



Product User Guide and Specification (PUGS)

Global L4 Sea and Sea-Ice Surface Temperature (SST/IST) Climate Data Record, Version 1.0

WP2-PUGS-SST/IST-v1.0

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History of document modifications

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List of datasets covered by this document

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WP2-FDDP-SST-v1.0	Global L4 Sea and Sea-Ice Surface Temperature (SST/IST) Climate Data Record (CDR), version 1.0	CDR	1.0	
WP2-ICDR-SST-v1.0	Global L4 Sea and Sea-Ice Surface Temperature (SST/IST) Interim Climate Data Record (ICDR) , version 1.0	ICDR	1.0	



Related documents

Reference ID	Document
D1	Embury, O., Good, S. (2023). Sea Surface Temperature version 3.0: Product User Guide and Specification. Copernicus Climate Change Service. Document ref. WP2-FDDP-2022-09_C3S2-Lot3_PUGS_of_v3.OSST_product_v1.0.
D2	GHRSSST data specification (GDS) 2.1 version 0; https://zenodo.org/records/6984989 .
D3	Climate and Forecast (CF) Conventions and Metadata, http://cfconventions.org
D4	Karagali et al. (2024) Global L4 Sea and Sea Ice Surface Temperature Climate Data Records, Version 1.0: Target Requirements and Gap Analysis Document. Copernicus Climate Change Service. Document ref. C3S2_312b_WP3_TRGAD_SST/IST_v1.2.
D5	Karagali et al. (2024) Global L4 Sea and Sea Ice Surface Temperature Climate Data Records, Version 1.0: Algorithm Theoretical Basis Document. Copernicus Climate Change Service. Document ref. C3S2_312b_WP2-FDDP-SST/IST_2024_ATBD_v1.X ¹ .
D6	Karagali et al (2024) Global L4 Sea and Sea Ice Surface Temperature Climate Data Records, Version 1.0: Product Quality Assessment Report. Copernicus Climate Change Service. Document ref. C3S2_312b_WP2-FDDP-SST/IST_202410_PQAR_v1.X ² .

¹Users should consult the latest version of the ATBD available.

²Users should consult the latest version of the PQAR available.



Acronyms

Acronym	Definition
AASTI	Arctic and Antarctic Ice Surface Temperatures from AVHRR
AMSR	Advanced Microwave Scanning Radiometer
ATSR	Along Track Scanning Radiometer
AVHRR	Advanced Very High Resolution Radiometer
ATBD	Algorithm Theoretical Basis Document
C3S	Copernicus Climate Change Service
CCI	Climate Change Initiative
CDR	Climate Data Record
CDS	Climate Data Store
CEDA	Centre for Environmental Data Analysis
DMI	Danish Meteorological Institute
ECMWF	European Centre for Medium-Range Weather Forecasts
ECV	Essential Climate Variable
EPS	EUMETSAT Polar System
ERS	European Remote Sensing
ESA	European Space Agency
EOCIS	UK Earth Observation Climate Information Service
EUMETSAT	European Meteorological Satellites
GAC	Global Area Coverage
GDS	GHRSSST Data Specification
GHRSSST	Group for High Resolution SST
GOES	Geostationary Operational Environmental Satellites
ICDR	Interim Climate Data Record
IR	Infrared
IST	Sea Ice Surface Temperature
L4	Level 4 data product



L3S	Level-3 Supercollated data product
L3U	Level-3 Uncollated data product
L3C	Level-3 Collated data product
L2P	Level-2 Pre-processed data product
L2	Level-2 data product
MCAS	Marine and Climate Advisory Service
MIZ	Marginal Ice Zone
MetNo	Norwegian Meteorological Institute
NOAA	National Oceanographic and Atmospheric Administration
NWP	Numerical Weather Prediction
NP	North Pole
OI	Optimal Interpolation
OSISAF	Ocean and Sea Ice Satellite Application Facility
PMW	Passive Microwave
PUGS	Product User Guide and Specifications
PQAR	Product Quality Assessment Report
POES	Polar Operational Environmental Satellites
RDAC	Regional Data Assembly Centre
R&D	Research and development
SIC	Sea ice concentration
SI	Sea Ice
SLSTR	Sea and Land Surface Temperature Radiometer
SST	Sea Surface Temperature
UWC-W	United Weather Centres West



General definitions

Climate Data Record (CDR) – A time series of measurements of sufficient length, consistency, and continuity to determine climate variability and change. Further satellite-based CDRs can be segmented into Fundamental CDRs (FCDRs), which are calibrated and quality-controlled sensor data that have been improved over time, and Thematic CDRs (TCDRs), which are geophysical variables derived from the FCDRs, such as sea surface temperature and cloud fraction. Consistency has been verified with datasets in a CDR through bespoke validation and quality assessment activities.

Interim Climate Data Record (ICDR) - A dataset that has been forward processed, using the baselined Climate Data Record algorithm and processing environment but whose consistency and continuity have not been verified. Eventually, it will be necessary to perform a new reprocessing of the CDR and ICDR parts together to guarantee consistency, and the new reprocessed data record will replace the old CDR.

Sea-ice concentration (SIC) – The fraction (percentage) of the sea surface area of the grid cell containing sea-ice.

Sea Surface Temperature (SST) – The temperature of the ocean water close to the surface.

SST_{20cm} – Sea Surface Temperature adjusted for the standard depth of 0.2 m and time representative of the daily mean, representative of the water temperature free, or almost free, of any diurnal warming.

Sea Ice – Corresponds to ocean surface covered by sea ice (>70%) thus the surface temperature is classified as sea-ice surface temperature (IST).

Sea Ice Surface Temperature (IST) - representative of the surface temperature over sea ice.

Marginal Ice Zone (MIZ) - a part of the seasonal ice zone that varies in width (100 to 200 kilometres) that extends from the ice edge into the ice pack, where waves and swells affect the ice; often characterized by highly variable ice conditions; in general, it is wider in the Antarctic than the Arctic.

Open ocean – Corresponds to ice-free ocean or containing very little ice (<15 %), thus the surface temperature is classified as sea surface temperature (SST).

Level-2 Pre processed (L2P) data product – Geophysical variables derived from Level 1 source data on the Level 1 grid (typically the satellite swath projection). Ancillary data and metadata added following GHRSSST Data Specification.



Level-3 Uncollated (L3U) data product – L2 data granules remapped to a regular latitude/longitude grid without combining observations from multiple source files. L3U files will typically be “sparse”, corresponding to a single satellite orbit.

Level-3 Collated (L3C) data product – SST observations from a single instrument combined into a space-time grid. In this project, a typical L3C file may contain all the observations from a single instrument in a 24-hour period.

Level-3 Super-Collated (L3S) data product – SST observations from many instruments combined into a space-time grid. In this project, a typical L3S file may contain all the observations from all available instruments in a 24-hour period.

Level 4 (L4) data product – SST observations from multiple instruments using an analysis system (e.g. optimal interpolation) to produce a gridded, gap-free product.



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Scope of the document

This document is the Product User Guide and Specification (PUGS) for the Copernicus Climate Change Service's (C3S) Level 4 Global Sea Surface and Sea Ice Surface Temperature (SST/IST) product. It builds upon the PUGS of the Level 4 SST CDR v3.0 dataset collection [D1]. This document describes the v1 combined Sea Surface Temperature and Sea-Ice Surface Temperature (SST/IST) CDR/ICDR produced by the Danish Meteorological Institute within the Copernicus Climate Change Service.

The main aim of the document is to aid users in understanding the data product, e.g. its features and limitations as well as enabling them to read and use the data. Details of the data format are provided including: data and flag variables, metadata, and naming conventions.

Executive summary

This document is the Product User Guide and Specification (PUGS) for the C3S Level 4 Sea Surface and Sea Ice Surface Temperature (SST/IST) CDR/ICDR products. The C3S L4 SST/IST CDR covers the period 1982-2021. It uses SST data from the ESA SST_cci v3.0 single-sensor L3U datasets as input, combining it with IST information from the C3S Level 3 SI-IST CDR and ICDR v1.1. The C3S L4 SST/IST ICDR covers the period 2022-2024. Using single-sensor SST L3U data from C3S/EOCIS/MCAS along with IST information from the C3S SI-IST v1.1 ICDR; the L4 SST/IST ICDR is intended to be used in combination with the corresponding SST/IST CDR.

The Global Level 4 CDR/ICDR products provide a global, spatially complete, daily analysis of combined SST and IST from multiple sensors. It can provide combined information on two Essential Climate Variables (ECV): the Sea Surface Temperature ECV and the Sea Ice ECV. The surface temperature fields represent the daily average SST at 20 cm depth over open ocean and the surface skin temperature over sea ice. An additional variable only containing SST over open ocean and sub-ice SST over the sea-ice covered regions is included so there is consistency with the other L4 SST CDR datasets (e.g. see [D1]) available through the C3S Climate Data Store. Both ICDR and CDR datasets are generated using the same software and algorithms originally developed within the MyOcean project and currently applied to the operational Multi-Year products for the SST and IST delivered to the Copernicus Marine Service.

The data files are in netCDF-4 format and follow the standard specification defined by the Group for High Resolution Sea Surface Temperature (GHRSSST) [D2]. This document contains information on the product itself, and the technical aspects of the product files and how they are packaged. Section 1 contains an overview of the product itself – the Global Level 4 SST/IST product, i.e. a daily, gap-free field of combined sea surface and sea-ice surface temperature from satellite observations. It provides a brief summary of the datasets used to produce it. Note that consulting the accompanying Algorithm Theoretical Basis document [D5], and Product Quality Assessment Report [D6] is highly recommended. Section 1 then provides information on the technical specifications of the product files, the parameters the product files contain, as well as some visualised examples of the data. Section 2 provides some useful software guidance and tools that can be used to explore and use the data.



1. The global level-4 SST/IST product

1.1 Product description

The global Sea Surface and Sea-Ice Temperature (SST/IST) Level 4 (L4) product provides a global, spatially complete, daily analysis of combined Sea Surface Temperature (SST) and Sea Ice Surface Temperature (IST) from multiple sensors. It can provide information on aspects of two Essential Climate Variables (ECV): the Sea Surface Temperature ECV and the Sea Ice ECV. The surface temperature fields represent the daily average SST at 20 cm depth over open ocean and the surface skin temperature over sea ice.

The data are made available as two main dataset collections: a Climate Data Record (CDR) and an Interim Climate Data Record (ICDR), both produced by the Copernicus Climate Change Service (C3S). The C3S ICDR is intended to be used in combination with the corresponding C3S CDR. Both ICDR and CDR datasets are generated using the same software and algorithm originally developed within the MyOcean project (Brasseur et al., 2013) and currently applied to the operational L4 Multi-Year products for the SST and IST delivered to the Copernicus Marine Service. The main frame of the processing algorithm relies on collecting the various single sensor products, the generation of an aggregated observational field from the single sensor input data, and the use of an Optimal Interpolation algorithm to fill in the gaps from missing data.

The data records consist of daily L4, gridded surface temperature fields covering the period from 1982 to end-2021 for the CDR with global coverage. Meanwhile, the ICDR provides an ongoing extension in time of the record from Jan-2022 onwards. Current data availability per instrument used for the L4 product is shown in Figure 1 below.

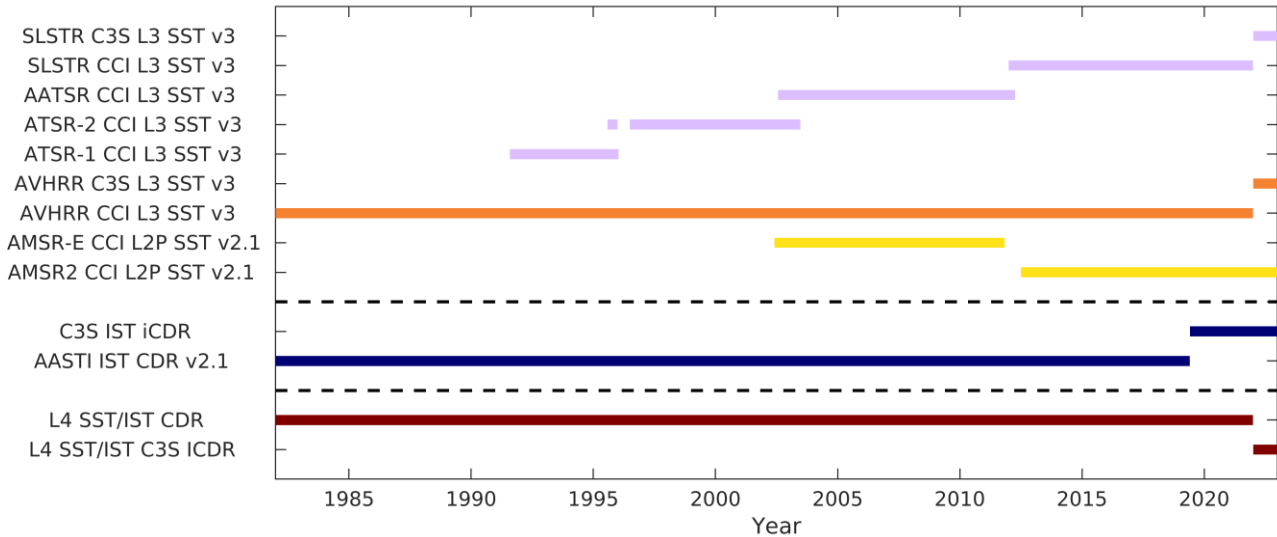


Figure 1. Input SST and IST data availability (purple, orange, yellow and blue) from different mission instruments, and CDR /ICDR (dark red) dataset’s temporal coverage and availability. Mission instrument datasets and C3S product lines are listed on the left-hand side. The ICDR provides an extension of the CDR from January 2022 onwards.

Each Level 3 SST file from the ESA SST_cci v3.0 product used for the generation of the L4 product contains two estimates of SSTs, i.e. a measure of the temperature of the skin of the water at the time it was observed and an estimate of the temperature at 20 cm depth as a daily mean. The temperature at 20 cm depth is used in the Optimal Interpolation at the Danish Meteorological Institute’s Optimal Interpolation (DMIOI) system for the generation of the L4 SST component in this product. Using of the adjusted daily mean SST to generate the L4 product aims to ensure the CDR and ICDR are stable with respect to the satellite overpass time. In addition, 20 cm SST is recommended for applications where long-term average changes are important. For the IST component, the surface skin temperature over sea-ice covered areas from the C3S L3 SI-IST CDR/ICDR v1.1. is used. Due to direct access to the production chain of the C3S L3 SI-IST CDR/ICDR v1.1 and to ensure control of how the IST component is ingested in the DMIOI processing chain, the L2P files on which the C3S L3 SI-IST CDR/ICDR v1.1, is based are used rather than the final L3 product.

The Level 4 product merges data from the level 3 SSTs and level 2P ISTs from all available input data (see Table 1) to create spatially complete, daily SST fields of average SST at 20 cm depth and IST at skin. The method for combining the input data is based on the DMI optimal interpolation scheme (DMIOI). More details can be found in Høyer and She (2007); Høyer et al. (2014); Nielsen-Englyst et al., 2023. Uncertainty information is provided along with the sea ice concentration information used to characterise the surface type and assign an SST or IST temperature.

**Table 1.** List of SST and IST input data used for the L4 processing.

Dataset product	Period	Source
SST_cci v3.0 L3U SST	1982-2021	ESA
SST ICDR	2022	C3S
SST ICDR	2023-2024	UK Earth Observation Climate Information Service (EOCIS) and Marine and Climate Advisory Service (MCAS)
AASTI v2.1 L2P IST	1982-2019	DMI & MetNo
C3S IST ICDR	2019-2024	C3S

In this way, it is ensured that the provided L4 field includes complete information for the surface temperature over open ocean and sea-ice based on satellite measurements as opposed to datasets containing only SST where over sea-ice, an estimated value for the water surface temperature is included, rather than actual measurements. Further, more detailed, information on how these L4 data are generated, and how the SST and IST measures are combined into the final product can be found in the accompanying Algorithm Theoretical Basis Document (ATBD: [D5]).

1.1.1 List of instruments

The instruments from which SST and IST data are retrieved are listed in Table 2.

Table 2. List of instruments and their satellite platforms, from which SST and IST measurements are retrieved. The operational timeframe for each instrument is also shown. The IST observations used in the CDR/ICDR are only from the AVHRR family of instruments.

Satellite	Instrument	Operations start	Operations end
NOAA-6	AVHRR/1	Jul 1979	Mar 1982
NOAA-7	AVHRR/2	Sep 1981	Feb 1985
NOAA-8	AVHRR/1	May 1983	Oct 1985
NOAA-9	AVHRR/2	Feb 1985	Nov 1988
NOAA-10	AVHRR/1	Nov 1986	Sep 1991
NOAA-11	AVHRR/2	Nov 1988	Dec 1994
ERS-1	ATSR-1	Jul 1991	Mar 2000
NOAA-12	AVHRR/2	Sep 1991	Dec 1998
NOAA-14	AVHRR/2	Jan 1995	Oct 2002
ERS-2	ATSR-2	Apr 1995	Sep 2011
NOAA-15	AVHRR/3	Oct 1998	Dec 2010
NOAA-16	AVHRR/3	Jan 2001	Dec 2010

**Table 2 (continued).**

Satellite	Instrument	Operations start	Operations end
NOAA-17	AVHRR/3	Jun 2000	Dec 2010
ENVISAT	(A)ATSR	Mar 2002	Apr 2012
AQUA	AMSR-E	Jun 2002	Oct 2011
NOAA-18	AVHRR/3	May 2005	Ongoing
MetOp-A	AVHRR/3	Oct 2006	Nov 2021
NOAA-19	AVHRR/3	Feb 2009	Ongoing
GCOM-W1	AMSR-2	Jul 2012	Ongoing
MetOp-B	AVHRR/3	Jan 2013	Ongoing
Sentinel 3A	SLSTR	Feb 2016	Ongoing
Sentinel 3B	SLSTR	Apr 2018	Ongoing
MetOp-C	AVHRR/3	Jan 2019	Ongoing

1.1.2 Auxiliary data

Sea Ice Concentration information is essential to classify open water points that have an SST value from Sea-Ice covered points that have an IST value. A new sea ice concentration (SIC) product, generated for the Copernicus Arctic Regional Reanalysis 2nd generation (CARRA2) Pan-Arctic extension (<https://climate.copernicus.eu/copernicus-arctic-regional-reanalysis-service>, referred to as DMI-MSC SIC) is used by the L4 analysis system for the northern hemisphere, while a re-run of the CARRA2 SIC processing has been produced for the southern hemisphere. The SIC product is a multi-source SIC composite based on SIC information from the EUMETSAT Ocean and Sea Ice Satellite Application Facility (OSI SAF) and ESA CCI Sea Ice products combined with different sources of ice charts. The following products are included in the SIC processing:

- OSI SAF global SIC CDR v3, OSI-450a, used for the period 1982 to 1991.
- The ESA CCI Sea ice CDR, SICCI-HR-SIC, used from 1992 to 2002 and in the gap in the AMSR satellite record, which occurs between the end of AMSR-E operations in October 2011 and the beginning of AMSR2 operations in May 2012.
- OSI-458 based on AMSR satellite record and used for the period from 2002 to 2020.
- A special rerun of OSI-458 produced by METNO to produce consistent sea ice fields after 2020.
- NIC ice charts used to identify land fast ice and to filter spurious sea ice along coasts.
- SHMI and FMI ice charts used for the Baltic region for the entire period.
- ESA SST_cci CDR v3 used to filter spurious sea ice.

The rationale behind using this multi-source SIC composite is to always use the most accurate SIC field available. Land spillover effects are more pronounced in the OSI-450a and SICCI-HR-SIC compared to OSI-458 which is based on the higher resolution AMSR-E/AMSR2 sensors. To improve



OSI-450a/SICCI-HR-SIC and to increase the consistency of the full SIC record, a number of filters have been applied to the SIC products using information from the NIC ice charts and the SST_cci CDR. In addition, an inter-sensor bias correction has been applied to increase the consistency of the combined SIC product. Both OSI-450a, SICCI-HR-SIC and OSI-458 have challenges in coastal regions, and for the Baltic Sea, Kattegat Bay and the Skagerrak Strait high resolution SIC information is used from the Swedish Meteorological and Hydrological Institute (SMHI; 1982-2011) and 1 km SIC fields (2012-present), which are based on ice charts.

Further information on the use of these auxiliary data can be found in the ATBD [D5].

1.2 Target requirements

Target requirements for both SST data and IST data are shown in Table 3. Their definition as defined in [D4], and the achieved levels are described for the period covered by the CDR (1982-2021), i.e. 40 years.

Table 3. Target and achieved requirements on spatial and temporal coverage, error and stability.

Component	Target (threshold) requirement	Level Achieved
Spatial coverage	Global (Global)	Achieved
Temporal coverage	>40 years (20 years)	42 years
Bias SST	0.1 K (0.1 K)	-0.02 K
Bias IST	1.5 K (2.5 K)	-2.5 K (with Tair as in situ)
Stability SST	0.001 K/yr (0.01 K/yr)	Not available at time of writing this document. Please see the associated PQAR document [D6].
Stability IST	0.01 K/y (0.03 K/yr)	Not available at time of writing this document. Please see the associated PQAR document [D6].



1.3 Data usage information

1.3.1 File naming convention

The output data are in netCDF4-classic format and follow the GHRSSST data specifications [D1]. The file names have the format:

<Date>120000-C3S2-L4_GHRSSST-SSTdepth-ISTskin-DMIOI-GLOB_<Dataset>-v02.0-fv01.0.nc

The variable components within braces: <component> are summarised in Table 1 and detailed in the following sections. Note:

- <Dataset> and <Extra> correspond to the GHRSSST <Additional Segregator> component and are therefore separated by an underscore (“_”) rather than a dash (“-”).
- The fixed version string “ v02.0 ” indicates that the file is a GDS 2.0 format file. The Climate Data Record version is indicated by the <Dataset> string.

Table 4. GDS 2.0 file-naming convention components.

Component	Definition	Description
<Date>	YYYYMMDD	The identifying date for this file in ISO8601 basic format
<Dataset>	CDR1.0 or ICDR1.0	Indicates if this file is CDR or ICDR and the version number; for L4 files this is prepended by ‘GLOB_’

1.3.1.1 Date

The identifying date for this file, using the ISO8601 basic format: YYYYMMDD.

1.3.1.2 Dataset

Indicates which (Interim) Climate Data Record this file belongs to. Current strings in use are CDR1.0 ICDR1.0.

Examples:

20210101120000-C3S2-L4_GHRSSST-SSTdepth-ISTskin-DMIOI-GLOB_ **CDR**-v02.0-fv01.0.nc
 20230105120000-C3S2-L4_GHRSSST-SSTdepth-ISTskin-DMIOI-GLOB_ **ICDR**-v02.0-fv01.0.nc

L4 files include GLOB_ (i.e. GLOB_CDR1.0 or GLOB_ICDR1.0) to maintain the convention used for other files produced with the DMIOI system.

1.3.2 Data format

The data files are in netCDF-4 format and are CF-compliant [D3], following the GDS [D2]. L4 files are on a global regular latitude/longitude grid (based on the WGS1984 geoid).



1.3.2.1 NetCDF Variable Attributes

Variables in the netCDF files include the standard metadata attributes listed in Table 5 below. These are recognised by most tools and utilities for operating with netCDF files.

Table 5. Table of standard variable attributes.

Attribute Name	Description
_FillValue	The number put into the data arrays where there are no valid data (before applying the scale_factor and add_offset attributes).
long_name	A descriptive name for the data.
standard_name	A unique descriptive name for the data, taken from the CF conventions [D3].
units	The units of the data after applying the scale_factor and add_offset conversion.
add_offset	After applying scale_factor below, add this to obtain the data in the units specified in the units attribute.
scale_factor	Multiply the data stored in the netCDF file by this number.
valid_range	Comma separated minimum and maximum valid value of the data (before applying scale_factor and add_offset).
comment	Miscellaneous information.
references	References that provide more information about the data.
source	A list of data sources used for the data in this variable.

1.3.2.2 Coordinate Grids

The coordinate variables are listed in Table 6 and discussed below.

Table 6. Table of coordinate variables.

Variable name	Dimensions	Description
lat	3600	Central latitude of each grid cell.
lon	7200	Central longitude of each grid cell.
time	1	Reference time of SST file, i.e. nominal time of the analysis.

1.3.2.3 Data variables

The L4 data files contain two main variables, the analysed surface temperature (analysed_st) which contains the combined observed sea surface (SST_{20cm}) and sea-ice surface (IST_{skin}) temperature field and the analysed sea surface temperature (analysed_sst) field which contains the observed sea surface (SST_{20cm}) temperature and the adjusted under-ice (or sub-ice) SST. Supporting variables contain metrics of the number, minimum, maximum and standard deviation of the observations used to estimate the analysed_st variable. A list of the relevant variables is included in Table 7.

**Table 7.** Main output variables included in the L4 files.

Variable name	Description
analysed_st	The surface temperature of the sea or sea ice at each location.
analysed_sst	The sea surface temperature over open ocean and under sea ice.

1.3.2.4 Uncertainty variables

Along with the data variables, the L4 files contain two variables containing the uncertainty estimates corresponding to the analysed_st and analysed_sst. These are described in Table 8.

Table 8. Uncertainty variables included in the L4 files.

Variable name	Description
analysed_st_uncertainty	Uncertainty in the sea or sea ice surface temperature at each location.
analysed_sst_uncertainty	Uncertainty in the sea surface temperature and under-ice surface temperature.

1.3.2.5 Auxiliary variables

Each grid cell has a bit mask to indicate if the cell corresponds to ocean, land or sea ice. A sea ice fraction variable is also included, indicating the percentage of sea ice on a given grid cell. These variables are explained in Table 9.

Table 9. Auxiliary variables included in the L4 files.

Variable name	Description
sea_ice_fraction	Sea ice fraction at each location in the grid.
sea_ice_fraction_flag	Flag indicating where the sea_ice_fraction is the original field (zero) and where it has been extrapolated (one).
mask	Information on whether is ocean, land, sea ice or marginal ice in each grid cell; set to 1 if the grid cell contains ocean; 2 for marginal ice zone (MIZ); 3 for sea-ice; 4 for lake and 8 for land.

Please note that the product mask's "lake" identifier refers only to the Caspian Sea. All other lakes are not represented and are thus classified as land in the dataset. Values in the mask variable can be used to identify only the ocean and Caspian Sea water grid points, sea-ice, land, and coastline.



1.3.3 Product contents

Examples of the data contained in one L4 product are shown below in Figure 2. Please note that the products do not include lakes (apart from the Caspian Sea); the mask variable can be used to identify only the ocean grid points.

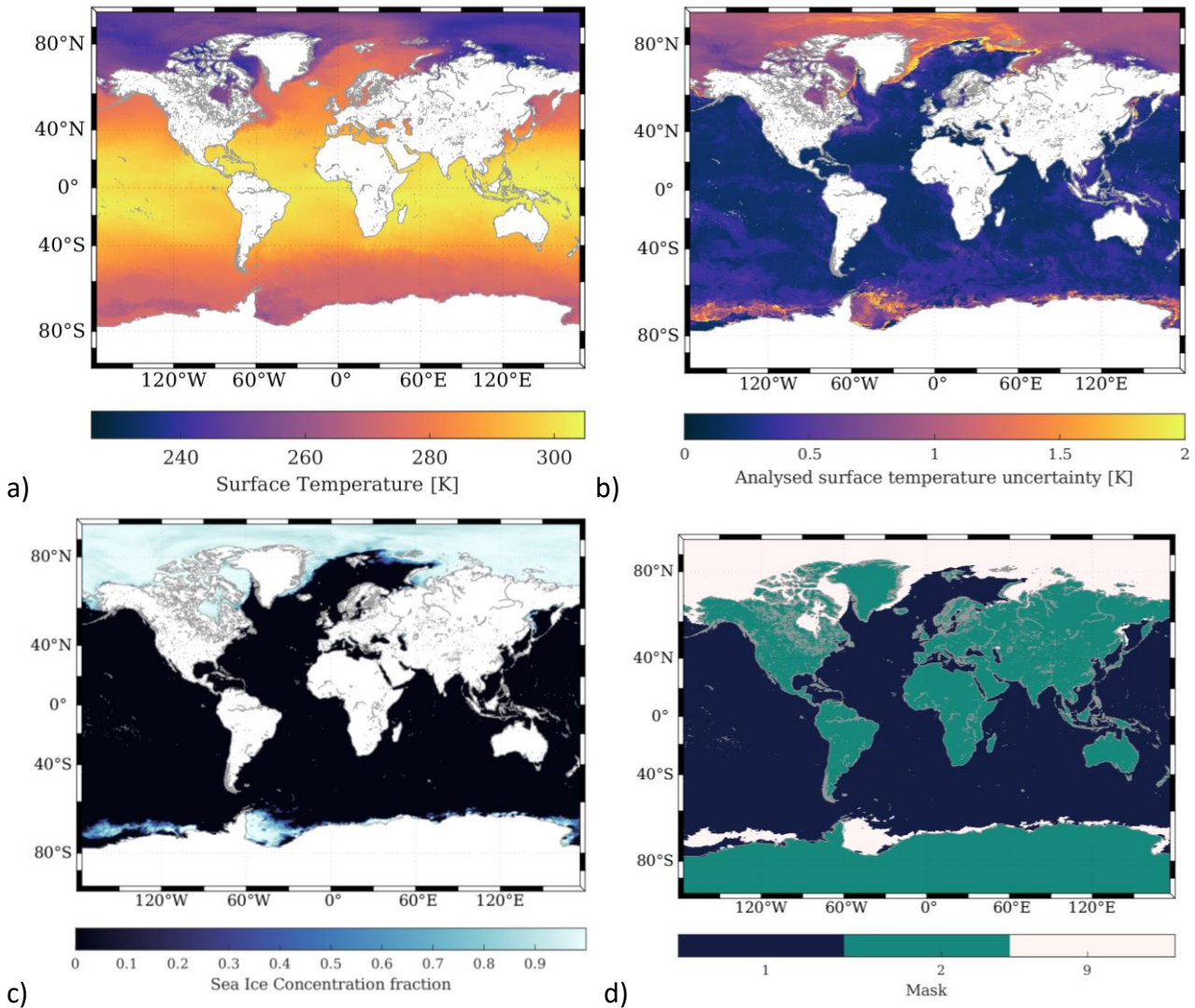


Figure 2. Example plots of L4 analysis variables for the 5th January 2023 (ICDR): a) analysed surface temperature in Kelvin (both sea and ice surface temperatures), b) uncertainty, c) sea ice concentration (from minimum zero to maximum 1) and d) mask for open ocean (1), land (2) and sea-ice (9).



2. Data access information

2.1 Data access

Data can be downloaded from the CDS, under “L4 v1.0 SST/IST”:

<https://cds.climate.copernicus.eu/datasets/satellite-sea-surface-temperature?tab=download>

2.2 Documentation

All relevant documentation is available in the CDS under “Documentation for L4 SST/IST CDR/ICDR”:

<https://cds.climate.copernicus.eu/datasets/satellite-sea-surface-temperature?tab=documentation>

2.3 Visualization tool

The dataset is also disseminated through the Copernicus Marine Service and the Marine Data Store offers a visualization tool, MyOcean Pro:

<https://data.marine.copernicus.eu/viewer/>

2.4 Programming languages

Numerous programming languages exist that can be used for reading and analysing netCDF files. These include both compiled languages such as Java, Fortran and C, and languages that allow interactive analysis and plotting of data. Some examples of the latter are:

- Python <http://www.python.org/> with add on modules such as:
 - netCDF4 <http://unidata.github.io/netcdf4-python/>
 - NumPy <http://www.numpy.org/>
 - matplotlib <http://matplotlib.org/>
 - Iris and Cartopy <http://scitools.org.uk/iris/>
- IDL <https://www.nv5geospatialsoftware.com/Products/IDL>
- MATLAB <https://www.mathworks.com/products/matlab.html>
- Grid Analysis and Display System (GrADS) <http://cola.gmu.edu/grads/>
- NCAR Command Language (NCL) <https://www.ncl.ucar.edu/>

2.5 Data provider

Data are produced by the National Centre for Climate Research at the Danish Meteorological Institute for the Copernicus Climate Change Service. For technical or scientific questions contact <https://climate.copernicus.eu/help-and-support> and/or myocean_po@dmi.dk



References

Brasseur, P., Bell, M., Johannessen, J.A., Le Traon, P.-Y, Sciller, A. (2013) The MyOcean project: scientific advances for operational ocean monitoring and forecasting. Ocean Science, Copernicus Publications. Available at: https://os.copernicus.org/articles/special_issue39.html [last accessed 1st October 2024].

Høyer, J. L. and She, J. (2007) Optimal interpolation of sea surface temperature for the North Sea and Baltic Sea, J. Mar. Sys., Vol 65, 1-4, pp. <https://doi.org/10.1016/j.jmarsys.2005.03.008> [last accessed 14th November 2024].

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Appendix A - Specifications for L4 SST/IST Analysis CDR

Example file structure (ncdump -h output):

```
netcdf \20000101120000-C3S2-L4_GHRSSST-SSTdepth-ISTskin-DMIOI-GLOB_CDR1.0-v02.0-fv01.0 {
dimensions:
  lon = 7200 ;
  lat = 3600 ;
  time = 1 ;
variables:
  float lon(lon) ;
    lon:standard_name = "longitude" ;
    lon:long_name = "longitude" ;
    lon:units = "degrees_east" ;
    lon:axis = "X" ;
    lon:valid_range = -180.f, 180.f ;
    lon:comment = "geographical coordinates, WGS84 projection" ;
  float lat(lat) ;
    lat:standard_name = "latitude" ;
    lat:long_name = "latitude" ;
    lat:units = "degrees_north" ;
    lat:axis = "Y" ;
    lat:valid_range = -90.f, 90.f ;
    lat:comment = "geographical coordinates, WGS84 projection" ;
  int time(time) ;
    time:standard_name = "time" ;
    time:long_name = "reference time of sst field" ;
    time:axis = "T" ;
    time:comment = "Nominal time of Level 4 analysis" ;
    time:units = "seconds since 1981-01-01" ;
    time:calendar = "gregorian" ;
  short analysed_st(time, lat, lon) ;
    analysed_st:_FillValue = -32768s ;
    analysed_st:standard_name = "surface_temperature" ;
    analysed_st:long_name = "analysed sea and ice surface temperature" ;
    analysed_st:units = "kelvin" ;
    analysed_st:comment = "" ;
    analysed_st:source = "AASTI v2 SST/IST, ESA CCI SST and C3S SST L2P products" ;
    analysed_st:valid_range = -6000s, 4500s ;
    analysed_st:add_offset = 273.15f ;
    analysed_st:scale_factor = 0.01f ;
  short analysis_error_st(time, lat, lon) ;
    analysis_error_st:_FillValue = -32768s ;
    analysis_error_st:long_name = "estimated error standard deviation of analysed_st" ;
    analysis_error_st:units = "kelvin" ;
    analysis_error_st:comment = "" ;
```



```

analysis_error_st:add_offset = 0.f ;
analysis_error_st:scale_factor = 0.01f ;
byte mask(time, lat, lon) ;
mask:_FillValue = -128b ;
mask:long_name = "land sea ice lake bit mask" ;
mask:comment = "Mask can be used to further filter the data" ;
mask:flag_meanings = "water land optional_lake_surface sea_ice optional_river_surface" ;
mask:source = "NAVOCEANO_landmask_v1.0, OSI-SAF, ESA CCI, CMEMS Baltic and SMHI
sea ice concentration" ;
mask:flag_masks = 1b, 2b, 4b, 8b, 16b ;
byte sea_ice_fraction(time, lat, lon) ;
sea_ice_fraction:_FillValue = -128b ;
sea_ice_fraction:standard_name = "sea_ice_area_fraction" ;
sea_ice_fraction:long_name = "sea ice area fraction" ;
sea_ice_fraction:units = "1" ;
sea_ice_fraction:comment = "" ;
sea_ice_fraction:source = "OSI-SAF, ESA CCI, NIC, CMEMS Baltic SMHI/FMI sea ice
concentration" ;
sea_ice_fraction:valid_range = 0b, 100b ;
sea_ice_fraction:add_offset = 0.f ;
sea_ice_fraction:scale_factor = 0.01f ;
short analysed_sst(time, lat, lon) ;
analysed_sst:_FillValue = -32768s ;
analysed_sst:standard_name = "sea_surface_temperature" ;
analysed_sst:long_name = "analysed sea and under-ice surface temperature" ;
analysed_sst:units = "kelvin" ;
string analysed_sst:comment = "The under-ice SST is the freezing point temperature TS,
computed as in Banzon et al. (2020), using Millero's formula (Fofonoff and Millard, 1983) and the
World Ocean Atlas 2018 salinity climatology (Garcia et al., 2019) and further adjusted by a constant
C and the sea ice concentration SIC." ;
analysed_sst:source = "AASTI v2 SST/IST, ESA CCI SST and C3S SST L2P products" ;
analysed_sst:valid_range = -6000s, 4500s ;
analysed_sst:add_offset = 273.15f ;
analysed_sst:scale_factor = 0.01f ;
byte sea_ice_fraction_flag(time, lat, lon) ;
sea_ice_fraction_flag:_FillValue = -128b ;
sea_ice_fraction_flag:long_name = "sea_ice_area_fraction_flag" ;
sea_ice_fraction_flag:comment = "The sea ice concentration flag is zero where the value is
the original SIC value and one where the sea ice concentration field has been extrapolated." ;
sea_ice_fraction_flag:flag_meanings = "original, extrapolated" ;
sea_ice_fraction_flag:source = "OSI-SAF, ESA CCI, NIC, CMEMS Baltic SMHI/FMI sea ice
concentration flag" ;
sea_ice_fraction_flag:flag_masks = 0b, 1b ;
sea_ice_fraction_flag:standard_name = "sea_ice_area_fraction_flag" ;
short analysis_error_sst(time, lat, lon) ;

```



```
analysis_error_sst:_FillValue = -32768s ;
analysis_error_sst:long_name = "estimated error standard deviation of analysed_sst" ;
analysis_error_sst:units = "kelvin" ;
analysis_error_sst:comment = "For the areas with under-ice SST computed, a fixed
uncertainty has been assigned." ;
analysis_error_sst:standard_name = "estimated error standard deviation of analysed_sst" ;
analysis_error_sst:scale_factor = 0.01f ;
```

```
// global attributes:
```

```
:Conventions = "CF-1.4, Unidata Observation Dataset v1.0" ;
:title = "Global Sea and Ice Surface Temperature, L4, 5km daily reprocessed SST and IST" ;
:summary = "DMI Sea and Ice Surface Temperature analysis created using multisensor
satellite surface temperature (ST) observations" ;
string :references = "Høyer, J. L. and She, J., Optimal interpolation of sea surface
temperature for the North Sea and Baltic Sea, J. Mar. Sys., Vol 65, 1-4, pp. 176-189, 2007. Høyer, J.
L., Le Borgne, P., & Eastwood, S., A bias correction method for Arctic satellite sea surface
temperature observations, Remote Sensing of Environment, 146, 201-213, 2014. Nielsen-Englyst, P.,
Høyer, J. L., Kolbe, W. M., Dybkjær, G., Laverge, T., Tonboe, R. T., Skarpalezos, S., Karagali, I., A
combined sea and sea-ice surface temperature climate dataset of the Arctic, 1982–2021, Remote
Sensing of Environment, 284, 113331, 2023." ;
:institution = "Danish Meteorological Institute, DMI" ;
:history = "Version 1.0" ;
:license = "These data are available free of charge under the Copernicus Climate Change
Service (C3S) data policy" ;
:id = "DMI-L4UHskin-GLOB-DMI_OI" ;
:naming_authority = "org.ghrsst" ;
:product_version = "Version 1.0" ;
:uuid = "d59e0252-bb82-45e1-ac85-04dbecc307c5" ;
:gds_version_id = "2.0" ;
:netcdf_version_id = "netcdf-4.4.1.1.6" ;
:date_created = "20240825T070856Z" ;
:file_quality_level = 3LL ;
:spatial_resolution = "0.05 degrees" ;
:time_coverage_start = "20000101T000000Z" ;
:time_coverage_end = "20000102T000000Z" ;
:geospatial_lon_min = -179.975 ;
:geospatial_lon_max = 179.975 ;
:geospatial_lat_min = -89.975 ;
:geospatial_lat_max = 89.975 ;
:source = "ESA SST CCI v3.0 and C3S v3.0 L3U, AASTiv2 IST L2P. OSI-SAF, ESA CCI, CMEMS
FMI and SMHI Sea ice concentration" ;
:platform = "NOAA-6 to NOAA-19, ERS-1, ERS-2, ENVISAT, SENTINEL-3 A/B, MetOp A/B,
AQUA, GCOM-W" ;
```



```

:platform_vocabulary = "CEOS mission table" ;
:instrument = "AVHRR, ATSR, ATSR-2, AATSR, SLSTR, AMSR-E, AMSR2" ;
:instrument_vocabulary = "CEOS instrument table" ;
:Metadata_Conventions = "Unidata Dataset Discovery v1.0" ;
:metadata_link = "http://data.nodc.noaa.gov/NESDIS_DataCenters/metadata/index.html" ;
:keywords = "Oceans > Ocean Temperature > Sea Surface Temperature" ;
:keywords_vocabulary = "NASA Global Change Master Directory (GCMD) Science
Keywords" ;
:standard_name_vocabulary = "NetCDF Climate and forecast (CF) Metadata Convention" ;
:geospatial_lat_units = "degrees north" ;
:geospatial_lon_units = "degrees east" ;
:geospatial_lat_resolution = 0.05 ;
:geospatial_lon_resolution = 0.05 ;
:geospatial_bounds = "(-179.975, 179.975, -89.975, 89.975)" ;
:acknowledgment = "Please acknowledge the use of these data with the following
statement: These data were provided by DMI and the Copernicus Climate Change Service (C3S)
project" ;
:creator_name = "Danish Meteorological Institute - DMI Copenhagen" ;
:creator_email = "myocean_po@dmi.dk" ;
:creator_url = "http://ocean.dmi.dk/satellite/" ;
:project = "Copernicus Climate Change Service (C3S) project" ;
:publisher_name = "C3S and DMI" ;
:publisher_url = "https://climate.copernicus.eu/" ;
:publisher_email = "https://climate.copernicus.eu/help-and-support,
myocean_po@dmi.dk" ;
:processing_level = "L4" ;
:cdm_data_type = "grid" ;
:comment = "IN NO EVENT SHALL DMI OR ITS REPRESENTATIVES BE LIABLE FOR ANY
DAMAGES WHATSOEVER INCLUDING, WITHOUT LIMITATION, SPECIAL, INDIRECT, INCIDENTAL OR
CONSEQUENTIAL DAMAGES OR DAMAGES FOR LOSS OF BUSINESS PROFITS OR SAVINGS, BUSINESS
INTERRUPTION, LOSS OF BUSINESS INFORMATION OR OTHER PECUNIARY LOSS ARISING OUT OF
THE USE OF OR THE BUSINESS INTERRUPTION, LOSS OF BUSINESS INFORMATION OR OTHER
PECUNIARY LOSS ARISING OUT OF THE USE OF OR THE INABILITY TO USE THIS DMI PRODUCT, EVEN
IF DMI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. THIS LIMITATION SHALL APPLY
TO CLAIMS OF PERSONAL INJURY TO THE EXTENT PERMITTED BY LAW. SOME COUNTRIES OR
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SPECIAL, INDIRECT, INCIDENTAL DAMAGES AND, ACCORDINGLY, SOME PORTIONS OF THESE
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ABOVE LIMITATIONS OR THE MAXIMUM LEGALLY APPLICABLE SUBSET OF THESE LIMITATIONS
APPLY TO YOUR USE OF THIS PRODUCT. WARNING: Some applications are unable to properly
handle signed byte values. If values are encountered > 127, please subtract 256 from this reported
value" ;
}

```



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