Delta time
18-19	Decimal scale factor	2	0	0
20	Number of bits	12	2	10

The reference value (Octet No 12-15) and the Binary scale factor (Octet No 16-17) may vary, though the binary scale factor should be 0 in most cases.

Section 6 (Bit Map Section)

The “Bit-map indicator” (Octet No. 6) is always 0 (a bit-map applies to this product). All data are missing on land pixels and on the water pixels where SST has not been computed.

All the three messages have the same bit map section.

Section 7 (Data Section)

The section 7 provides the data according to the Data Representation Template number given in octets 10-11 of Section 5.

The following table gives the meanings of the three types of data :

data	meanings
SST	Water temperature (in deg. K)
Quality level	An index value with the following meanings : 2: bad 3: suspect 4: acceptable 5: excellent (note: unprocessed and masked cases are set as missing values)
Delta time	Signed delta time (in minutes) from Reference time of Data (given in Section 1). Individual pixel can be determined as follows : Pixel time = Reference time of Data + Delta time

A2.3 Grid characteristics

GBL product

Projection	Equidistant cylindrical
Resolution	0.05 °
Size	7200 columns x 3600 lines
Upper left corner pixel center	89.975 N / 179.975 W

Converting between pixel coordinates (column, line) and geographical ones (longitude,latitude) is straithforward by using the linear relations :

```
longitude = -179.975 + 0.05 ( column - 1)
latitude  =   89.975 - 0.05 ( line   - 1)
```

where :

- longitude and latitude are in degrees,
- $1 \le$ column $\le$ 7200
- $1 \le$ line $\le$ 3600

NAR product

Projection	Polar stereographic true at 45°N
Resolution	2 km
Size	4096 columns x 3072 lines
Central meridian	0°
Upper left corner pixel center	43.765273°N / 76.018069°W

Converting between pixel coordinates (column, line) and geographical ones (longitude,latitude) can be done using the PROJ4 library cartographic projection library with the following “proj4 string” :

```
+proj=stere +a=6356775 + b=6356775  +lat_0=90 +lat_ts=45 +lon_0=0
```

The Appendix A.4 gives two demo programs using the PROJ4 library for that purpose.

9. Appendix A.3 : Accessing data by using the ECMWF GRIB API

The ECMWF GRIB API is an application program interface accessible from C and FORTRAN programs developed for encoding and decoding WMO FM-92 GRIB edition 1 and edition 2 messages. A useful set of command line tools is also provided to give quick access to grib messages.

For more details see :

https://software.ecmwf.int/wiki/display/GRIB/Home

The following examples have been tested with the 1.3.0 version of the GRIB API.

A3.1 Definition of template 4.31

In order to decode properly the GBL and NAR GRIB2 file with the grib_api software a file named template.4.31.def should be added in the $GRIB_DEFINITION_PATH/grib2 directory, where $GRIB_DEFINITION_PATH is the environment variable pointing to the definitions files to be used with grib_api (typically $INSTALL_DIR/share_grib_api/definitions if $INSTALL_DIR is the directory where grib_api has been installed. This definition file should content the following text :

```
# For grib2 to grib1 convertion
constant dataRepresentationType = 90;


# START 2/template.4.31 ----------------------------------------------------
# TEMPLATE 4.31, Satellite Product
#  Parameter category
codetable[1] parameterCategory 'grib2/4.1.[discipline:l].table';

#  Parameter number
codetable[1] parameterNumber 'grib2/4.2.[discipline:l].
[parameterCategory:l].table';

#  Type of generating process
codetable[1] typeOfGeneratingProcess 'grib2/4.3.table';

#  Observation generating process identifier
# (defined by originating Centres)
unsigned[1] observationGeneratingProcessIdentifier ;

#  Number of contributing spectral bands
# (NB)

unsigned[1] numberOfContributingSpectralBands  ;

unsigned[2] satelliteSerie1 ;
unsigned[2] satelliteNumber1 ;
unsigned[2] instrumentType1 ;
unsigned[1] scaleFactorOfCentralWaveNumber1 = missing() : can_be_missing ;
unsigned[4] scaledValueOfCentralWaveNumber1 = missing() : can_be_missing ;

unsigned[2] satelliteSerie2 ;
```

```
unsigned[2] satelliteNumber2 ;
unsigned[2] instrumentType2 ;
unsigned[1] scaleFactorOfCentralWaveNumber2 = missing() : can_be_missing ;
unsigned[4] scaledValueOfCentralWaveNumber2 = missing() : can_be_missing ;

unsigned[2] satelliteSerie3 ;
unsigned[2] satelliteNumber3 ;
unsigned[2] instrumentType3;
unsigned[1] scaleFactorOfCentralWaveNumber3 = missing() : can_be_missing ;
unsigned[4] scaledValueOfCentralWaveNumber3 = missing() : can_be_missing ;


# END   2/template.4.31 --------------------------------------------------
```

A3.2 How to split a GRIB2 product file

One simple way to split a GBL or NAR GRIB2 file into the three GRIB2 messages (SST, Confidence level, Delta time) is to use the grib_copy tool provided in the GRIB API distribution :

```
grib_copy -w parameterCategory=3,parameterNumber=0 product.grb sst.grb
grib_copy -w parameterCategory=192,parameterNumber=1 product.grb conf.grb
grib_copy -w parameterCategory=192,parameterNumber=2 product.grb dtime.grb
```

10. Appendix A.4 : Locating the NAR data by using PROJ4 library

PROJ4 is a cartographic library accessible from C.

For more details see :

http://proj.maptools.org/

The following examples have been tested with the 4.5.0 version of the PROJ4 library. As they are demo programs no check of the return values is performed.

NAR_fwd : (longitude, latitude) → (column,line)

```
// NAR_fwd : Demo program showing how to compute the (column,line) point
// of the NAR grid corresponding to a (longitude,latitude) coordinates
// using the proj4 library.
// using the proj4 library.
// syntax : NAR_fwd lon lat
// where lon and lat are the longitude and latitude in degrees
// example :
// NAR_fwd -76.018069 43.765273
// lon=-76.018069 lat=43.765273 column=1.000000 line=1.000000
#include <stdlib.h>
#include <stdio.h>

#include <math.h>
#include <proj_api.h>

int main(int argc, char *argv[]) {

#define LON_ORG -76.018069 // longitude of first grid point is 76.018069W
#define LAT_ORG  43.765273 // latitude of first grid point is  43.765273N

#define DELTA_X  2000 // x direction grid length is 2 km ; scanningMode : scan
in +i direction
#define DELTA_Y -2000 // y direction grid length is 2 km ; scanningMode : scan
in -j direction

char str_proj[]="+proj=stere +a=6378160 +b=6356775 +lat_0=90 +lat_ts=45
+lon_0=0"; // proj4 string

double lon;
double lat;

lon=atof(argv[1]);
lat=atof(argv[2]);

// proj4 initialization
projPJ pj;
pj= pj_init_plus(str_proj);

// computing the (x,y) coordinates of the origin (1,1) grid point
projUV lp;
projUV xy;
double x_org;
```

```
double y_org;

lp.u=LON_ORG * DEG_TO_RAD;
lp.v=LAT_ORG * DEG_TO_RAD;
xy = pj_fwd(lp,pj);
x_org=xy.u;
y_org=xy.v;

// computing the (x,y) coordinates of the (lat,lon) position
double column;
double line;
lp.u=lon * DEG_TO_RAD;
lp.v=lat * DEG_TO_RAD;
xy = pj_fwd(lp,pj);
column= 1 + ( ( xy.u - x_org ) / DELTA_X );
line   = 1 + ( ( xy.v - y_org ) / DELTA_Y );

fprintf(stdout,"lon=%f lat=%f column=%f line=%f\n",lon,lat,column,line);

exit(0);

}
```

NAR_inv: (column, line) → (longitude,latitude)

```
// NAR_inv : Demo program showing how to compute the
// (longitude,latitude) coordinates of a (column,line) point of
// the NAR grid using the proj4 library.
// syntax : NAR_inv column line
// where column and line are the coordinates of the point
// 1<= column <=4096
// 1<= line <= 3072
// example :
// NAR_inv 1 1
// column=1.000000 line=1.000000 lon=-76.018069 lat=43.765273
#include <stdlib.h>
#include <stdio.h>

#include <math.h>
#include <proj_api.h>

int main(int argc, char *argv[]) {

#define LON_ORG -76.018069 // longitude of first grid point is 76.018069W
#define LAT_ORG  43.765273 // latitude of first grid point is  43.765273N

#define DELTA_X  2000 // x direction grid length is 2 km ; scanningMode : scan
in +i direction
#define DELTA_Y -2000 // y direction grid length is 2 km ; scanningMode : scan
in -j direction

char str_proj[]="+proj=stere +a=6378160 +b=6356775 +lat_0=90 +lat_ts=45
+lon_0=0"; // proj4 string

// getting the options
double column; // [1,4096]
```

```
double line;   // [1,3072]
column=atof(argv[1]);
line=atof(argv[2]);

// proj4 initialization
projPJ pj;
pj= pj_init_plus(str_proj);

// computing the (x,y) coordinates of the origin (1,1) grid point
projUV lp;
projUV xy;
double x_org;
double y_org;

lp.u=LON_ORG * DEG_TO_RAD;
lp.v=LAT_ORG * DEG_TO_RAD;
xy = pj_fwd(lp,pj);
x_org=xy.u;
y_org=xy.v;

// computing the (lon,lat) coordinates of the (column,line) igrid point
double lat;
double lon;
xy.u=x_org + DELTA_X * (column-1);
xy.v=y_org + DELTA_Y * (line  -1);
lp = pj_inv(xy,pj);
lon=lp.u * RAD_TO_DEG;
lat=lp.v * RAD_TO_DEG;

fprintf(stdout,"column=%f line=%f lon=%f lat=%f\n",column,line,lon,lat);

exit(0);

}
```