The Recommended GHRSST Data Specification (GDS) GDS 2.1

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The Recommended GHRSST Data Specification (GDS)
GDS 2.1 Technical Specifications

Compiled by the GHRSST International Science Team 2019
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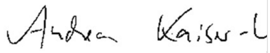
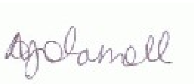
GHRSST Project Office	Andrea Kaiser-Weiss	GHRSST Quality Assurance and Revision Control		1/10/2010
GDS-2.1 External Review Board	Anne O'Carroll	GHRSST External Review Board		1/10/2010
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		variable names, removed attributes for some flags) • Replaced outdated R/G TS description	
GPO/Chiara Bearzotti	Formatting, updates	GPO contact details updated, link to Zenodo DOI, formatting of the cover pages	12 August 2022

Executive Summary

A new generation of integrated Sea Surface Temperature (SST) data products are being provided by the Group for High Resolution Sea Surface Temperature (GHRSST). L2 products are provided by a variety of data providers in a common format. L3 and L4 products combine, in near-real time, various SST data products from several different satellite sensors and in situ observations and maintain fine spatial and temporal resolution needed by SST inputs to a variety of ocean and atmosphere applications in the operational and scientific communities. Other GHRSST products provide diagnostic data sets and global multi-product ensemble analysis products. Retrospective reanalysis products are provided in a non-real time critical offline manner. All GHRSST products have a standard format, include uncertainty estimates for each measurement, and are served to the international user community free of charge through a variety of data transport mechanisms and access points that are collectively referred to as the GHRSST Regional/Global Task Sharing (R/GTS) framework.

The GHRSST Data Specification (GDS) Version 2.1 is a technical specification of GHRSST products and services. It consists of a technical specification document (this volume) and a separate Architecture Dcument (GSA). The GDS technical documents are supported by a User Manual and a complete description of the GHRSST ISO-19115-2 metadata model GDS-2.1 represents a consensus opinion of the GHRSST international community on how to optimally combine satellite and in situ SST data streams within the R/GTS. The GDS also provides guidance on how data providers might implement SST processing chains that contribute to the R/GTS.

This document first provides an overview of GHRSST followed by detailed technical specifications of the adopted file naming specification and supporting definitions and conventions used throughout GHRSST and the technical specifications for all GHRSST Level 2P, Level 3, Level 4, and GHRSST Multi-Product Ensemble data products. In addition, the GDS-2.1 Technical Specification provides controlled code tables and best practices for identifying sources of SST and ancillary data that are used within GHRSST data files.

The GDS document has been developed for data providers who wish to produce any level of GHRSST data product and for all users wishing to fully understand GHRSST product conventions, GHRSST data file contents, GHRSST and Climate Forecast definitions for SST, and other useful information. For a complete discussion and access to data products and services see https://www.ghrsst.org, which is a central portal for all GHRSST activities.

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Figures in this document

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1 Applicable Documents

The following documents contain requirements and information applicable to this document and must be consulted together with this document.

[AD-1] GDS-2.1 Interface control Document (ICD), Version 1.0, available from https://www.ghrsst.org/resources/ghrsst-project-documents/

[AD-2] GHRSST User's Guide available from https://www.ghrsst.org/resources/ghrsst-project-documents/ and netCDF user manuals and tools available from https://www.unidata.ucar.edu/software/netcdf/

[AD-3] netCDF Climate and Forecast (CF) Metadata Conventions version 1.7 or late available from https://cfconventions.org/Data/cf-conventions/cf-conventions-1.9/cf-conventions.html http://cfconventions.org

[AD-4] COARDS Conventions available from https://ferret.pmel.noaa.gov/Ferret/documentation/coards-netcdf-conventions

[AD-5] UDUNITS-2 package available from https://www.unidata.ucar.edu/software/udunits/

[AD-6] ISO 8601, The International Standard for the representation of dates and times, https://www.iso.org/iso-8601-date-and-time-format.html

[AD-7] Unidata Attribute Conventions for Dataset Discovery (ACDD), available from https://wiki.esipfed.org/Attribute_Convention_for_Data_Discovery_1-3

[AD-8] Current version (CF-1.7 or later) of the standard name table can be found at http://cfconventions.org/Data/cf-standard-names/current/build/cf-standard-name-table.html

[AD-9] NetCDF Climate and Forecast (CF) community mail list, available at http://cfconventions.org/discussion.html

[AD-10] NASA Global Change Master directory (GCMD) Science Keywords and Associated Directory Keywords, available at **https://www.earthdata.nasa.gov/learn/find-data/idn/gcmd-keywords**

[AD-11] **G**HRSST R/G TS System Architecture (GSA), v1.0, 04-11-2019, available online at: DOI 10.5281/zenodo.4926439

2 Reference Documents

The following documents can be consulted when using this document as they contain relevant information:

[RD-1] GHRSST PP Data Product User manual (GDS1.5) https://www.ghrsst.org/resources/ghrsst-project-documents/

[RD-2] Donlon, C. J., I. Robinson, K. S Casey, J. Vazquez-Cuervo, E Armstrong, O. Arino, C. Gentemann, D. May, P. LeBorgne, J. Piollé, I. Barton, H Beggs, D. J. S. Poulter, C. J. Merchant, A. Bingham, S. Heinz, A Harris, G. Wick, B. Emery, P. Minnett, R. Evans, D. Llewellyn-Jones, C. Mutlow, R. Reynolds, H. Kawamura and N. Rayner, 2007. The Global Ocean Data Assimilation Experiment (GODAE) high Resolution Sea Surface Temperature Pilot Project (GHR*SST-PP). Bull. Am. Meteorol. Soc*., Vol. 88, No. 8, pp. 1197-1213, (DOI:10.1175/BAMS-88-8-1197).

[RD-3] Donlon, C. J., I. Robinson, K. S Casey, J. Vazquez-Cuervo, E Armstrong, O. Arino, C. Gentemann, D. May, P. LeBorgne, J. Piollé, I. Barton, H Beggs, D. J. S. Poulter, C. J. Merchant, A. Bingham, S. Heinz, A Harris, G. Wick, B. Emery, P. Minnett, R. Evans, D. Llewellyn-Jones, C. Mutlow, R. Reynolds, H. Kawamura and N. Rayner, 2009. The Global Ocean Data Assimilation Experiment (GODAE) high Resolution Sea Surface Temperature Pilot Project (GHRSST-PP). *Oceanography*, Vol. 22, No. 3.

[RD-4] Donlon, C. J., P. Minnett, C. Gentemann, T. J. Nightingale, I. J. Barton, B. Ward and, J. Murray, 2002. Towards Improved Validation of Satellite Sea Surface Skin Temperature Measurements for Climate Research, *J. Climate*, Vol. 15, No. 4, pp. 353-369.

[RD-5] Donlon, C. J. and the GHRSST-PP Science Team, 2006. The GHRSST-PP User Requirement Document, available from the International GHRSST Project Office, https://www.ghrsst.org/resources/ghrsst-project-documents/

[RD-6] Donlon, C. J. and the GHRSST-PP Science Team, 2006. The GHRSST-PP Development and Implementation Plan (GDIP), 10.5281/zenodo.4700520

[RD-7] Global Climate Observing system, 2004. Implementation plan for the Global observing system for climate in support of the UNFCCC, GCOS – 92, WMO/TD No. 1219, available from World Meteorological Organization.

[RD-8] Faugere,Y., P.Le Borgne and H.Roquet, 2001. Realisation d'une climatologie mondiale de la temperature de surface de la mer a echelle fine, La Meteorologie, Vol. 35, pp. 24-35.

[RD-9] Reynolds, R. W., T. M. Smith, C. Liu, D. B. Chelton, K. S. Casey, and M. G. Schlax, 2007: Daily high-resolution blended analyses for sea surface temperature. J. Climate, 20, 5473-5496. Analysis data available from http://www.ncdc.noaa.gov/oa/climate/research/sst/oi-daily.php and from the GHRSST LTSRF at http://ghrsst.nodc.noaa.gov

[RD-10] Smith, N.R. and Koblinsky, C., 2001. The ocean observing system for the 21st Century, a consensus statement. In: Koblinsky, C. and Smith, N.R. (Eds.), Observing the Oceans in the 21st Century, pp 1-25, GODAE Project Office, Bureau of Meteorology, Melbourne, Australia.

[RD-11] The Second Report on the Adequacy of the Global Observing Systems for Climate in Support of the UNFCCC, GCOS – 82, April 2003 (WMO/TD No. 1143), Available online at http://www.wmo.int/pages/prog/gcos/index.php

[RD-12] Satellite Observation of the Climate System: The Committee on Earth Observation Satellites (CEOS) Response to the Global Climate Observing System (GCOS) Implementation Plan, Available online at http://www.ceos.org/pages/CEOSResponse_1010A.pdf

[RD-13] Smith, N. 2001. Report of the GODAE High Resolution SST Workshop. October 30–November 1, 2000. Available from the International GODAE Project Office, (https://www.godae-oceanview.org/), 64 pp.

[RD-14] Casey, K.S. and P. Cornillon, 1999. A comparison of satellite and in situ based sea surface temperature climatologies, J. Climate, vol. 12, no. 6, pp. 1848-1863. Original climatology data available from http://podaac.jpl.nasa.gov/DATA_CATALOG/avhrrinfo.html and most recent versions from http://pathfinder.nodc.noaa.gov

3 Acronym and abbreviation list

AATSR	Advanced Along Track Scanning Radiometer
ABOM	Australian Bureau of Meteorology RDAC
ACDD	Unidata Attribute Conventions for Dataset Discovery
AD	Applicable Document
AMSR-E	Advanced Microwave Scanning Radiometer - Earth Observing System
AUS	Australian regional analysis area
AVHRR	Advanced Very High Resolution Radiometer
CDL	network Common Data form Language
CF	Climate Forecast (convention of netCDF)
CICS	Cooperative Institute for Climate and Satellites
CTD	Conductivity, Temperature, Depth (in situ ocean measurements)
DAS-TAG	Data Assembly and Systems Technical Advisory Group
DMI	Danish Meteorological Institute
ECV	Essential Climate Variable
ECMWF	European Centre for Medium-range Weather Forecasting
ENVISAT	Environmental Satellite
EO	Earth Observation
ESA	European Space Agency
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
EUR	European RDAC
GAL	Area around the Galapagos Islands
GCOS	Global Climate Observing System
GDAC	Global Data Assembly Centre
GDIP	GHRSST development and implementation plan
GDS	GHRSST Data Specification
GHRSST	Group for High Resolution SST
GHRSST-PO	International GHRSST Project Office
GHRSST-PP	The GODAE High Resolution Sea Surface Temperature Pilot Project
GMES	Global Monitoring for Environment and Security
GMPE	GHRSST Multi Product Ensemble
GLOB	Global coverage data sets
GODAE	Global Ocean Data Assimilation Experiment
GOES	Geostationary Operational Environmental Satellite
GOS	Gruppo di Oceanografia da Satellite
ICD	Interface Control Document
IC-TAG	Inter comparison Technical Advisory Group
IR	Infrared
ISO	International Organization for Standardization
JAXA	Japan Aerospace Exploration Agency
JPL	Jet Propulsion Laboratory
L2	Level-2 data products
L2P	Level-2 Pre-processed data product

L3	Level 3 data products
L3U	Level 3 un-collated data product
L3C	Level 3 collated data product
L3S	Level 3 super-collated product
L4	Level 4 data product
LAS	Live Access Server
LTSRF	Long Term Stewardship and Reanalysis Facility
MED	Mediterranean Sea area
METNO	Norwegian Meteorological Institute
MMR	Master Metadata Repository
MODIS	Moderate Resolution Imaging Spectroradiometer
MSG	METEOSAT Second Generation
MTSAT	Multi-functional Transport Satellite Imager
MW	MicroWave
MYO	MyOcean
NAAPS	Navy Aerosol Analysis Prediction System
NAVO	US Naval Oceanographic Office
NCEP	NOAA National Centers for Environmental Prediction (US)
NCDC	NOAA National Climatic Data Center (US)
netCDF	Network Common Data Format
NEODAAS	NERC Observation Data Acquisition and Analysis Service
NIR	Near Infrared
NOAA	National Oceanic and Atmospheric Administration (US)
NOC	National Oceanography Centre, Southampton
NODC	NOAA National Oceanographic Data Center (US)
NOP	Numerical Ocean Prediction
NSEABALTIC	North Sea and Baltic Region
NWE	North-West of Europe
NWP	Numerical Weather Prediction
OI	Optimal Interpolation
OSDPD	NOAA Office of Satellite Data Processing and Distribution (US)
OSISAF	EUMETSAT Ocean and Sea Ice Satellite Applications Facility
PO.DAAC	Physical Oceanography Distributed Active Archive Centre (US)
RD	Reference document
RDAC	Regional Data Assembly Centre
REMSS	Remote Sensing Systems, CA, USA
R/GTS	Regional/Global Task Sharing framework of GHRSST
RSMAS	Rosenstiel School of Marine and Atmospheric Science, University of Miami
SEVIRI	Spinning Enhanced Visible and Infrared Imager
SLSTR	Sea and Land Surface Temperature Radiometer
SSI	Surface Solar Irradiance
SSM/I	Special sensor microwave imager
SSES	Sensor Specific Error Statistics
SST	Sea Surface Temperature
STVAL	Sea Surface Temperature Validation Working Group
TAG	Technical Advisory Group

THREDDS	Thematic Realtime Environmental Distributed Data Services
TIR	Thermal Infrared
TMI	TRMM Microwave Imager
TRMM	Tropical Rainfall Mapping Mission
UKMO	UK Met Office
UNFCCC	United Nations Framework Convention on Climate Change
UPA	United Kingdom Multi-Mission Processing and Archiving Facility
URL	Universal Resource Locator
UTC	Coordinated Universal Time
WG	Working Group
WMO	World Meteorological Organization
XML	Extensible Mark-up Language

4 Document Conventions

The following sub-sections describe the notation conventions and data storage types that are used throughout this GDS-2.1 Technical Specification. Implementation projects are expected to adhere to the nomenclature and style of the GDS-2.1 in their own documentation as much as possible to facilitate international coordination of documentation describing the data products and services within the GHRSST R/GTS framework [RD-2].

4.1 Use of text types

The text styles defined in Table 4-1 are used throughout the GDS.

Table 4-1 Definition of text styles used in the GDS

Text type	Meaning	Example
Bold Courier font	Denotes a variable name	**dt_analysis**
Bold Courier font	Denotes a netCDF attribute name	**gds_version_id**
Arial	Denotes regular text.	This is normal text.

4.2 Use of colour in tables

The colours defined in Table 4-2 are used throughout the GDS.

Table 4-2 Definition of colour styles used in the GDS

Colour	Meaning	Example
Grey	Denotes a table column name	**Variable**
Blue	Denotes a mandatory item	**analysed_sst**
Violet	Denotes an item mandatory for only certain situations	**dt_analysis**
Yellow	Denotes an optional item	**experimental_field**
Green	Denotes grid dimensions	**ni=1024**
Pink	Denotes grid variable dimensions	**float lat(nj, ni)**

4.3 Definitions of storage types within the GDS-2.1

Computer storage types referred to in the GDS are defined in Table 4-3 and follow those used in netCDF.

Table 4-3 Storage type definitions used in the GDS

Name	Storage Type
byte	8 bit signed integer
short	16 bit signed integer
int (or long)	32 bit signed integer
float	32 bit floating point
double	64 bit floating point
string	Character string

5 Scope and Content of this Document

The GDS Technical Specification is written for those wishing to create or use any GHRSST product and requiring detailed technical information on their contents and specifications. It provides the technical specifications for all GHRSST data sets used within the GHRSST Regional/Global Task Sharing (R/GTS) Framework. An overview of GHRSST and the GDS presented followed by a detailed technical specification of the GHRSST file naming specification, supporting definitions and conventions. The technical specifications for all GHRSST Level 2P (L2P), Level 3 (L3), Level 4 (L4), and GHRSST Multi-Product Ensemble (GMPE) data products are then provided. The GDS also provides code tables and best practices for identifying sources of SST and ancillary data within GHRSST data files.

This document has been developed for data providers who wish to produce any level of GHRSST data product and for all users wishing to fully understand the file naming convention, GHRSST data file contents, GHRSST and Climate Forecast definitions for SST, and other useful information. Additional information describing GHRSST, and its component international services is available at http://www.ghrsst.org and many relevant GHRSST web sites are listed on the last page of this document.

6 Overview of GHRSST and the GDS-2.1

GHRSST [RD-2] is an international consortium representing commercial enterprises, academic institutions, research organizations, and operational agencies that collaborate to provide accurate, high resolution, and consistently formatted SST observations and analyses from space-based platforms. This section briefly provides information on the importance of SST, an overview and history of GHRSST, and context for understanding the GDS-2.1.

6.1 The Importance of SST

Sea Surface Temperature at the ocean-atmosphere interface is a fundamental variable for understanding, monitoring, and predicting fluxes of heat, momentum, and gas at a variety of scales that determine complex interactions between atmosphere and ocean. The ocean stores heat from the sun and redistributes it from the tropical regions to higher latitudes and to the less dense atmosphere regulating global weather and climate. Through the hydrological cycle the coupled system controls terrestrial life by redistributing fresh water over the land surface. From large ocean gyres and atmospheric circulation cells that fuel atmospheric depression systems, storms and hurricanes with their attendant wind waves and storm surges, to local scale phenomena such as the generation of sea breezes and convection clouds, SST at the ocean-atmosphere interface has a significant societal impact.

Accurate knowledge of global SST distribution and temporal variation at finer spatial resolution is needed as a key input to numerical weather prediction (NWP) and numerical ocean prediction (NOP) systems to constrain the modelled upper-ocean circulation and thermal structure at daily, seasonal, decadal, and climatic time scales, for the exchange of energy between the ocean and atmosphere in coupled ocean-atmosphere models, and as boundary conditions for ocean forecasting models. Such models are widely used operationally for various applications including maritime safety, military operations, ecosystem assessments, fisheries support, and tourism.

In addition, well-defined and quantified error estimates of SST are also required for climate time series that can be analysed to reveal the role of the ocean in short and long term climate variability. A 30 year record of satellite SST observations is available now, that grows on a daily basis. SST climate data records that are used to provide the GCOS SST Essential Climate Variable (ECV) [RD-7], [RD-11], [RD-12] are essential to monitoring and understanding climate variability, climate-ecosystem interactions such as coral reef health and sustainable fisheries management, and critical issues like sea level rise and changing sea ice patterns.

6.2 GHRSST History

In 1998, SST data production was considered a mature component of the observing system with demonstrated capability and data products. However, SST product availability was limited to a few data sets that were large, scientific in format and difficult to exchange in a near real time manner. Product accuracy was considered insufficient for the emerging NWP and NOP systems. Uncertainty estimates for SST products were unavailable with SST products complicating their application by the NWP and NOP data assimilation community. At the same time the number of applications requiring an accurate high resolution SST data stream was growing.

Considering these issues, the Global Ocean Data Assimilation Experiment (GODAE) [RD-10] defined the minimum data specification required for use in operational ocean models, stating that SST observations with global coverage, a spatial resolution of 10 km and an accuracy of <0.4 K need to be updated every six hours [RD-10].

Despite the network of SST observations from ships and buoys, the only way to achieve these demanding specifications was to make full use of space-based observations. An integrated and international approach was sought to improve satellite SST measurements, based on four principles:

(1) Respond to user SST requirements through a consensus approach,
(2) Organize activities according to principles of shared responsibility and subsidiarity, handling matters with the lowest, smallest, or least centralized competent group possible,
(3) Develop complementarities between independent measurements from earth observation satellites and in situ sensors,
(4) Maximize synergy benefits of an integrated SST measurement system and end-to-end user service.

These foundations enabled the international ocean remote sensing community, marine meteorologists, Space Agencies, and ocean modellers to combine their energies to meet the GODAE requirements by establishing the GODAE High Resolution Sea Surface Temperature Pilot Project (GHRSST-PP). GHRSST-PP established four main tasks relevant to the development of the SST observing system:

(1) Improve SST data assembly/delivery,
(2) Test available SST data sources,
(3) Perform inter-comparison of SST products,
(4) Develop applications and data assimilation of SST to demonstrate the benefit of the improved observing system.

GHRSST-PP successfully demonstrated that the requirements of GODAE could be met when significant amounts of GHRSST-PP data became available in 2006 and was instrumental in defining the shape and form of the modern-era SST measurement system and user service over the last 10 years [RD-2].

At the end of the GODAE period in 2009, the GHRSST-PP evolved into the Group for High Resolution SST (GHRSST). GHRSST built on the successes of the pilot project phase and continued a series of international workshops that were held during 2000-2009. These workshops established a set of user requirements for all GHRSST activities in five areas:

(1) Scientific development and applications,
(2) Operational agency requirements,
(3) SST product specifications,
(4) Programmatic organization of an international SST service,
(5) Developing scientific techniques to improve products and exploit the observing system.

These requirements were critical to establishing the GHRSST framework and work plan and formed an essential part of the GHRSST evolution. By establishing and documenting clear requirements in a consultative manner at the start of the project and through all stages of its development, GHRSST was able to develop confidently and purposefully to address the needs of the international SST user community.

6.3 GHRSST Organization

Over the last two decades, GHRSST established and now continues to provide an internationally distributed suite of user focused services in a sustained Regional/Global Task Sharing (R/GTS) framework [AD-11] that addresses international organizational challenges and recognizes the implementing institutional capacities, capabilities, and funding prospects. Long term stewardship, user support and help services, and standards-based data management and interoperability have been developed and are operated within the R/GTS on a daily basis.

The first GHRSST Level 2P datasets were made available in 2006. Since then the GHRSST R/G TS framework did not change up to 2019. Datasets produced from the collection of international 14 Regional Data Assembly Centres (RDACs) were ingested by a Global Data Assembly Centre (GDAC), such as the US GDAC located at the NASA Jet Propulsion Laboratory, Physical Oceanography Active Archive Data Center PO.DAAC). These data were made available for public distribution via a number of access protocols, tools and services, and also staged for ingestion. Final archiving and further distribution services were performed by the Long-term Stewardship and Reanalysis Facility (LTSRF) located at the NOAA National Center for Environmental Information (NCEI). This initial GHRSST R/G TS Framework is presented in Figure 6-1.

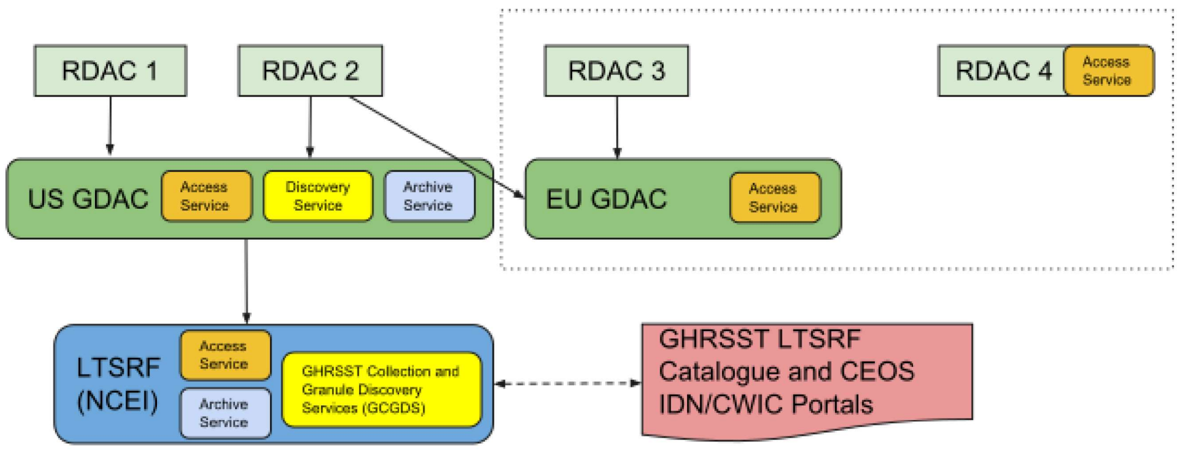

Figure 6-1: The initial (2006 to 2019) R/G TS framework. Data and metadata from data producers (RDACs) flow first to a GDAC (such as JPL GDAC or the less comprehensive EU GDAC). After 30 days this flow is also ingested by the NOAA LTSRF. The JPL GDAC has the most comprehensive metadata catalogue. LTSRF has the most comprehensive data archive. All GHRSST metadata are also ingested by the NASA CEOS CWIC repository.

Although this initial paradigm has functioned well, it has deviated from its initial design with the growing number of producers and datasets. As seen in the dashed box in Figure, a new GDAC was set-up in Europe, delivering products not available at the US GDAC, while other producers (e.g. CMEMS, Copernicus/EUMETSAT, and JAXA) are also now delivering products through their own services without any push to a GDAC. It was recognized by the GHRSST data management experts, through discussions from 2017 to 2019, and confirmed at the annual GHRSST science team meetings, that a more defined sharing of data management resources would be beneficial to the future growth of GHRSST and encourage more participation by other potential data producers. The specification of the GHRSST data management paradigm for the next years is the focus of the next sections. It can be summarised by a more distributed system where no entity, but the GHRSST Project Office, plays a central role anymore, as shown on Figure 6-2.

In the new R/G TS framework, there are now only two types of entities: data producers (GDP or GHRSST Data Producers) and distributing centres (DAC or Data Assembly Centre). The two roles can be combined by a single institution (for example, EUMETSAT which produces and delivers Sentinel-3 A & B products). The GHRSST Project Office (GHRSST-PO) provides and maintains on its portal a central catalogue of all GHRSST datasets providing collection (dataset) level metadata, and federated search and discovery services. Each DAC must implement a minimum set of services for granule data access, search and discovery, production/distribution metrics and long-term archiving.

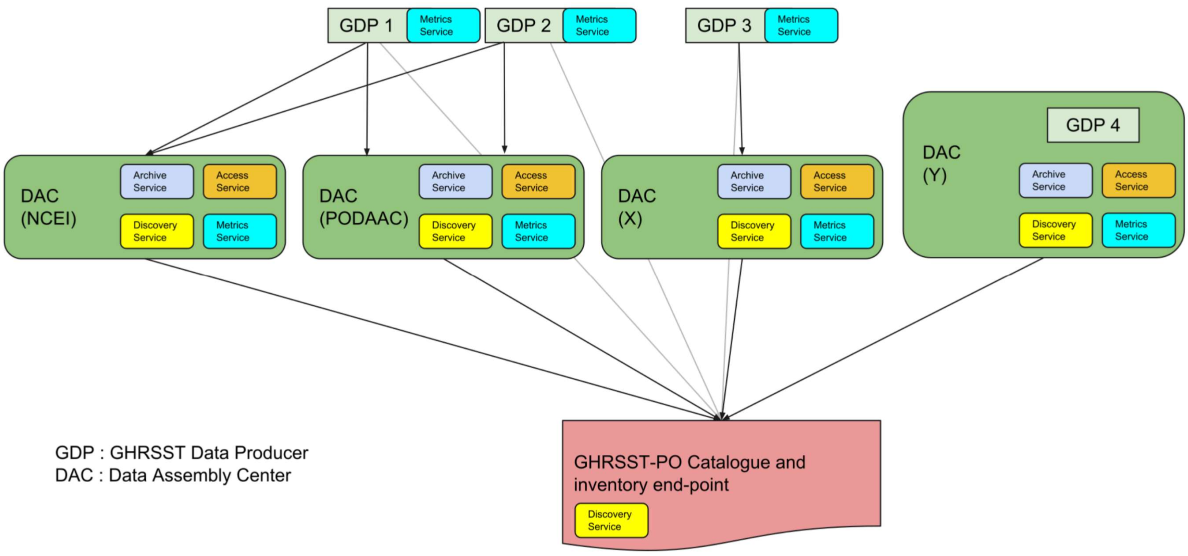

Figure 6-2: Revised architecture proposal. Multiple interfaces are now available to data producers. Each data node implements interface, distribution, archiving and metadata services for the datasets they are responsible for. Data and metadata from data producers (GDPs) flow first to a DAC (like PO.DAAC, before as the US GDAC). There is no more GDAC with the commitment to host all GHRSST datasets, it is now a shared task between DACs and some datasets can be distributed by several DACs. The GHRSST-PO portal allows the user to discover and search all GHRSST products and granules without prior knowledge of who is the producer or distributor.

Each component of the R/GTS is independently managed and operated by different institutions and agencies. The R/GTS itself is coordinated by the international GHRSST Science Team, which receives guidance and advice from the GHRSST Advisory Council. A GHRSST Project Office coordinates the overall framework.

6.4 Overview of the GDS-2.1

The GHRSST R/GTS was made possible through the establishment of a rigorous GHRSST Technical Data Specification (GDS), which instructed international satellite data providers on how to process satellite data streams, defined the format and content of the data and metadata, and documented the basic approaches to providing uncertainty estimates and auxiliary data sets. The GHRSST-PP established the first GDS (v1.6) [RD-1], which formed the basis of all GHRSST data production from 2005 through today. Since 2010 the Version 2 of the GDS has been used in operations, with minor updates occurring from time to time.

All GHRSST products entering the R/GTS must strictly follow the common GDS when generating L2P, L3, L4, and GMPE data. As a result, users with common tools to read data from one RDAC can securely use data from any of the others as well as the GDAC and LTSRF without a need to re-code. Table 6-1 provides a summary of GDS-2.1 data products and their basic characteristics.

The remainder of this document provides the detailed specifications for GHRSST L2P, L3, L4, and GMPE products, their file naming convention, metadata requirements, and all necessary tables, conventions, and best practices for creating and using GHRSST data.

Table 6-1 GHRSST data products specified by the GDS-2.1.

<table>
<tr><th>SST Product</th><th>L2 Pre-Processed [Section 8]</th><th>L3 Uncollated [Section 1010]</th><th>L3 Collated [Section 10]</th><th>L3 Super-collated [Section 10]</th><th>Analyzed SST [Section 11]</th><th>GHRSST Multi-Product Ensemble SST [Section 12]</th></tr>
<tr><td>Acronym</td><td>L2P</td><td>L3U</td><td>L3C</td><td>L3S</td><td>L4</td><td>GMPE</td></tr>
<tr><td rowspan="2">Description</td><td rowspan="2">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.</td><td>L2 data granules remapped to a space grid without combining any observations from overlapping orbits.</td><td>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.</td><td>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.</td><td rowspan="2">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</td><td rowspan="2">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.</td></tr>
<tr><td colspan="3">L3 GHRSST products do not use analysis or interpolation procedures to fill gaps where no observations are available</td></tr>
<tr><td>Grid specification</td><td>Native to SST data format</td><td>Defined by data provider</td><td>Defined by data provider</td><td>Defined by data provider</td><td>Defined by data provider</td><td>Defined by data provider</td></tr>
<tr><td>Temporal resolution</td><td>Native to SST data stream</td><td>Native to data stream</td><td>Defined by data provider</td><td>Defined by data provider</td><td>Defined by data provider</td><td>Defined by data provider</td></tr>
<tr><td>Delivery timescale</td><td>As available,
Ideally within 3 hours from acquisition at satellite</td><td>As available, Ideally within 3 hours from acquisition at satellite</td><td>As available, Ideally within 3 hours from acquisition at satellite</td><td>As available, Ideally within 3 hours from acquisition at satellite</td><td>Analyzed product processing window as defined by data provider.</td><td>As available, ideally within 24 hours of the input L4 products being available.</td></tr>
<tr><td>Target accuracy</td><td>Native to data stream</td><td>Native to data stream</td><td><0.4 K</td><td><0.4 K</td><td>< 0.4 K absolute,
0.1 K relative</td><td>< 0.4 K</td></tr>
<tr><td>Error statistics</td><td>Native to data stream if available, sensor specific error statistics otherwise</td><td>Native to data stream if available, sensor specific error statistics otherwise</td><td>Derived from input data for each output grid point.</td><td>Derived from input data for each output grid point.</td><td>Analysis error defined by data provider for each output grid point (no input data statistics are retained)</td><td>The standard deviation of the input L4 analyses is provided. This is not an error estimate but provides some idea of uncertainty.</td></tr>
<tr><td>Coverage</td><td>Native to data stream</td><td>Native to data stream</td><td>Defined by data provider</td><td>Defined by data provider</td><td>Defined by data provider</td><td>Defined by data provider</td></tr>
</table>

7 GDS-2.1 Filenames and Supporting Conventions

Striving to achieve a flexible naming convention that maintains consistency across processing levels and better serves user needs, the GDS-2.1 uses a single form for all GHRSST data files. An overview of the format is presented below in Section 7.1 along with example filenames. Details on each of the filename convention components are provided in Sections 7.2 through 7.8.

In addition, a best practice has been established for creating character strings used to describe GHRSST SST products and sources of ancillary data. These strings, and associated numeric codes for the SST products, are used within some GHRSST data files but are not part of the filename convention itself. The best practice is described in Section 7.9.

7.1 Overview of Filename Convention and Example Filenames

The filenaming convention for the GDS-2.1 is shown below.

<Indicative Date><Indicative Time>-<RDAC>-<Processing Level>_GHRSST-<SST Type>-<Product String>-<Additional Segregator>-v<GDS Version>-fv<File Version>.<File Type>

The variable components within braces ("< >") are summarized in Table 7-1 below and detailed in the following sections. Note that dashes ("-") **are reserved** to separate elements of the file name and **should not** be used in any GHRSST code or the <Additional Segregator> element. Example filenames are given later in this section. While no strict limit to filename length is mandated, RDACs are encouraged to keep the length to less than 240 characters to increase readability and usability.

Table 7-1 GDS-2.1 Filenaming convention components.

Name	Definition	Description
<Indicative Date>	YYYYMMDD	The identifying date for this data set. See Section 7.2.
<Indicative Time>	HHMMSS	The identifying time for this data set. The time used is dependent on the <Processing Level> of the data set: L2P: start time of granule L3U: start time of granule L3C and L3S: centre time of the collation window L4 and GMPE: nominal time of analysis All times should be given in UTC. See Section 7.3.
<RDAC>	The RDAC where the file was created	The Regional Data Assembly Centre (RDAC) code, listed in Section 7.4.
<Processing Level>	The data processing level code (L2P, L3U, L3C, L3S, or L4)	The data processing level code, defined in Section 7.5.
<SST Type>	The type of SST data included in the file	Conforms to the GHRSST definitions for SST, defined in Section 7.6.

<Product String>	A character string identifying the SST product set. The string is used uniquely within an RDAC but may be shared across RDACs.	The unique “name” within an RDAC of the product line. See Section 7.7 for the product string lists, one each for L2P, L3, L4, and GMPE products. See Section 7.7.
<Additional Segregator>	Optional text to distinguish between files with the same <Product String>. Dashes are not allowed within this element.	This text is used since the other filename components are sometimes insufficient to uniquely identify a file. For example, in L2P or L3U (un-collated) products this is often the original file name or processing algorithm. Note, underscores should be used, not dashes. For L4 files, this element should begin with the appropriate regional code as defined in Section 7.8. This component is optional but must be used in those cases were non-unique filenames would otherwise result.
<GDS Version>	*nn.n*	Version number of the GDS used to process the file. For example, GDS-2.1 = “02.1”.
<File Version>	*xx.x*	Version number for the file, for example, “01.0”.
<File Type>	netCDF data file suffix (nc) or ISO metadata file suffix (xml)	Indicates this is a netCDF file containing data or its corresponding ISO-19115 metadata record in XML.

L2_GHRSST Filename Example
20070503132300-NAVO-L2P_GHRSST-SSTblend-AVHRR17_L-SST_s0123_e0135-v02.1-fv01.0.nc

The above file contains GHRSST L2P blended SST data for 03 May 2007, from AVHRR LAC data collected from the NOAA-17 platform. The granule begins at 13:23:00 hours. It is version 1.0 of the file and was produced by the NAVO RDAC in accordance with the GDS-2.1. The <Additional Segregator> text is “SST_s0123_e0135”.

L3_GHRSST Filename Example
20070503110153-REMSS-L3C_GHRSST-SSTsubskin-TMI-tmi_20070503rt-v02.1-fv01.0.nc

The above file was produced by the REMSS RDAC and contains collated L3 sub-skin SST data from the TMI instrument for 03 May 2007. The collated file has a centre time of at 11:01:53 hours. It is version 1.0 of the file and was produced according to GDS-2.1 specifications. Its <Additional Segregator> text is “tmi_20070503rt”.

L4_GHRSST Filename Example
20070503120000-UKMO-L4_GHRSST-SSTfnd-OSTIA-GLOB-v02.1-fv01.0.nc

The above file contains L4 foundation SST data produced at the UKMO RDAC using the OSTIA system. It is global coverage, contains data for 03 May 2007, was produced to GDS-2.1

specifications and is version 1.0 of the file. The nominal time of the OSTIA analysis is 12:00:00 hours.

7.2 <Indicative Date>

The identifying date for this data set, using the format YYYYMMDD, where YYYY is the four-digit year, MM is the two-digit month from 01 to 12, and DD is the two-digit day of month from 01 to 31. The date used should best represent the observation date for the dataset.

7.3 <Indicative Time>

The identifying time for this data set in UTC, using the format HHMMSS, where HH is the two-digit hour from 00 to 23, MM is the two-digit minute from 00 to 59, and SS is the two-digit second from 00 to 59. The time used is dependent on the <Processing Level> of the data set:

L2P: start time of granule
L3U: start time of granule
L3C and L3S: centre time of the collation window
L4 and GMPE: nominal time of analysis

All times should be given in UTC and should be chosen to best represent the observation time for this dataset. Note: RDACs should ensure the applications they use to determine UTC proprerly account for leap seconds.

7.4 <RDAC>

Codes used for GHRSST Regional Data Assembly Centres (RDACs) are available on the GHRSST website (https://www.ghrsst.org/resources/ghrsst-data-specification-gds-tables/). New codes are assigned by the GHRSST Data And Systems Technical Advisory Group (DAS-TAG) and entered into the table upon agreement by the GDAC, LTSRF, and relevant RDACs.

7.5 <Processing Level>

Satellite data processing level definitions can lead to ambiguous situations, especially regarding the distinction between L3 and L4 products. GHRSST identified the use of analysis procedures to fill gaps where no observations exist to resolve this ambiguity. Within GHRSST filenames, the <Processing Level> codes are shown below in Table 7-2. GHRSST currently establishes standards for L2P, L3U, L3C, L3S, and L4 (GHRSST Multi-Product Ensembles known as GMPE are a special kind of L4 product for which GHRSST also provides standards).

Table 7-2 GHRSST Processing Level Conventions and Codes

Level	<Processing Level> Code	Description
Level 0	L0	Unprocessed instrument and payload data at full resolution. GHRSST does not make recommendations regarding formats or content for data at this processing level.
Level 1A	L1A	Reconstructed unprocessed instrument data at full resolution, time referenced, and annotated with ancillary information,

		including radiometric and geometric calibration coefficients and geo-referencing parameters, computed and appended, but not applied, to L0 data. GHRSST does not make recommendations regarding formats or content for data at this processing level.
Level 1B	L1B	Level 1A data that have been processed to sensor units. GHRSST does not currently make recommendations regarding formats or content for L1B data.
Level 2 Pre-processed	L2P	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.
Level 3	L3U L3C L3S	Level 2 variables mapped on a defined grid with reduced requirements for ancillary data. Uncertainty estimates are still mandatory. Three types of L3 products are defined: • **Un-collated (L3U):** L2 data granules remapped to a space grid without combining any observations from overlapping orbits • **Collated (L3C)**: observations combined from a single instrument into a space-time grid • **Super-collated (L3S):** observations combined from multiple instruments into a space-time grid. Note that L3 GHRSST products do not use analysis or interpolation procedures to fill gaps where no observations are available.
Level 4	L4	Data sets created from the analysis of lower level data that result 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 products are a type of L4 dataset.

Note that within GHRSST, all L2P files require a full set of extensive ancillary data such as wind speeds and times of observation that are provided as 'dynamic flags' that users can manipulate to filter data according to their own quality criteria. L2P files form the basis of higher-level products and are often the best level products for data assimilation. The requirement for dynamic flags is particularly important in this context. Higher-level L3 products are often intended for general use or created for input to Level 4 analysis systems so the requirement for extensive ancillary data is reduced. Since some GHRSST RDACs only process data natively on grids (especially in the case of geostationary platform observations), the GDS-2.1 L3 specification is flexible enough to allow for the creation of L3 files which meet all the content requirements of a L2P file. In all L2P and L3 cases, bias and standard deviation uncertainty estimates are mandatory.

The distinction between L3 GHRSST and L4 GHRSST data is made primarily on whether or not any gap-filling techniques are employed, not on whether data from multiple instruments is used in the L3 product. If no gap filling procedure (such as optimal interpolation) is used, then the product remains a L3 GHRSST product. GHRSST defines three kinds of L3 files: un-collated (L3U), collated (L3C), and super-collated (L3S). If gap filling is used to fill all observations gaps, then the resulting gap-free data are considered L4 GHRSST data products.

7.6 <SST Type>

In conjunction with the NetCDF Climate and Forecast (CF) community [AD-9] the GHRSST Science Team agreed on the CF standard names for "SST" shown in the following figure and described in more detail below. The names were first included in CF-1.3, and the current version of the standard name table can be found in [AD-8]. In addition, the GHRSST Science Team agreed to use the CF Naming Convention [AD-3] for variable names that do not already exist as part of the CF Convention. CF definitions are used in the GDS and across GHRSST and are shown schematically in Figure 7-3. The different kinds of SST are detailed later in this section and the relevant <SST Type> codes to be used in the filenames are provided.

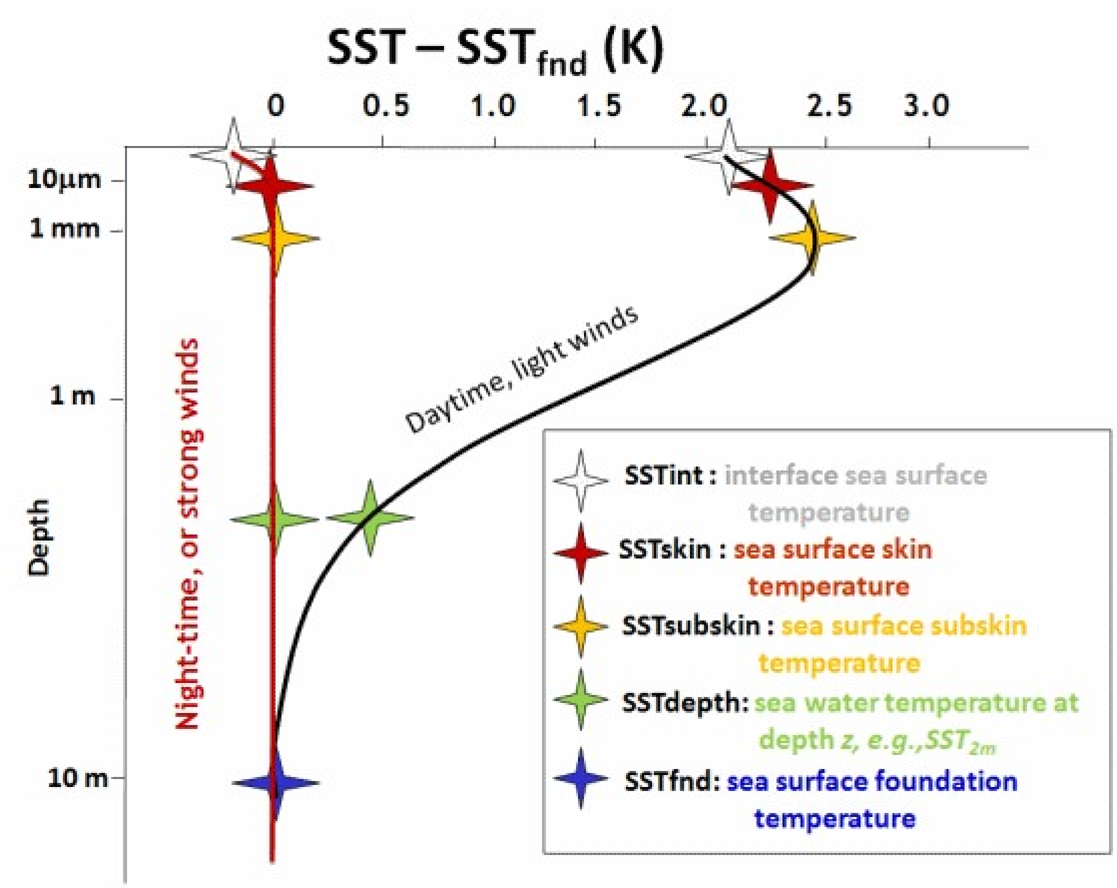

Figure 7-3. Overview of SST measurement types used within GHRSST.

Sea_surface_temperature (GHRSST <SST Type>: SSTint):

CF Definition: *sea_surface_temperature is usually abbreviated as "SST". It is the temperature of sea water near the surface (including the part under sea-ice, if any), and not the interface temperature, whose standard name is surface_temperature. For the temperature of sea water* *at a particular depth or layer, a data variable of sea_water_temperature with a vertical coordinate axis should be used.*

Additional details: The interface temperature (SSTint) is a theoretical temperature at the precise air-sea interface. It represents the hypothetical temperature of the topmost layer of the ocean water and could be thought of as an even mix of water and air molecules. SSTint is of no practical use because it cannot be measured using current technology. It is important to note that it is the SSTint that interacts with the atmosphere. Within GHRSST, most variables containing SST are named "sea_surface_temperature" to simplify the development of client applications wishing to read these variables. The variable attribute "standard_name" indicates the precise form of the SST, using the following definitions. More detail is given in the Level 2P (Section 9), Level 3 (Section 10), and Level 4 (Section 11) specification.

Sea_surface_skin_temperature (GHRSST <SST Type>: SSTskin):

CF Definition: *The surface called "surface" means the lower boundary of the atmosphere. The sea surface skin temperature is the temperature measured by an infrared radiometer typically operating at wavelengths in the range 3.7 - 12 micrometers. It represents the temperature within the conductive diffusion-dominated sub-layer at a depth of approximately 10 - 20 micrometers below the air-sea interface. Measurements of this quantity are subject to a large potential diurnal cycle including cool skin layer effects (especially at night under clear skies and low wind speed conditions) and warm layer effects in the daytime.*

Additional Details: The sea surface skin temperature (SSTskin) as defined above represents the actual temperature of the water across a very small depth of approximately 20 micrometers. This definition is chosen for consistency with the majority of infrared satellite and ship mounted radiometer measurements.

Sea_surface_subskin_temperature (GHRSST <SST Type>: SSTsubskin):

CF Definition: *The surface called "surface" means the lower boundary of the atmosphere. The sea surface subskin temperature is the temperature at the base of the conductive laminar sub-layer of the ocean surface, that is, at a depth of approximately 1 - 1.5 millimetres below the air-sea interface. For practical purposes, this quantity can be well approximated to the measurement of surface temperature by a microwave radiometer operating in the 6 - 11 gigahertz frequency range, but the relationship is neither direct nor invariant to changing physical conditions or to the specific geometry of the microwave measurements. Measurements of this quantity are subject to a large potential diurnal cycle due to thermal stratification of the upper ocean layer in low wind speed high solar irradiance conditions.*

Additional Details: The sea surface subskin temperature (SSTsubskin) represents the temperature at the base of the thermal skin layer. The difference between SSTint and SSTsubskin is related to the net flux of heat through the thermal skin layer. SSTsubskin is the temperature of a layer approximately 1 mm thick at the ocean surface.

Sea_water_temperature (GHRSST <SST Type>: SSTdepth or SST_z):

CF Definition: *The general term, "bulk" sea surface temperature, has the standard name sea_surface_temperature with no associated vertical coordinate axis. The temperature of sea water at a particular depth (other than the foundation level) should be reported using the standard name sea_water_temperature and, wherever possible, supplying a vertical coordinate axis or scalar coordinate variable.*

Additional Details: Sea water temperature (SSTdepth or SST_{z}, for example $SST_{1.5m}$) is the terminology adopted by GHRSST to represent in situ measurements near the surface of the ocean that have traditionally been reported simply as SST or "bulk" SST. For example SST_{6m} would refer to an SST measurement made at a depth of 6 m. Without a clear statement of the precise depth at which the SST measurement was made, and the circumstances surrounding the measurement, such a sample lacks the information needed for comparison with, or validation of satellite-derived estimates of SST using other data sources. The terminology has been introduced to encourage the reporting of depth (z) along with the temperature.

All measurements of water temperature beneath the SSTsubskin are obtained from a wide variety of sensors such as drifting buoys having single temperature sensors attached to their hull, moored buoys that sometimes include deep thermistor chains at depths ranging from a few meters to a few thousand meters, thermosalinograph (TSG) systems aboard ships recording at a fixed depth while the vessel is underway, Conductivity Temperature and Depth (CTD) systems providing detailed vertical profiles of the thermohaline structure used during hydrographic surveys and to considerable depths of several thousand meters, and various expendable bathythermograph systems (XBT). In all cases, these temperature observations are distinct from those obtained using remote sensing techniques and measurements at a given depth should be referred to as sea_water_temperature qualified by a depth in meters rather than sea surface temperatures. The situation is complicated further when one considers ocean model outputs for which the SST may be the mean SST over a layer of the ocean several tens of meters thick.

Sea_surface_foundation_temperature (GHRSST <SST Type>: SSTfnd):

CF Definition: *The surface called "surface" means the lower boundary of the atmosphere. The sea surface foundation temperature is the water temperature that is not influenced by a thermally stratified layer of diurnal temperature variability (either by daytime warming or nocturnal cooling). The foundation temperature is named to indicate that it is the temperature from which the growth of the diurnal thermocline develops each day, noting that on some occasions with a deep mixed layer there is no clear foundation temperature in the surface layer. In general, sea surface foundation temperature will be similar to a night-time minimum or pre-dawn value at depths of between approximately 1 and 5 meters. In the absence of any diurnal signal, the foundation temperature is considered equivalent to the quantity with standard name sea_surface_subskin_temperature. The sea surface foundation temperature defines a level in the upper water column that varies in depth, space, and time depending on the local balance between thermal stratification and turbulent energy and is expected to change slowly over the course of a day. If possible, a data variable with the standard name sea_surface_foundation_temperature should be used with a scalar vertical coordinate variable to specify the depth of the foundation level. Sea surface foundation temperature is measured at the base of the diurnal thermocline or as close to the water surface as possible in* *the absence of thermal stratification. Only in situ contact thermometry is able to measure the sea surface foundation temperature. Analysis procedures must be used to estimate sea surface foundation temperature value from radiometric satellite measurements of the quantities with standard names sea_surface_skin_temperature and sea_surface_subskin_temperature. Sea surface foundation temperature provides a connection with the historical concept of a "bulk" sea surface temperature considered representative of the oceanic mixed layer temperature that is typically represented by any sea temperature measurement within the upper ocean over a depth range of 1 to approximately 20 meters. The general term, "bulk" sea surface temperature, has the standard name sea_surface_temperature with no associated vertical coordinate axis. Sea surface foundation temperature provides a more precise, well-defined quantity than "bulk" sea surface temperature and, consequently, is more representative of the mixed layer temperature. The temperature of sea water at a particular depth (other than the foundation level) should be reported using the standard name sea_water_temperature and, wherever possible, supplying a vertical coordinate axis or scalar coordinate variable.*

Additional Details: Through the definition of the CF standard names, GHRSST is attempting to discourage the use of the term “bulk SST”, replacing it instead with sea_water_temperature (SSTdepth) and a depth coordinate, or sea_surface_foundation_temperature (SSTfnd) and a depth coordinate if possible, if the observation comes from the base of the diurnal thermocline.

Blended SST (GHRSST <SST Type>: SSTblend):
In addition to the CF standard names defined above, GHRSST also uses the term “Blended SST” for ambiguous cases when the depth or type of SST is not well known. This ambiguity in depth may arise in some L4 analysis products that merge multiple types of SST from satellite and in situ observations. Note, however, that many L4 analysis systems do attempt to specifically create a sea surface foundation temperature, SSTfnd.

The SST codes and CF standard names defined above and used within GHRSST are summarized along with their key characteristics in Table 7-3.

Table 7-3 GHRSST <SST Type> code and summary table.

GHRSST <SST Type>	CF Standard Name	Approximate Depth	Typically Observed by…
SSTint	**sea_surface_temperature**	0 meters	Not presently measureable
SSTskin	**sea_surface_skin_temperature**	10 – 20 micrometers	Infrared radiometers operating in a range of wavelengths form 3.7 to 12 micrometers
SSTsubskin	**sea_surface_subskin_temperature**	1 – 1.5 millimetres	Microwave radiometers operating in a range of frequencies from 6-11 gigahertz
SSTdepth	**sea_water_temperature**	Specified by vertical coordinate (e.g., SST_{5m})	In situ observing systems

SSTfnd	**sea_surface_foundation_temperature**	1-5 meters pre-dawn	In situ observing systems
SSTblend	None	Unknown	Blend of satellite and in situ observations

7.7 <Product String>

The product strings are used within the GHRSST filename convention and within the GHRSST unique data set codes described in Section 7.9. The satellite platform and satellite sensor entries are also used in the netCDF global attributes, **platform** and **sensor**, for all GHRSST product files. See Section 8.2 for more information on the required **global attributes**.

In order to improve the consistency of these product strings across producers, and avoid maintaining specific GHRSST tables, we recommend to use the CEOS tables as vocabulary for satellite platform and sensor name:

- CEOS platform table: http://database.eohandbook.com/database/missiontable.aspx
- CEOS sensor table: http://database.eohandbook.com/database/instrumenttable.aspx

Note: unfitted characters for file naming (like '/' or spaces) can be replaced with '-'.

The following code nomenclature is recommended for the single sensor products:

<platform code>_<sensor code>(_<additional text if needed>)

As an example, a product string for a METOP-A AVHRR product would be : Metop-A_AVHRR-3

7.8 <Additional Segregator>

It is possible for the preceding combination of filename components to result in a non-unique filename for any GHRSST product level. In those situations, the use of the <Additional Segregator> must be used to ensure each distinct file has a unique file name. In addition, RDACs are free to use this component to add other information to their file names. Some providers, for example, use the name of the original L1b file. Others enter start and stop times of the file in this component, or the dataset processing version. Note that in the case of GHRSST L4 files the <Additional Segregator> element must begin with a code that specifies the approximate region covered by the SST analysis product. There are two primary reasons for this requirement, the first of which is to ensure uniqueness in the file names in the cases where an RDAC is using the same L4 analysis system (for example, "ODYSSEA") to create products for multiple regions (for example, "GAL" (Galapagos Islands Region) and "MED" (Mediterranean Region)). The second reason is that users need to quickly identify at a glance the approximate domain of the L4 products. Users should note that the geographical coordinates associated with each area code are explicitly intended to be only approximate, and not strict. For example, an RDAC producing a near-global coverage data may choose to only produce data on a grid that extends to 85°S. Such a product would use the "GLOB" code. Users must retrieve the precise latitude and longitude limits directly from the L4 netCDF data files.

7.9 GHRSST Unique Text Strings and Numeric Codes

This section describes the best practices that have been developed for creating unique text strings and numeric codes that are needed in various places within some GHRSST files. Note that these strings are not part of the filename convention described above, but, like filenames, they apply to all GHRSST product levels and so are described in this part of the GDS.

SST Variable Text Strings and Numeric Codes
For each official GHRSST product, a unique numeric code and associated text string is defined. The string is listed in the global attribute **id** (see Section 8.2) for each netCDF file in the product collection. The unique numerical values and text strings for GHRSST SST datasets are established by agreement between the relevant RDAC, GDAC, and the LSTRF, following the Best Practice defined later in this Section. The GHRSST L2P, L3, L4 and GMPE product specifications (Sections 9, 10, 11, and 12, respectively) also require the providing RDAC to use these text strings directly within the netCDF global attribute **source** to indicate the sources of SST used to create the product. In the event that a non-GHRSST dataset is used as a source, as in the case of an L2P product that uses a Level 1 dataset as its source, it too must have an established text string following the best practice below (to the extent possible).

The associated numeric codes are used in some L3S files, which must describe the SST sources pixel-by-pixel in a variable named **source_of_sst** if more than one SST source is used. If only one source is used, the variable **source_of_sst** is not needed and instead the source is indicated simply by using the text string in the global attribute **source** (see Section 8.2 and Section 10.29) as indicated earlier.

Ancillary and Optional Variable Text Strings and Numeric Codes
GHRSST L2P, L3, L4 and GMPE product specifications (Sections 9, 10, 11, and 12, respectively) also require the providing RDAC to indicate text strings and associated numeric codes directly within the netCDF global and variable attributes for the sea surface temperature or ancillary sea ice fraction, aerosol depth indicator, climatologies, surface solar irradiance, wind speed, and when relevant, for optional and experimental variables. These text strings and codes do not need to be unique across different data sets, but must be consistent within a given data set and clearly specified within each netCDF file. In these cases, the variable in question should contain an attribute called **flag_meanings** together with a variable called **flag_values**. The **flag_values** attribute shall contain a comma-separated list of the numeric codes for the sources of data used whose order matches the space-separated text strings in the **flag_meanings** attribute.

Best Practice for Establishing Character Strings
A best practice has been established for defining the text strings to be used in these GHRSST attributes. While a rigid standard for the text strings is not possible, the following best practice should be applied to the extent possible for GHRSST SST datasets and the ancillary and optional variables:

<Product String>-<RDAC>-<Processing Level>-<Additional Segregator>-v<Product Version>

The definitions of the components match the definitions from the file naming convention, found in Table 7-1. The component <Product Version> is used to distinguish different versions of the same dataset and should be of the form *x.y* where *x* is the major and *y* is the minor version. For ancillary and optional variables, an attempt should be made to follow these conventions to the extent possible. If there is no appropriate GHRSST RDAC to use in the string, then it is recommended that a commonly used acronym for the centre responsible be used. It is recommended that the <Additional Segregator> should be one of ICE, ADI, CLIM, SSI, and WSP, for ancillary sea ice fraction, aerosol depth indicator, climatologies, surface solar irradiance, and wind speed variables, respectively.

Note that many SST text strings not meeting this best practice were established under the GDS version 1 and are already in use.

These codes are used in the GHRSST Central Catalogue as product identifiers.

8 GDS-2.1 Data Product File Structure

8.1 Overview of the GDS-2.1 netCDF File Format

GDS-2.1 data files preferentially use the **netCDF-4 Classic** format. A major advantage to the use of NetCDF-4 format products from the producer's perspective is that no additional metadata records are required when using this format since the GDAC and LTSRF can easily extract it from the files without having to decompress the entire file.

These GDS-2.1 formatted data sets must comply with the Climate and Forecast (CF) Conventions, v1.7 [AD-3] or later because these conventions provide a practical standard for storing oceanographic data in a robust, easily-preserved for the long-term, and interoperable manner. The CF-compliant netCDF data format is flexible, self-describing, and has been adopted as a *de facto* standard for many operational and scientific oceanography systems. Both netCDF and CF are actively maintained including significant discussions and inputs from the oceanographic community (see http://cf-pcmdi.llnl.gov/discussion/index_htmlhttp://cfconventions.org/discussion.html). The CF convention generalizes and extends the Cooperative Ocean/Atmosphere Research Data Service (COARDS, [AD-4]) Convention but relaxes the COARDS constraints on dimension order and specifies methods for reducing the size of datasets. The purpose of the CF Conventions is to require conforming datasets to contain sufficient metadata so that they are self-describing, in the sense that each variable in the file has an associated description of what it represents, physical units if appropriate, and that each value can be located in space (relative to earth-based coordinates) and time. In addition to the CF Conventions, GDS-2.1 formatted files follow some of the recommendations of the Unidata Attribute Convention for Dataset Discovery (ACDD, [AD-7]).

In the context of netCDF, a variable refers to data stored in the file as a vector or as a multidimensional array. Each variable in a GHRSST netCDF file consists of a 2-dimensional [i x j], 3-dimensional [i *x* j x k], or 4-dimensional [i x j x k x l] array of data. The dimensions of each variable must be explicitly declared in the dimension section.

Within the netCDF file, global attributes are used to hold information that applies to the whole file, such as the data set title. Each individual variable must also have its own attributes, referred to as variable attributes. These variable attributes define, for example, an offset, scale factor, units, a descriptive version of the variable name, and a fill value, which is used to indicate array elements that do not contain valid data. Where applicable, SI units should be used and described by a character string, which is compatible with the Unidata UDUNITS-2 package [AD-5].

All GHRSST GDS-2.1 files conform to this structure and share a common set of netCDF global attributes. These global attributes include those required by the CF Convention plus additional ones required by the GDS-2.1. The required set of global attributes is described in Section 8.2 and entities within the GHRSST R/GTS framework are free to add their own, as long as they do not contradict the GDS-2.1 and CF requirements.

Following the CF convention, each variable also has a set of variable attributes. The required variable attributes are described in Section 8.3. In a few cases, some of these variable attributes may not be relevant for certain variables or additional variable attributes may be required. In those cases, the variable descriptions in each of the L2P, L3, L4, and GMPE product specifications (Sections 9, 10, 11, and 12) will identify the differences and specify requirements for each product. As with the global attributes, entities within the GHRSST R/GTS framework are free to add their own variable attributes, as long as they do not contradict the GDS-2.1 and CF requirements.

While the exact volumes can vary, an average L2P file will use about 33 bytes per pixel, an L3 file 28 bytes per pixel, and an L4 file about 8 bytes per pixel. The data type encodings for each variable are fixed except for the experimental fields, which are flexible and can chosen by the producing RDAC.

8.2 GDS-2.1 netCDF Global Attributes

Table 8-1 below summarizes the global attributes that are mandatory for every GDS-2.1 netCDF data file. More details on the CF-mandated attributes (as indicated in the Source column) are available at: http://cfconventions.org/cf-conventions/cf-conventions.html#attribute-appendix and information on the ACDD recommendations is available at https://wiki.esipfed.org/Attribute_Convention_for_Data_Discovery_1-3.

Table 8-1 Mandatory global attributes for GDS-2.1 netCDF data files (blue are mandatory, purple are optional, orange are deprecated attributes from previous GDS versions)

Global Attribute Name	Format	Description	Source
Conventions	string	A comma-separated list of the conventions that are followed by the dataset. For files that follow this version of ACDD, include the string 'ACDD-1.3'. (This attribute is defined in NUG 1.7.) **Example**: Conventions = "CF 1.7, ACDD 1.3, ISO 8601";	ACDD 1.3, CF 1.7

title	string	A short phrase or sentence describing the dataset. In many discovery systems, the title will be displayed in the results list from a search, and therefore should be human readable and reasonable to display in a list of such names. This attribute is recommended by the NetCDF Users Guide (NUG) and the CF conventions. **Example**: title = "VIIRS L2P Sea Surface Skin Temperature" ;	ACDD 1.1, ACDD 1.3, CF 1.7
summary	string	A paragraph describing the dataset, analogous to an abstract for a paper. **Example**: summary = "Sea surface temperature (SST) retrievals produced at the NASA OBPG for the Visible Infrared Imaging Radiometer Suite (VIIRS) sensor on the Suomi National Polar-Orbiting Parnership (Suomi NPP) platform. These have been reformatted to GHRSST GDS version 2 Level 2P specifications by the JPL PO.DAAC." ;	ACDD 1.1, ACDD 1.3
references	string	Published or web-based references that describe the data or methods used to produce it. Recommend URIs (such as a URL or DOI) for papers or other references. This attribute is defined in the CF conventions. **Example**: references = "GHRSST Data Processing Specification v2r5" ;	ACDD 1.3, CF 1.7

institution	string	The name of the institution principally responsible for originating this data. This attribute is recommended by the CF convention. **Example**: institution = "NASA Jet Propulsion Laboratory (JPL) Physical Oceanography Distributed Active Archive Center (PO.DAAC)/NASA Goddard Space Flight Center (GSFC), Ocean Biology Processing Group (OBPG)/University of Miami Rosential School of Marine and Atmospheric Science (RSMAS)" ;**Error! Reference source not found.**.	ACDD 1.1, ACDD 1.3, CF 1.7
history	string	Provides an audit trail for modifications to the original data. This attribute is also in the NetCDF Users Guide: 'This is a character array with a line for each invocation of a program that has modified the dataset. Well-behaved generic netCDF applications should append a line containing: date, time of day, user name, program name and command arguments.' To include a more complete description you can append a reference to an ISO Lineage entity; see NOAA EDM ISO Lineage guidance. **Example**: history = "VIIRS L2P created at JPL PO.DAAC by combining OBPG SNPP_SST and SNPP_SST3, and outputing to the GHRSST GDS2 netCDF file format" ;	ACDD 1.1, ACDD 1.3, CF 1.7

comment	string	Miscellaneous information about the data, not captured elsewhere. This attribute is defined in the CF Conventions. **Example**: comment = "L2P Core without DT analysis or other ancillary fields; Night, Start Node:Descending, End Node:Descending; WARNING Some applications are unable to properly handle signed byte values. If values are encountered > 127, please subtract 256 from this reported value; Quicklook" ;	ACDD 1.1, ACDD 1.3
license	string	Provide the URL to a standard or specific license, enter "Freely Distributed" or "None", or describe any restrictions to data access and distribution in free text. GHRSST data sets should be freely and openly available to comply with the R/GTS framework, with no restrictions. However, if a user should submit a simple registration via a web form, for example, the URL could be given here. **Example**: license = "GHRSST protocol describes data use as free and open." ;	ACDD ACDD 1.1, ACDD 1.3
id	string	An identifier for the data set, provided by and unique within its naming authority. The combination of the "naming authority" and the "id" should be globally unique, but the id can be globally unique by itself also. IDs can be URLs, URNs, DOIs, meaningful text strings, a local key, or any other unique string of characters. The id should not include white space characters. Here the unique GHRSST character string for this product. All GHRSST SST products have one, and they are listed in **Error! Reference source not found.**. **Example**: id = "VIIRS_NPP-JPL-L2P-v2016.0" ;	ACDD 1.1, ACDD 1.3

naming_authority	string	The organization that provides the initial id (see above) for the dataset. The naming authority should be uniquely specified by this attribute. We recommend using reverse-DNS naming for the naming authority; URIs are also acceptable. Fixed as "org.ghrsst" following ACDD convention. **Example**: naming_authority = "org.ghrsst" ;	ACDD 1.1, ACDD 1.3
product_version	string	Version identifier of the data file or product as assigned by the data creator. For example, a new algorithm or methodology could result in a new product_version. It may be different than the file version used in the file naming convention (Section 7). **Example**: product_version = "2016.0" ;	ACDD 1.3
uuid	string	A uuid (Universal Unique Identifier) is a 128-bit number used to uniquely identify some object or entity on the Internet. Depending on the specific mechanisms used, a uuid is either guaranteed to be different or is, at least, extremely likely to be different from any other uuid generated until 3400 A.D. See http://en.wikipedia.org/wiki/Universally_Unique_Identifier for more information and tools. **Example**: uuid = "b6ac7651-7b02-44b0-942b-c5dc3c903eba" ;	GDS
gds_version_id	string	GDS version used to create this data file. For example, "2.1".	GDS
netcdf_version_id	string	Version of netCDF libraries used to create this file. For example, "4.1.1"	GDS

date_created	string	The date on which this version of the data was created. (Modification of values implies a new version, hence this would be assigned the date of the most recent values modification.) Metadata changes are not considered when assigning the date_created. The ISO 8601:2004 extended date format is recommended. **Example**: date_created = "2016-10-14T21:00:25" ;	ACDD 1.1, ACDD 1.3
date_modified	string	The date on which the data was last modified. Note that this applies just to the data, not the metadata. The ISO 8601:2004 extended date format is recommended. **Example:** date_modified = "2016-10-14T21:00:25" ;	ACDD 1.1, ACDD 1.3
date_issued	string	The date on which this data (including all modifications) was formally issued (i.e., made available to a wider audience). Note that these apply just to the data, not the metadata. The ISO 8601:2004 extended date format is recommended. **Example**: date_issued = "2016-10-14T21:00:25" ;	ACDD 1.1, ACDD 1.3
date_metadata_modified	string	The date on which the metadata was last modified. The ISO 8601:2004 extended date format is recommended. **Example**: date_metadata_modified = "2016-10-14T21:00:25" ;	ACDD 1.3
file_quality_level	integer	A code value: 0 = unknown quality 1 = extremely suspect (frequent problems, e.g. with known satellite problems) 2 = suspect (occasional problems, e.g. after launch) 3 = excellent (no known problems)	GDS

spatial_resolution	string	A string describing the approximate resolution of the product. For example, "1.1km at nadir"	GDS
start_time	string	DEPRECATED – replaced by time_coverage_start attribute. Representative date and time of the start of the granule in the ISO 8601 compliant format of "yyyymmddThhmmssZ". The exact meaning of this attribute depends the type of granule: • L2P: first measurement in granule (identical to 'time' netCDF variable) • L3U: start time of granule • L3C and L3S: representative start time of first measurement in the collation • L4: representative start time of the analysis (start_time and stop_time together represent the valid period of the L4 granule)	GDS
time_coverage_start	string	Describes the time of the first data point in the data set. Use the ISO 8601:2004 date format, of "yyyy-mm-ddThh:mm:ssZ". The exact meaning of this attribute depends the type of granule: • L2P: first measurement in granule (identical to 'time' netCDF variable) • L3U: start time of granule • L3C and L3S: representative start time of first measurement in the collation L4: representative start time of the analysis (start_time and stop_time together represent the valid period of the L4 granule) **Example**: time_coverage_start = "2016-09-01T08:12:01" ;	ACDD 1.1, ACDD 1.3

stop_time	string	DEPRECATED – replaced by time_coverage_end attribute. Representative date and time of the end of the granule in the ISO 8601 compliant format of "yyyymmddThhmmssZ". The exact meaning of this attribute depends the type of granule: • L2P: last measurement in granule • L3U: stop time of granule • L3C and L3S: representative stop time of last measurement in collation • L4: representative stop time of the analysis (start_time and stop_time together represent the valid period of the L4 granule)	GDS
time_coverage_end	string	Describes the time of the last data point in the data set. Use ISO 8601:2004 date format, of "yyyy-mm-ddThh:mm:ssZ". The exact meaning of this attribute depends the type of granule: • L2P: last measurement in granule • L3U: stop time of granule • L3C and L3S: representative stop time of last measurement in collation L4: representative stop time of the analysis (start_time and stop_time together represent the valid period of the L4 granule) **Example**: time_coverage_end = "2016-09-01T08:17:59" ;	ACDD 1.1, ACDD 1.3
northernmost_latitude	float	DEPRECATED – replaced by geospatial_lat_max Decimal degrees north, range -90 to +90. This is equivalent to ACDD geospatial_lat_max.	GDS
southernmost_latitude	float	DEPRECATED – replaced by geospatial_lat_min Decimal degrees north, range -90 to +90. This is equivalent to ACDD geospatial_lat_min.	GDS

easternmost_longitude	float	DEPRECATED – replaced by geospatial_lon_max Decimal degrees east, range -180 to +180. This is equivalent to ACDD geospatial_lon_max.	GDS
westernmost_longitude	float	DEPRECATED – replaced by geospatial_lon_min Decimal degrees east, range -180 to +180. This is equivalent to ACDD geospatial_lon_min.	GDS
source	string	The method of production of the original data. If it was model-generated, source should name the model and its version. If it is observational, source should characterize it. This attribute is defined in the CF Conventions. Examples: 'temperature from CTD #1234'; 'world model v.0.1'. **Example**: source = "VIIRS sea surface temperature observations for the OBPG"	ACDD 1.3, CF 1.7
platform	string	Name of the platform(s) that supported the sensor data used to create this data set or product. Platforms can be of any type, including satellite, ship, station, aircraft or other. Indicate controlled vocabulary used in platform_vocabulary. We recommend for consistency to use the CEOS mission table (http://database.eohandbook.com/database/missiontable.aspx). Provide as a comma separated list if there is more than one. **Example**: platform = "Suomi NPP" ;	ACDD 1.3

platform_vocabulary	string	Controlled vocabulary for the names used in the "platform" attribute. We recommend for consistency to use the CEOS mission table (http://database.eohandbook.com/database/missiontable.aspx). **Example**: platform_vocabulary = "CEOS mission table";	ACDD 1.3
sensor	string	DEPRECATED – replaced by ‘instrument’. Sensor(s) used to create this data file. Select from the entries found in the Satellite Sensor column of Product String and provide as a comma separated list if there is more than one.	GDS
instrument	string	Name of the contributing instrument(s) or sensor(s) used to create this data set or product. Indicate controlled vocabulary used in instrument_vocabulary. We recommend for consistency to use the CEOS mission table (http://database.eohandbook.com/database/instrumenttable.aspx). Provide as a comma separated list if there is more than one. **Example**: sensor = "VIIRS" ;	ACDD 1.3
instrument_vocabulary	string	Controlled vocabulary for the names used in the "instrument" attribute. **Example**: instrument_vocabulary = "CEOS instrument table";	ACDD 1.3

metadata_link	string	A URL that gives the location of more complete metadata. A persistent URL is recommended for this attribute. It is recommended to link to the product description in the GHRSST central catalogue. **Example**: metadata_link = "https://cmr.earthdata.nasa.gov/search/collections.umm_json?ShortName=VIIRS_N20-STAR-L2P-v2.80" ;	ACDD 1.3
keywords	string	A comma-separated list of key words and/or phrases. Keywords may be common words or phrases, terms from a controlled vocabulary (GCMD is often used), or URIs for terms from a controlled vocabulary (see also "keywords_vocabulary" attribute). **Example**: keywords = "Oceans, Ocean Temperature, Sea Surface Temperature , Sea Surface Skin Temperature" ;	ACDD 1.1, ACDD 1.3
keywords_vocabulary	string	If you are using a controlled vocabulary for the words/phrases in your "keywords" attribute, this is the unique name or identifier of the vocabulary from which keywords are taken. If more than one keyword vocabulary is used, each may be presented with a prefix (e.g.,“NASA Global Change Master Directory (GCMD) Science Keywords” as defined in [AD-10]) and a following comma, so that keywords may optionally be prefixed with the controlled vocabulary key. **Example**: keywords_vocabulary = "NASA Global Change Master Directory (GCMD) Science Keywords" ;[AD-10]	ACDD 1.1, ACDD 1.3

standard_name_vocabulary	string	The name and version of the controlled vocabulary from which variable standard names are taken. (Values for any standard_name attribute must come from the CF Standard Names vocabulary for the data file or product to comply with CF.) **Example**: 'CF Standard Name Table v27'.	ACDD 1.1, ACDD 1.3
geospatial_lat_min	float	Describes a simple lower latitude limit; may be part of a 2- or 3-dimensional bounding region. Geospatial_lat_min specifies the southernmost latitude covered by the dataset. **Example**: geospatial_lat_min = -63.1404f ;	ACDD 1.1, ACDD 1.3
geospatial_lat_max	float	Describes a simple upper latitude limit; may be part of a 2- or 3-dimensional bounding region. Geospatial_lat_max specifies the northernmost latitude covered by the dataset. **Example:** geospatial_lat_max = -36.7432f ;	ACDD 1.1, ACDD 1.3
geospatial_lat_units	string	Units for the latitude axis described in "geospatial_lat_min" and "geospatial_lat_max" attributes. These are presumed to be "degree_north"; other options from udunits may be specified instead. **Example:** geospatial_lat_units = "degrees_north" ;	ACDD 1.1, ACDD 1.3
geospatial_lat_resolution	float	Information about the targeted spacing of points in latitude. Recommend describing resolution as a number value followed by the units. Examples: '100 meters', '0.1 degree'. For level 1 and 2 swath data this is an approximation of the pixel resolution. **Example**: geospatial_lat_resolution = 0.0075f ;	ACDD 1.1, ACDD 1.3

geospatial_lon_min	float	Describes a simple longitude limit; may be part of a 2- or 3-dimensional bounding region. geospatial_lon_min specifies the westernmost longitude covered by the dataset. See also geospatial_lon_max. **Example**: geospatial_lon_min = -143.09f ;	ACDD 1.1, ACDD 1.3
geospatial_lon_max	float	Describes a simple longitude limit; may be part of a 2- or 3-dimensional bounding region. geospatial_lon_max specifies the easternmost longitude covered by the dataset. Cases where geospatial_lon_min is greater than geospatial_lon_max indicate the bounding box extends from geospatial_lon_max, through the longitude range discontinuity meridian (either the antimeridian for -180:180 values, or Prime Meridian for 0:360 values), to geospatial_lon_min; for example, geospatial_lon_min=170 and geospatial_lon_max=-175 incorporates 15 degrees of longitude (ranges 170 to 180 and -180 to -175). **Example**: geospatial_lon_max = -88.893f ;	ACDD 1.1, ACDD 1.3
geospatial_lon_units	string	Units for the longitude axis described in "geospatial_lon_min" and "geospatial_lon_max" attributes. These are presumed to be "degree_east"; other options from udunits may be specified instead. **Example**: geospatial_lon_units = "degrees_east" ;	ACDD 1.1, ACDD 1.3

geospatial_lon_resolution	float	Information about the targeted spacing of points in longitude. Recommend describing resolution as a number value followed by units. Examples: '100 meters', '0.1 degree'. For level 1 and 2 swath data this is an approximation of the pixel resolution. **Example**: geospatial_lon_resolution = 0.0075f ;	ACDD 1.1, ACDD 1.3
geospatial_vertical_min	float	Describes the numerically smaller vertical limit; may be part of a 2- or 3-dimensional bounding region. See geospatial_vertical_positive and geospatial_vertical_units. **Example**: geospatial_vertical_min = 0.00f;	ACDD 1.1, ACDD 1.3
geospatial_vertical_max	float	Describes the numerically larger vertical limit; may be part of a 2- or 3-dimensional bounding region. See geospatial_vertical_positive and geospatial_vertical_units. **Example**: geospatial_vertical_max = 1000.00f;	ACDD 1.1, ACDD 1.3
geospatial_vertical_resolution	float	Information about the targeted vertical spacing of points. Example: '25 meters' **Example**: geospatial_vertical_resolution = 25.0f;	ACDD 1.1, ACDD 1.3

geospatial_vertical_units	string	Units for the vertical axis described in "geospatial_vertical_min" and "geospatial_vertical_max" attributes. The default is EPSG:4979 (height above the ellipsoid, in meters); other vertical coordinate reference systems may be specified. Note that the common oceanographic practice of using pressure for a vertical coordinate, while not strictly a depth, can be specified using the unit bar. Examples: 'EPSG:5829' (instantaneous height above sea level), 'EPSG:5831' (instantaneous depth below sea level). **Example**: geospatial_vertical_units = 'meters';	ACDD 1.1, ACDD 1.3
geospatial_vertical_positive	string	One of 'up' or 'down'. If up, vertical values are interpreted as 'altitude', with negative values corresponding to below the reference datum (e.g., under water). If down, vertical values are interpreted as 'depth', positive values correspond to below the reference datum. Note that if geospatial_vertical_positive is down ('depth' orientation), the geospatial_vertical_min attribute specifies the data's vertical location furthest from the earth's center, and the geospatial_vertical_max attribute specifies the location closest to the earth's center. **Example**: geospatial_vertical_positive = 'down';	ACDD 1.1, ACDD 1.3

geospatial_bounds	string	Describes the data's 2D or 3D geospatial extent in OGC's Well-Known Text (WKT) Geometry format (reference the OGC Simple Feature Access (SFA) specification). The meaning and order of values for each point's coordinates depends on the coordinate reference system (CRS). The ACDD default is 2D geometry in the EPSG:4326 coordinate reference system. The default may be overridden with geospatial_bounds_crs and geospatial_bounds_vertical_crs (see those attributes). EPSG:4326 coordinate values are latitude (decimal degrees_north) and longitude (decimal degrees_east), in that order. Longitude values in the default case are limited to the (-180, 180) range. Example: "POLYGON ((40.26 -111.29, 41.26 -111.29, 41.26 -110.29, 40.26 -110.29, 40.26 -111.29))". **Example**: geospatial_bounds = "(-143.09, -63.1404, -88.893, -36.7432)";	ACDD 1.1 ACDD 1.3
geospatial_bounds_crs	string	The coordinate reference system (CRS) of the point coordinates in the geospatial_bounds attribute. This CRS may be 2-dimensional or 3-dimensional, but together with geospatial_bounds_vertical_crs, if that attribute is supplied, must match the dimensionality, order, and meaning of point coordinate values in the geospatial_bounds attribute. If geospatial_bounds_vertical_crs is also present then this attribute must only specify a 2D CRS. EPSG CRSs are strongly recommended. If this attribute is not specified, the CRS is assumed to be EPSG:4326. Examples: "EPSG:4979" (the 3D WGS84 CRS), "EPSG:4047". **Example**: geospatial_bounds_crs = "WGS84";	ACDD 1.3

geospatial_bounds_vertical_crs	string	The vertical coordinate reference system (CRS) for the Z axis of the point coordinates in the geospatial_bounds attribute. This attribute cannot be used if the CRS in geospatial_bounds_crs is 3-dimensional; to use this attribute, geospatial_bounds_crs must exist and specify a 2D CRS. EPSG CRSs are strongly recommended. There is no default for this attribute when not specified. Examples: "EPSG:5829" (instantaneous height above sea level), "EPSG:5831" (instantaneous depth below sea level), or "EPSG:5703" (NAVD88 height). **Example**: geospatial_bounds_vertical_crs = "EPSG:5831";	ACDD 1.3
acknowledgment	string	A place to acknowledge various types of support for the project that produced this data. **Example**: Acknowledgment = "The VIIRS L2P sea surface temperature data are sponsored by NASA. Data may be freely distributed" ;	ACDD 1.1, ACDD 1.3
creator_name	string	The name of the person (or other creator type, such as a RDAC, specified by the creator_type attribute) principally responsible for creating this data. **Example**: creator_name = "JPL PO.DAAC" ;	ACDD 1.1, ACDD 1.3
creator_url	string	The URL of the of the person (or other creator type specified by the creator_type attribute) principally responsible for creating this data. **Example**: creator_url = "http://podaac.jpl.nasa.gov";	ACDD 1.1, ACDD 1.3

creator_email	string	The email address of the person (or other creator type specified by the creator_type attribute) principally responsible for creating this data. **Example**: creator_email = "ghrsst@jpl.nasa.gov" ;	ACDD 1.1, ACDD 1.3
creator_type	string	Specifies type of creator with one of the following: 'person', 'group', 'institution', or 'position'. If this attribute is not specified, the creator is assumed to be a person. For a RDAC, use here '*institution*'. **Example**: creator_type = "institution":	ACDD 1.3
creator_institution	string	The institution of the creator; should uniquely identify the creator's institution. This attribute's value should be specified even if it matches the value of publisher_institution, or if creator_type is institution. **Example**: creator_institution = "JPL PO.DAAC/GHRSST";	ACDD 1.3
project	string	The name of the project(s) principally responsible for originating this data. Multiple projects can be separated by commas, as described under Attribute Content Guidelines. Examples: 'PATMOS-X', 'Extended Continental Shelf Project'. **Example:** "Group for High Resolution Sea Surface Temperature"	ACDD 1.1, ACDD 1.3
program	string	The overarching program(s) of which the dataset is a part. A program consists of a set (or portfolio) of related and possibly interdependent projects that meet an overarching objective. Examples: 'GHRSST', 'NOAA CDR', 'NASA EOS', 'JPSS', 'GOES-R'. **Example**: program= " NASA Earth Science Data Information and System (ESDIS)"	ACDD 1.3

contributor_name	string	The name of any individuals, projects, or institutions that contributed to the creation of this data. May be presented as free text, or in a structured format compatible with conversion to ncML (e.g., insensitive to changes in whitespace, including end-of-line characters). **Example**: contributor_name = "PO.DAAC/OBPS/REMAS";	ACDD 1.3
contributor_role	string	The role of any individuals, projects, or institutions that contributed to the creation of this data. May be presented as free text, or in a structured format compatible with conversion to ncML (e.g., insensitive to changes in whitespace, including end-of-line characters). Multiple roles should be presented in the same order and number as the names in contributor_names. **Example**: contributor_role = "PO.DAAC convert the VIIRSS_NPP SST to GDS2 format, OBPS processed the L2P SST, and RSMAS provided the algorithm model ";	ACDD 1.3
publisher_name	string	The name of the person (or other entity specified by the publisher_type attribute) responsible for publishing the data file or product to users, with its current metadata and format. **Example:** publisher_name = "The GHRSST Project Office" ;	ACDD 1.1, ACDD 1.3
publisher_url	string	The URL of the person (or other entity specified by the publisher_type attribute) responsible for publishing the data file or product to users, with its current metadata and format. **Example**: publisher_url = "http://www.ghrsst.org" ;	ACDD 1.1, ACDD 1.3

publisher_email	string	The email address of the person (or other entity specified by the publisher_type attribute) responsible for publishing the data file or product to users, with its current metadata and format. **Example**: publisher_email = "gpo@ghrsst.org" ;	ACDD 1.1, ACDD 1.3
publisher_type	string	Specifies type of publisher with one of the following: 'person', 'group', 'institution', or 'position'. If this attribute is not specified, the publisher is assumed to be a person. **Example**: publisher_type = "institution";	ACDD 1.3
publisher_institution	string	The institution that presented the data file or equivalent product to users; should uniquely identify the institution. If publisher_type is institution, this should have the same value as publisher_name. **Example**: publisher_institution = "PO.DAAC";	ACDD 1.3
processing_level	string	A textual description of the processing (or quality control) level of the data. GHRSST definitions are the options: L2P, L3U, L3C, L3S, L4 and GMPE **Example**: processing_level = "L2P" ;	ACDD 1.1, ACDD 1.3
cdm_data_type	string	The data type, as derived from Unidata's Common Data Model Scientific Data types and understood by THREDDS. (This is a THREDDS "dataType", and is different from the CF NetCDF attribute 'featureType', which indicates a Discrete Sampling Geometry file in CF.). “swath” or “grid”. **Example**: cdm_data_type = "swath" ;	ACDD 1.1, ACDD 1.3

8.3 GDS-2.1 netCDF Variable Attributes

Table 8-2 Variable attributes for GDS-2.1 netCDF data files (blue are mandatory, purple are optional, orange are deprecated attributes from previous GDS versions)

Variable Attribute Name	Format	Description	Source
_FillValue	Must be the same as the variable type	Assigned value in the data file designating a null or missing observation This value must be of the same type as the storage (packed) type; should be set as the minimum value for this type. Note that some netCDF readers are unable to cope with signed bytes and may, in these cases, report fill as 128. Some cases will be reported as unsigned bytes 0 to 255. Required for the majority of variables except mask and l2p_flags. Best practices specifies that for satellite datasets there should not be a _FillVlalue for geolocation or time variables. **Example**: _FillValue = -32767s ;	CF 1.7
units	String	The units of the variable's data values. This attribute value should be a valid udunits string. The "units" attribute is recommended by the NetCDF Users Guide, the COARDS convention, and the CF convention (http://www.unidata.ucar.edu/software/udunits/udunits-1/udunits.txt). [AD-5] For a given variable (e.g. wind speed), these must be the same for each dataset. Required for the majority of variables except mask, quality_level, and l2p_flags. **Example**: units = "kelvin" ;	ACDD 1.1, ACDD 1.3, CF 1.7

scale_factor	Must be expressed in the unpacked data type	Slope of scaling relationship applied to transform measuement data to appropriate geophysical quantity representations. Should not be used if the scale_factor is '1' and add_offset is '0' To be multiplied by the variable to recover the original value. Defined by the producing RDAC. Valid values within **value_range**, **value_min** and **valid_max** should be transformed by **scale_factor** and **add_offset**, otherwise skipped to avoid floating point errors. **Example**: scale_factor = 0.005f ;	CF 1.7
add_offset	Must be expressed in the unpacked data type	Intercept of scaling relationship applied to transform measurement data to appropriate geophysical quantity representations. Should not be used if the scale_factor is '1' and add_offset is '0' To be added to the variable after multiplying by the scale factor to recover the original value. If only one of **scale_factor** or **add_offset** is needed, then both should be included anyway to avoid ambiguity, with **scale_factor** defaulting to 1.0 and **add_offset** defaulting to 0.0. Defined by the producing RDAC. Valid values within **value_range**, **value_min** and **valid_max** should be transformed by **scale_factor** and **add_offset**, otherwise skipped to avoid floating point errors. **Example**: add_offset = 273.15f ;	CF 1.7

long_name	String	A long descriptive name for the variable (not necessarily from a controlled vocabulary). This attribute is recommended by the NetCDF Users Guide, the COARDS convention, and the CF convention. **Example:** **Example:**	ACDD 1.1, ACDD 1.3, CF 1.7
valid_range	Expressed in same data type as variable	Comma separated minimum and maximum values of the physical quantity defining the valid measurement range. The fill value should be outside this valid range. Note that some netCDF readers are unable to cope with signed bytes and may, in these cases, report valid min as 129. Some cases as unsigned bytes 0 to 255. Values outside of the **valid_range** will be treated as missing values. Required for all variables except variable time. **Example:** valid_range = 0.0f, 500.0f ;	CF 1.7
valid_min	Expressed in same data type as variable	DEPRECATED – replaced with **valid_range** Minimum valid value for this variable once they are packed (in storage type). The fill value should be outside this valid range. Note that some netCDF readers are unable to cope with signed bytes and may, in these cases, report valid min as 129. Some cases as unsigned bytes 0 to 255. Values outside of **valid_min** and **valid_max** will be treated as missing values. Required for all variables except variable time.	CF

valid_max	Expressed in same data type as variable	DEPRECATED – replaced with **valid_range** Maximum valid value for this variable once they are packed (in storage type). The fill value should be outside this valid range. Note that some netCDF readers are unable to cope with signed bytes and may, in these cases, report valid min as 127. Required for all variables except variable time.	CF
standard_name	String	A long descriptive name for the variable taken from a controlled vocabulary of variable names. We recommend using the CF convention and the variable names from the CF standard name table (http://cfconventions.org/Data/cf-standard-names/36/build/cf-standard-name-table.html). For the complete list of standard name strings, see [AD-8]. This attribute is recommended by the CF convention. **Do not** include this attribute if no standard_name exists. [AD-8]**Example:** standard_name = "sea_surface_skin_temperature" ;	ACDD 1.1, ACDD 1.3, CF 1.7
comment	String	Optional attribute field allowing provision of further free-form information about the variable or the methods used to produce it. **Example**: comment = "sea surface temperature from 11 and 12 um (thermal IR) channels" ;	CF 1.7

source	string	**For L2P and L3 files**: For a data variable with a single source, use the GHRSST unique string listed in **Error! Reference source not found.** if the source is a GHRSST SST product. For other sources, following the best practice described in Section 7.9 to create the character string. If the data variable contains multiple sources, set this string to be the relevant "sources of" variable name. For example, if multiple wind speed sources are used, set **source** = source_of_wind_speed. **For L4 and GMPE files**: follow the **source** convention used for the global attribute of the same name, but provide in the comma-separated list only the sources relevant to this variable.	CF 1.7
references	string	Published or web-based references that describe the data or methods used to produce it. Note that while at least one reference is required in the global attributes (See Table 8-1), references to this specific data variable may also be given.	CF 1.7
axis	String	Corresponding variable axis for plotting (eg. X, Y, Z). For use with coordinate variables only. The attribute 'axis' may be attached to a coordinate variable and given one of the values "X", "Y", "Z", or "T", which stand for a longitude, latitude, vertical, or time axis respectively. See: http://cfconventions.org **Example** (for lat variable): axis = "Y";	CF 1.7

positive	String	For use with a vertical coordinate variables only. May have the value “up” or “down”. For example, if an oceanographic netCDF file encodes the depth of the surface as 0 and the depth of 1000 meters as 1000 then the axis would set positive to “down”. If a depth of 1000 meters was encoded as -1000, then positive would be set to “up”. See the section on vertical-coordinate in [AD-3]	CF 1.7
coordinates	String	This attribute contains a space separated list of all the coordinates corresponding to the variable. The list should contain all the auxiliary coordinate variables and optionally the coordinate variables. See the section on coordinate-system in [AD-3]. This attribute must be provided if the data are on a non-regular lat/lon grid (map projection or swath data). **Example**: coordinates = "time lat lon";	CF 1.7
grid_mapping	String	Describes the horizontal coordinate system used by the data. The grid_mapping attribute should point to a variable which would contain the parameters corresponding to the coordinate system. That named variable is called a grid mapping variable and is of arbitrary type since it contains no data. Its purpose is to act as a container for the attributes that define the mapping. There are typically several parameters associated with each coordinate system. CF defines a separate attributes for each of the parameters. Some examples are "semi_major_axis", "inverse_flattening", "false_easting". See the section on mappings-and-projections in [AD-3]. [AD-3]**Example**: grid_mapping = "geostationary"	CF 1.7

flag_meanings	String	Define the physical meaning of each flag_masks bit field with a single text string. CF allows a single variable to contain both flag_values and flag_masks. The interpretation of the flags in such cases is slightly tricky. In such cases flag_masks is used to "group" a set of flag_values into a nested conditional. Words within a phrase should be connected with underscores. Please see the example 3.5 in the CF document on how to interpret flag_meanings in such cases. NCEI recommends that boolean and enumerated flags be kept in separate variables. **Example**: flag_meanings = "microwave land ice lake river" ;	CF 1.7
flag_values	Must be the same as the variable type	Its values identify the flagged conditions by performing a bitwise AND of the variable value and each flag masks value. For example, if the variable value is of type unsigned byte and equal to 5 and the flag_masks are 1b, 2b, 4b, 8b, 16b, 32b. The binary encoding of 5 is 00000101 and the binary encoding of the flags are 00000001, 00000010, 00000100, 00001000, 00010000, 00100000. Now bitwide AND of the value with the masks returns 00000001, 00000000, 00000100, 00000000, 00000000, 00000000 respectively or 1b,0,4b,0,0,0,0,0 in decimal. So the masks corresponding to 1b and 4b are "true", rest are "false". Used primarily for **quality_level** and “**source_of_xxx**” variables. **Example:** flag_values = 1b, 5b ;	CF 1.7

flag_masks	Must be the same as the variable type	A number of independent Boolean conditions using bit field notation by setting unique bits in each flag_masks value. The flag_masks attribute is the same type as the variable to which it is attached, and contains a list of values matching unique bit fields. (CF document 3.5 Flags;http://cfconventions.org/Data/cf-conventions/cf-conventions-1.6/build/cf-conventions.pdf). Used primarily for **l2p_flags** variable. *Note: CF allows the use of both flag_masks and flag_values attributes in a single variable to create sets of masks that each have their own list of flag_values (see http://cf-pcmdi.llnl.gov/documents/cf-conventions/1.5/ch03s05.html#id2710752 for examples), but this practice is discouraged.* **Example**: flag_masks = 1b, 2b, 4b, 8b, 16b;	CF 1.7
depth	String	Use this to indicate the depth for which the SST data are valid.	GDS
height	String	Use this to indicate the height for which the wind data are specified.	GDS
time_offset	Must be expressed in the unpacked data type	Difference in hours between an ancillary field such as **wind_speed** and the SST observation time	GDS

coverage_content_type	String	An ISO 19115-3 code to indicate the source of the data -- MD_CoverageContentTypeCode (https://geonetwork-opensource.org/manuals/3.10.x/en/annexes/standards/iso19115-3.2018.html#standard-codelists-coverage-content-mrc-md-coveragecontenttypecode). For example, image, thematicClassification, physicalMeasurement, auxiliaryInformation, qualityInformation, referenceInformation, modelResult, or coordinate. **Example**: coverage_content_type = "physicalMeasurement" ;	ACDD 1.1, ACDD 1.3

8.4 GDS-2.1 coordinate variable definitions

NetCDF coordinate variables provide scales for the space and time axes for the multidimensional data arrays, and must be included for all dimensions that can be identified as spatio-temporal axes. Coordinate arrays are used to geolocate data arrays on non-orthogonal grids, such as images in the original pixel/scan line space, or complicated map projections. Required attributes are **units** and **_FillValue**. Elements of the coordinate array need not be monotonically ordered. The data type can be any and scaling may be implemented if required. **add_offset** and **scale_factor** have to be adjusted according to the sensor resolution and the product spatial coverage. If the packed values can not stand on a short, float can be used instead (multiplying the size of these variables by two).

'**time**' is the reference time of the SST data array. The GDS-2.1 specifies that this reference time should be extracted or computed to the nearest second and then coded as continuous UTC time coordinates in **seconds from 00:00:00 UTC January 1, 1981** (which is the definition of the **GHRSST origin time**, chosen to approximate the start of useful AVHRR SST data record). Note that the use of UDUNITS in GHRSST implies that that calendar to be used is the default mixed Gregorian/Julian calendar.

The reference time used is dependent on the <Processing Level> of the data and is defined as follows:

- L2P: start time of granule;
- L3U: start time of granule;
- L3C and L3S: centre time of the collation window;
- L4 and GMPE: nominal time of the analysis.

The coordinate variable '**time**' is intended to minimize the size of the **sst_dtime** variable (e.g., see Section 9.4), which stores offsets from the reference time in seconds for each SST pixel. '**time**' also facilitates aggregation of all files of a given dataset along the time axis with such tools as THREDDS and LAS.

x (columns) and y (lines) grid dimensions are referred either as '**lat**' and '**lon**' or as '**ni**' and '**nj**'. **lon** and **lat** must be used if data are mapped on a regular grid (some geostationary products). **ni** and **nj** are used if data are mapped on a non-regular grid (curvilinear coordinates) or following the sensor scanning pattern (scan line, swath). It is preferred that **ni** should be used for the across-track dimension and **nj** for the along-track dimension.

Coordinate vectors are used for data arrays located on orthogonal (but not necessarily regularly spaced) grids, such as a geographic (lat-lon) map projections. The only required attribute is **units**. The elements of a coordinate vector array should be in monotonically increasing or decreasing order. The data type can be any and scaling may be implemented if required.

A **coordinate's** variable (= "**lon lat**"): must be provided if the data are on a non-regular lat/lon grid (map projection or swath data).

A **grid_mapping** (= "projection name"): must be provided if the data are mapped following a projection. Refer to the CF convention [AD-3] for standard projection names.

Note on lat/lon arrays

`**lat**` and `**lon**` arrays are the only arrays stored as *float* in GHRSST product files and therefore can represent a major fraction of the overall data volume. As an optimization factor, producers are encouraged to make use of the **least_significant_digit** argument when creating these NetCDF variables (refer for instance to https://unidata.github.io/netcdf4-python/): in the most current GHRSST products, there is no need for a precision larger than 3 digits and it can be a big volume saver.

Regular latitudlongitude grids

This is the simplest case. Many L3, L4, and GMPE products as well as some geostationary L2P products are provided on a regular lat/lon grid. On such a projection, only two coordinate variables are requested and they can be stored as vector arrays. Longitudes should range from -180 to +180, corresponding to 180 degrees West to 180 degrees East. Latitudes should range from -90 to +90, corresponding to 90 degrees South to 90 degrees North. There should be no **_FillValue** for latitude and longitude and all SST pixels should have a valid value latitude and longitude.

It is recommended that for Level 3 and Level 4 data products the **time** dimension be specified as **unlimited**. **Note that the time dimension for L2P data files is strictly defined as time=1 (unlimited dimension not allowed).** This strict definition is because L2P data are swath based and the geospatial information may change across consecutive time slabs. Although in GHRSST L3 and L4 granules there is only one time dimension (**time=1**) and variable **time** has only one value (seconds since 1981), setting an unlimited dimension for **time** will allow netCDF tools and utilities to easily concatenate (and average for example) a series of time consecutive GHRSST granules. The following CDL is provided as an example:

```
netcdf example {
        dimensions:
        lat = 1801 ;
        lon = 3600 ;
        time = UNLIMITED ; // (strictly set to 1 for L2P)
        variables:
        …
}
```

For these cases, **dimension** and **coordinate** variables shall be used for a regular lat/lon grid as shown in Table 8-3. No specific variable attributes are required for other variables (like **sea_surface_temperature** as shown in the example given in Table 8-3.

Table 8-3 Example CDL for GDS-2.1 geographic regular latitude/longitude grids

netcdf example { **dimensions:**
lat = 1024 ; **lon = 1024 ;** **time = unlimited ;**
variables:
float lat(lat) ; **lat:standard_name = "latitude" ;** **lat:units = "degrees_north" ;** **lat:valid_range = -90., 90. ;** **lat:coverage_content_type = "coordinate" ;** **lat:comment = "geographical coordinates, WGS84 projection" ;** **float lon(lon) ;** **lon:standard_name = "longitude" ;** **lon:units = "degrees_east" ;** **lon:valid_range = -180., 180. ;** **lon:coverage_content_type = "coordinate" ;**

```
 lon:comment = "geographical coordinates, WGS84 projection" ;
long time(time) ;
 time:long_name = "reference time of sst file" ;
 time:standard_name = "time" ;
 time:units = "seconds since 1981-01-01 00:00:00" ;
 time:coverage_content_type = "coordinate" ;
short sea_surface_temperature(time, lat, lon) ;
 sea_surface_temperature:standard_name="sea_surface_skin_temperature";
 sea_surface_temperature:long_name="Skin temperature of the sea surface";
 sea_surface_temperature:units = "kelvin" ;
 sea_surface_temperature:_FillValue = -32768s ;
 sea_surface_temperature:add_offset = 273.15f ;
 sea_surface_temperature:scale_factor = 0.01f ;
 sea_surface_temperature:valid_range = -200s, 5000s ;
 sea_surface_temperature:coverage_content_type = "physicalMeasurement" ;
 sea_surface_temperature:source = "EUMETSAT SAF O&SI" ;
 sea_surface_temperature:comment = "These SST values are representative of the top 10 micrometers of the
sea surface and were generated on a regular grid" ;
}
```

Non-regular latitude/longitude grids (projection)

For gridded data using a specific projection (such as stereographic projection), lat/lon have to be stored in 2-D arrays. When data are gridded following the sensor pattern, no projection can be associated and lat/lon data have to be stored in 2-D arrays. Dimensions cannot be referred to as lat/lon any more since the x and y axes of the grid are not related to the latitude or longitude axis. Each variable must explicitly provide a reference to its coordinate variables (**coordinates** variable attribute) and to the related projection (**grid_mapping** variable attribute) described in a specific variable (for example, **stereographic_polar** in the example given in Table 8-4; refer to CF convention [AD-3] for standard names).

In these cases, **dimension** and **coordinate** variables shall be used for a non-regular lat/lon grid (projection) as shown in Table 8-4. A specific projection coordinate variable shall be added (for example, **polar_stereographic**), following the CF-1.7 or later convention. The specific variable attributes '**coordinates = "lon lat"**' and '**grid_mapping = "polar_stereographic"**' are required for each other variables (like '**sea_surface_temperature**' in the example given in Table 8-4). If the projection has additional information e.g. polar_projection details, these shall be included in the **comment** attribute.

Note that variable attributes such as **grid_mapping** may be set differently (when using a different kind of projection) or completely removed (for swath products or regular grids if required).

Table 8-4 Example CDL for Non-regular latitude/longitude grids (projections)

```
netcdf example {
dimensions:
 ni = 1024 ;
 nj = 1024 ;
 time = 1 ;
variables:
 float lat(nj, ni) ;
```

```
 lat:standard_name = "latitude" ;
 lat:units = "degrees_north" ;
 lat:valid_range = -90., 90. ;
 lat:coverage_content_type = "coordinate";
 lat:comment = "geographical coordinates, WGS84 projection" ;
float lon(nj, ni) ;
 lon:standard_name = "longitude" ;
 lon:units = "degrees_east" ;
 lon:valid_range = -180., 180. ;
 lon:coverage_content_type = "coordinate";
 lon:comment = "geographical coordinates, WGS84 projection" ;
long time(time) ;
 time:long_name = "reference time of sst file" ;
 time:standard_name = "time" ;
 time:units = "seconds since 1981-01-01 00:00:00 " ;
 time:coverage_content_type = "coordinate" ;
short sea_surface_temperature(time, nj, ni) ;
 sea_surface_temperature:standard_name="sea_surface_skin_temperature";
 sea_surface_temperature:long_name="Skin temperature of the sea surface";
 sea_surface_temperature:units = "kelvin" ;
 sea_surface_temperature:_FillValue = -32768s ;
 sea_surface_temperature:add_offset = 273.15 ;
 sea_surface_temperature:scale_factor = 0.01 ;
 sea_surface_temperature:valid_range = -200s, 5000s ;
 sea_surface_temperature:coverage_content_type = "physicalMeasurement" ;
 sea_surface_temperature:coordinates = "lon lat" ;
 sea_surface_temperature:grid_mapping = "polar_stereographic" ;
 sea_surface_temperature:source = "EUMETSAT SAF O&SI" ;
 sea_surface_temperature:comment = "These SST values are representative of the top 10 micrometers of the sea
surface and were projected on a polar stereographic grid" ;
}
```

Non-regular latitude/longitude grids (projection) – alternative without explicit latitude/longitude

For gridded data using a fixed specific projection (such as geostationary projection), the same lat/lon 2-D arrays are repeated from file to file. If a fixed projection can be associated to lat/lon data, it is also permitted by CF convention to provide a projection variable defining this projection, instead of providing explicit latitude/longitude 2-D arrays as in the previous section. This usually allows to save significant storage (which is interesting for products with a high temporal repetitiveness such as geostationary products in satellite projection) while being less user friendly since users will have to calculate their own latitude/longitude 2-D arrays from the projection parameters (this is done automatically in some CF compliant tools).

The projection variable must be named with the projection name used in the product (like '**geostationary**' below). It is dimensionless and of type **int**. The naming and content of this projection variable is described in CF conventions (http://cfconventions.org/cf-conventions/cf-conventions.html#appendix-grid-mappings).

The x (abscissa) and y (ordinate) rectangular coordinates must be provided in **ni** and **nj** variables, identified by the standard_name attribute values projection_x_coordinate and projection_y_coordinate respectively. In the case of this geostationary projection, the projection coordinates in this projection are directly related to the scanning angle of the satellite instrument, and their units are radians.

Each variable must explicitly provide a reference to its coordinate variables (**coordinates** variable attribute) and to the related projection (**grid_mapping** variable attribute) described in a specific variable (e.g. **geostationary** in the example given in Table 8-5; refer to CF convention [AD-3] for standard names).

In these cases, **dimension** and **coordinate** variables shall be used for a non-regular lat/lon grid (projection) as shown in Table 8-4. A specific projection coordinate variable shall be added (for example, **polar_stereographic**), following the CF-1.7 or later convention. The specific variable attributes '**coordinates = "nj ni"**' and '**grid_mapping = "geostationary"**' are required for each other variables (like '**sea_surface_temperature**' in the example given in Table 8-5).

Table 8-5 Example CDL for Non-regular latitude/longitude grids (projections) alternative form with no explicit latitudes/longitudes

```
netcdf example {
dimensions:
 ni = 1024 ;
 nj = 1024 ;
 time = 1 ;
variables:
 long time(time) ;
  time:long_name = "reference time of sst file" ;
  time:standard_name = "time" ;
  time:units = "seconds since 1981-01-01 00:00:00 " ;
  time:coverage_content_type = "coordinate";
 float nj(nj) ;
        nj:axis = "Y" ;
        nj:units = "radians" ;
        nj:long_name = "y coordinate of projection" ;
        nj:standard_name = "projection_y_coordinate" ;
        nj:valid_range = -0.151844f, 0.151844f ;
  nj:coverage_content_type = "coordinate";
 float ni(ni) ;
        ni:axis = "X" ;
        ni:units = "radians" ;
        ni:long_name = "x coordinate of projection" ;
        ni:standard_name = "projection_x_coordinate" ;
        ni:valid_range = -0.151844f, 0.151844f ;
  ni:coverage_content_type = "coordinate";
 int geostationary ;
  geostationary:grid_mapping_name = "geostationary" ;
  geostationary:semi_major_axis = 6378137. ;
  geostationary:semi_minor_axis = 6356752.314245 ;
  geostationary:inverse_flattening = 298.257223563 ;
  geostationary:perspective_point_height = 35786023. ;
  geostationary:latitude_of_projection_origin = 0. ;
  geostationary:longitude_of_projection_origin = -75. ;
  geostationary:false_easting = 0. ;
  geostationary:false_northing = 0. ;
  geostationary:sweep_angle_axis = "x" ;
  geostationary:horizontal_datum_name = "WGS_1984" ;
```

```
 geostationary:reference_ellipsoid_name = "WGS 84" ;
 geostationary:prime_meridian_name = "Greenwich" ;
 geostationary:geographic_crs_name = "GEOS" ;
short sea_surface_temperature(time, nj, ni) ;
 sea_surface_temperature:standard_name="sea_surface_skin_temperature";
 sea_surface_temperature:long_name="Skin temperature of the sea surface";
 sea_surface_temperature:units = "kelvin" ;
 sea_surface_temperature:_FillValue = -32768s ;
 sea_surface_temperature:add_offset = 273.15 ;
 sea_surface_temperature:scale_factor = 0.01 ;
 sea_surface_temperature:valid_range = -200s, 5000s ;
 sea_surface_temperature:coverage_content_type = "physicalMeasurement" ;
 sea_surface_temperature:coordinates = "nj ni" ;
 sea_surface_temperature:grid_mapping = "geostationary" ;
 sea_surface_temperature:source = "EUMETSAT SAF O&SI" ;
 sea_surface_temperature:comment = "These SST values are representative of the top 10 micrometers of the sea surface over the native geostationary satellite grid" ;
}
```

Non-regular latitude/longitude grids (swath)

In this case where data are gridded following the sensor pattern, no projection can be associated and lat/lon data have to be stored in 2-D arrays. Dimensions cannot be referred to as lat/lon anymore since x and y axes of the grid are no more related to the latitude or longitude axis. Instead, dimensions ni and nj should be used to describe the swath. As a best practice, the ni dimension should refer to the cross-track direction and the nj dimension should refer to the along-track direction of a polar orbiting (or similar) satellite sensor swath. For geostationary sensors ni also refers to the cross-disk direction and nj the along-disk direction. Each variable must explicitly provide a reference to its coordinate variables (using the **coordinates** variable attribute).

Dimension and coordinate variables shall be used for a non-regular lat/lon grid (swath product file) as shown in Table 8-6. The specific variable attribute '**coordinates =** "**lon lat**"' is required for each of the variables (like '**sea_surface_temperature**' below).

Table 8-6 Example CDL for GDS-2.1 Non-regular latitude/longitude grids (swath)

```
netcdf example {
dimensions:
 ni = 1000 ;
 nj = 40000 ;
 time = 1 ;
variables:
 float lat(nj, ni) ;
  lat:standard_name = "latitude" ;
  lat:units = "degrees_north" ;
  lat:coverage_content_type = "coordinate" ;
 float lon(nj, ni) ;
  lon:standard_name = "longitude" ;
  lon:units = "degrees_east" ;
  lon:coverage_content_type = "coordinate" ;
 long time(time) ;
  time:long_name = "reference time of sst file" ;
  time:standard_name = "time" ;
  time:units = "seconds since 1981-01-01 00:00:00" ;
  time:coverage_content_type = "coordinate" ;
 short sea_surface_temperature(time, nj, ni) ;
  sea_surface_temperature:standard_name="sea_surface_skin_temperature";
  sea_surface_temperature:long_name="Skin temperature of the sea surface";
  sea_surface_temperature:units = "kelvin" ;
  sea_surface_temperature:_FillValue = -32768s ;
  sea_surface_temperature:add_offset = 273.15 ;
  sea_surface_temperature:scale_factor = 0.01 ;
  sea_surface_temperature:valid_range = -200s, 5000s ;
  sea_surface_temperature:coverage_content_type = "physicalMeasurement" ;
  sea_surface_temperature:coordinates = "lon lat" ;
  sea_surface_temperature:source = "EUMETSAT SAF O&SI" ;
  sea_surface_temperature:comment = "These SST values are representative of the top 10 micrometers of
the sea surface and are provided on their native, non regular latitude/longitude grid (swath)." ;
}
```

9 Level 2 Pre-processed (L2P) Product Specification

9.1 Overview description of the GHRSST L2P data product

The GHRSST Level-2 Pre-processed (L2P) products are the basic building blocks from which all other GHRSST SST data products can be derived. L2P data products should ideally be made available within the GHRSST R/GTS framework to the user community in real time within 3 hours after the reception of data at the satellite. For every L2P file that is generated, appropriate ISO metadata (specified in Section 12.1) must also be created and registered at the GHRSST Master Metadata Repository (MMR) system (see [AD-1] for more details).

L2P products include SST data as delivered by a data provider in their native format (swath, grid, or vector), together with a number of ancillary fields that simplify interpretation an application of the SST data. The main difference between input L2 SST data file and the output GHRSST L2P data file is that additional confidence data and sensor specific error estimates for each pixel value are included and the original SST data files are reformatted into the L2P specification. No adjustments to the input L2 SST measurements are allowed but instead, sensor specific error statistics are used to provide bias error and standard deviation estimates. A user wishing to correct L2P SST data can apply these estimates to the SST values directly. Full orbit input data files may be split into ascending and descending files or smaller granules and a unique L2P output may be generated for each file. The common format of L2P products allows data users to code with the security so that as new satellite derived SST data sets are brought on-line, very minimal code changes are required to make full use of new L2P data. Time previously spent on coding different i/o routines for each satellite data set can now be spent applying the data to various applications and societal benefits instead.

The GHRSST Science Team agreed at the 6th GHRSST Science Team Meeting, Met Office, Exeter, United Kingdom, May 14th – 20th 2005, 6 mandatory fields form the core data content of a GHRSST L2P data file. These fields will be known as L2P 'core' (L2Pcore) fields. In addition to metadata records, global attributes and geo-location and time information, RDACs must produce the following L2Pcore within an L2P file:

- Sea Surface Temperature data (**sea_surface_temperature**),
- Time differences of SST measurements from a reference time (**sst_dtime**),
- SST Sensor Specific Error Statistic (SSES) measurement bias estimate (**sses_bias**),
- SSES measurement standard deviation estimate (**sses_standard_deviation**),
- Flags specific to each L2P data set that help users interpret data (**l2p_flags**),
- A quality level for each measurement (**quality_level)**,

In addition there are a number of auxiliary fields (L2Paux) that must be provided before the L2P data product is admitted into the GHRSST R/GTS:

- **dt_analysis** – the difference between satellite SST measurements and a defined reference climatology of SST
- An estimate of surface wind speed (**wind_speed)**

- An estimate of sea ice fraction (**sea_ice_fraction)**
- An estimate of atmospheric aerosol (as an aerosol dynamic indicator, **aerosol_dyanamic_indicator)**

When an L2P file contains all L2Pcore and L2Paux fields together with full L2P ISO metadata, it will be called a full-L2P file. Best practice dictates that RDACs should add the remaining auxiliary fields (L2Paux) prior to submission at the GDAC. Only full L2P data files should be registered and ingested at the GHRSST GDAC and LTSRF system. These distinctions will assist in the data management of the GHRSST GDS-2.1.

Missing L2Paux fields not provided by an RDAC may be added by the GDAC with prior arrangement. In this case data required the L2Paux files will be procured, checked for quality and interpolated or processed according to the GDS-2.1 specification by the GDAC.

Optional experimental fields may be used by RDAC to provide additional information at the data provider's discretion. It may be necessary to use an additional netCDF coordinate variable when including experimental fields.

GDS-2.1 L2P data products are configured as shown in Table 9-1, which can be used to locate appropriate information in this document.

Table 9-1 Summary description of the contents of a GHRSST L2P data file

netCDF File Contents	Description	Units	Section	Required
Global Attributes	A collection of required global attributes describing general characteristics of the file	Various	8.2	Mandatory
Geolocation Data	Information to permit locating data on non-orthogonal grids	RDAC defined	8.4	Mandatory
sea_surface_temperature	SST measurement	K	9.3	Mandatory
sst_dtime	Deviation in time of SST measurement from reference time	sec	9.4	Mandatory
sses_bias	Sensor Specific Error Statistic (SSES) bias error	K	9.5	Mandatory
sses_standard_deviation	SSES standard deviation uncertainty	K	9.6	Mandatory

dt_analysis	The difference between input SST and a GHRSST L4 SST analysis from the previous 24 hour period	K	9.7	Mandatory
wind_speed	Closest (in time) 10 m surface wind speed from satellite or analysis	ms^{-1}	9.8	Mandatory
wind_speed_dtime_from_sst	Time difference of **wind_speed** data from input L2 SST measurement	hours	9.9	Mandatory
source_of_wind_speed	Sources of **wind_speed** data	code	9.10	Mandatory when multiple sources used
sea_ice_fraction	Closest (in time) sea ice fraction from satellite or analysis	Unit less	9.11	Mandatory
sea_ice_fraction_dtime_from_sst	Time difference of **sea_ice_fraction** data from input L2 SST measurement specified in hours. For single sources, simply set a variable attribute **sea_ice_fraction:sea_ice_fraction_dtime_from_sst =** “difference time in hours”.	hours	9.12	Mandatory when multiple sources used
source_of_sea_ice_fraction	Sources of **sea_ice_fraction** data	code	9.13	Mandatory when multiple sources used
aerosol_dynamic_indicator	Atmospheric aerosol indicator	Various	9.14	Mandatory infrared SST data
adi_dtime_from_sst	Time difference between the **aerosol_dynamic_indicator** value and SST measurement	hours	9.15	Mandatory when **aerosol_dynamic_indicator** included
source_of_adi	Source of atmospheric aerosol indicator data	code	9.16	Mandatory when multiple sources used

l2p_flags	Data flag values	code	9.17	Mandatory
quality_level	Overall indication of L2P data quality	code	9.18	Mandatory
satellite_zenith_angle	Calculated satellite zenith angle (measured at the Earth's surface between the satellite and the zenith)	degrees	9.19	Optional
solar_zenith_angle	Calculated solar zenith angle (the angle between the local zenith and the line of sight to the sun, measured at the Earth's surface)	degrees	9.20	Optional
surface_solar_irradiance	Near contemporaneous surface solar irradiance	Wm^{-2}	9.21	Optional
ssi_dtime_from_sst	Time difference between the **surface_solar_irradiance** value and SST measurement	hours	9.22	Mandatory when **surface_solar_irradiance** included
source_of_ssi	Sources of **surface_solar_irradiance** data	code	9.23	Optional
Optional experimental fields defined by RDAC	Optional/experimental data	RDAC defined	9.24	Optional

9.2 L2P data record format specification

Table 9-2 provides an overview of the GHRSST L2P product pixel data record that should be created for each input L2 SST measurement contained within a L2P file. In the following sections, each variable within the L2P data file is described in detail.

Table 9-2 L2P SST data record content.

Variable Name (Definition Section, CDL Example)	Description	Units / data type
sea_surface_temperature (Section 9.3, Table 9-3)	SST measurement values from input L2 satellite data set. L2 SST data are not adjusted in any manner and are identical to the input data set.	kelvin int

	Use attribute '**sea_surface_temperature:source =** "<code from Section 7.9>" to specify the L2 input product source.	
sst_dtime (Section 9.4, Table 9-5)	Deviation in time of SST measurement from reference time stored in the netCDF global variable **time** (defined as the start time of granule for L2P). Minimum resolution should be one second.	seconds short
sses_bias (Section 9.5, Data producers are reminded to choose appropriate scale_factors and add_offsets for their data, and to strive for scale_factors as close to 0.01 as possible without "oversaturating" the values. Table 9-6)	Sensor Specific Error Statistic (SSES) bias error estimate generated by data provider The specific SSES methodology should be described in L2P documentation from the data provider. The GHRSST ST-VAL TAG will maintain a summary document of all SSES schemes at https://www.ghrsst.org/resources/single-sensor-error-statistic-sses/	kelvin byte
sses_standard_deviation (Section 9.6, Table 9-7)	SSES standard deviation uncertainty generated by data provider. The specific SSES methodology should be described in L2P documentation from the data provider. The GHRSST ST-VAL TAG will maintain a summary document of all SSES schemes at https://www.ghrsst.org/resources/single-sensor-error-statistic-sses/	kelvin byte
dt_analysis (Section 9.7, Table 9-9)	The difference between input SST and a GHRSST L4 SST analysis from the previous 24 hour period. The GHRSST L4 analysis chosen for a given L2P data set variable should be consistent for all L2P products as far as practically possible. If no L4 analysis is available then an alternative L4 analysis or a reference mean SST climatology may be used. If storage as *byte* does not allow the provider to offer the full precision required for this field, storage as a *short* is optionally permitted though *byte* is preferred.	kelvin byte (or short)
wind_speed (Section 9.8, Table 9-10)	10 m surface wind speed near contemporaneous to the input SST measurement from satellite or analysis.	ms^{-1} byte

	Wind speed data should be provided at a minimum resolution of 1 ms^{-1} and data producers shall use **scale_factor** and **add_offset** to scale data to an appropriate resolution (higher resolution is better). The difference in time between SST measurement and **wind_speed** data shall be recorded in the L2P variable **wind_speed_dtime_from_sst.** If all the times have the same value, then using an attribute **wind_speed:time_offset** is sufficient and the variable wind_speed_dtime_from_sst is not required. If multiple sources of wind speed data are used, the variable **source_of_wind_speed** shall be used to indicate their source following the format requirements shown in Section 7.9. In addition, the units of all sources used in the file shall be identical. If a unique source is used (this is recommended) the attribute **'wind_speed:source =** "< string defined by best practice in Section 7.9>" is considered sufficient.	
wind_speed_dtime_from_sst (Section 9.9, Table 9-11)	Time difference of **wind_speed** data from input L2 SST measurement specified in hours.	Hours byte
source_of_wind_speed (Section 9.10, Table 9-12)	When multiple sources of wind speed data are used in the variable **wind_speed**, the variable **source_of_wind_speed** shall be used to record the source of the wind speed data used. If a unique source of wind speed data is used (this is recommended) the variable attribute **'wind_speed:source =** "<string defined by best practice in Section 7.9>" shall be sufficient and the variable **source_of_wind_speed** Is not required. >". If the values in that single source all have the same time, then a variable level attribute **wind_speed:time_offset =** "difference time in hours" are considered sufficient and the variable **wind_speed_dtime_from_sst** is not required.	Code byte

sea_ice_fraction (Section 9.11, Table 9-13)	Fractional Sea Ice contamination data. Ranges from 0 to 1. This field is only required if there is actually sea ice in the input L2 data set. Do not provide an array of missing data values. When multiple sources of sea ice fraction data are used in the variable **sea_ice_fraction**, the variable **source_of_sea_ice_fraction** shall be used to record the source of the sea ice fraction data used and the difference in time between SST measurement and **sea_ice_fraction** data shall be recorded in the variable **sea_ice_fraction_dtime_from_sst.** In addition, the units of all sources used in the file shall be identical. If a unique source of sea ice fraction data is used (this is recommended), the variable attribute **'sea_ice_fraction:source =** "<string defined by best practice in Section 7.9>". If the values in that single source all have the same time, then a variable level attribute **sea_ice_fraction:time_offset =** “difference time in hours” are considered sufficient and the variables **source_of_sea_ice_fraction** and **sea_ice_fraction_dtime_from_sst** are not required. The variable attribute **sea_ice_fraction:sea_ice_treatment** shall specify how the sea ice information has been treated by the data provider.	Percent byte
sea_ice_fraction_dtime_from_sst (Section 9.12, Table 9-14)	Time difference of **sea_ice_fraction** data from input L2 SST measurement specified in hours. This variable is mandatory when multiple sources of sea_ice_fraction are used. If only one source is used, simply set a variable attribute **sea_ice_fraction: time_offset =** “difference time in hours”.	Hours byte
source_of_sea_ice_fraction (Section 9.13, Table 9-15)	When multiple sources of sea ice fraction data are used in the variable **sea_ice_fraction**, the variable **source_of_sea_ice_fraction** shall be used to record the source of the sea ice fraction data used.	Code byte

	If a unique source of sea ice fraction data is used (this is recommended), the variable attribute **'sea_ice_fraction:source =** "<string defined by best practice in Section 7.9>" " is sufficient and the variable **source_of_sea_ice_fraction** Is not needed.	
aerosol_dynamic_indicator (Section 9.14, Table 9-16)	The variable **aerosol_dynamic_indicator** (ADI) is used to indicate the presence of atmospheric aerosols that may cause errors in the atmospheric correction of infrared satellite data when retrieving SST. The variable **aerosol_dynamic_indicator** is mandatory only when the input SST data set has been derived from an infrared satellite instrument. The atmospheric aerosol data used to fill the variable **aerosol_dynamic_indicator** is chosen by the data provider as the most appropriate aerosol indicator for a given input SST data set. (e.g., SDI might be used for MSG SEVIRI, a view difference might be used for AATSR, and aerosol optical depth may be used from a model or another satellite system). When multiple sources of atmospheric aerosol indicator data are used in the variable **aerosol_dynamic_indicator**, the variable **source_of_adi** shall be used to record the source of the aerosol indicator data used. In addition, the units of all sources used in the file shall be identical. If a unique source of atmospheric aerosol indicator data is used (this is recommended), the variable attribute **'aerosol_dynamic_indicator:source =** "<string defined by best practice in Section 7.9>" is sufficient and the variable **source_of_aerosol_dynamic_indicator** is not required. If all the times have the same value, then using an attribute **aerosol_dynamic_indicator:time_offset** is sufficient and the variable **adi_dtime_from_sst** is not required.	Scaled value byte

<table>
<tr>
<td>adi_dtime_from_sst

(Section 9.15, Table 9-17)</td>
<td>The time difference between the aerosol_dynamic_indicator value and SST measurement recorded in hours.</td>
<td>Hours
byte</td>
</tr>
<tr>
<td>source_of_adi

(Section 9.16, Table 9-18)</td>
<td>When multiple sources of atmospheric aerosol indicator data are used in the variable aerosol_dynamic_indicator , the variable source_of_adi shall be used to record the source of the aerosol indicator data used.

If a unique source of atmospheric aerosol indicator data is used (this is recommended), the variable attribute aerosol_dynamic_indicator:source = "<string defined by best practice in Section 7.9>" is sufficient and the variable source_of_adi Is not required.</td>
<td>Code
byte</td>
</tr>
<tr>
<td>l2p_flags

(Section 9.17, Table 9-20)</td>
<td>The variable l2p_flags is used to (a) specify the type of input SST data (either infrared or passive microwave instrument derived), (b) pass through native flags from the input L2 SST data set and (c) record any additional information considered important for the user of an L2P data set.

The variable l2p_flags is split into two sections: the first 6 bits of the L2P variable l2p_flags are generic flags that are common to all L2P data files; bits 6-15 are defined by the L2P data provider and are specific to each L2 input data stream.

The tables below define the bit field and their meanings. The least significant bit (bit 0) starts on the right.

<table>
<tr><th>Bit</th><th>Common flags</th></tr>
<tr><td>0</td><td>Passive microwave data</td></tr>
<tr><td>1</td><td>Land</td></tr>
<tr><td>2</td><td>Ice</td></tr>
<tr><td>3</td><td>Lake (if known)</td></tr>
<tr><td>4</td><td>River (if known)</td></tr>
<tr><td>5</td><td>Spare</td></tr>
</table>

<table>
<tr><th>Bit</th><th>l2p_flags definition</th></tr>
</table>
</td>
<td>Flags
int</td>
</tr>
</table>

<table>
<tr><td></td><td><table><tr><td>6-15</td><td>Defined by L2 data provider and described in the flag_meanings, and flag_masks variable attributes.

Please refer to L2P data provider documentation</td></tr></table></td><td></td></tr>
<tr><td>quality_level

(Section 9.18, Table 9-21)</td><td>The L2P variable quality_level is used to provide an overall indication of L2P data quality.

The L2P variable quality_level will reflect CEOS QA4EO (Quality Indicator) guidelines.

An incremental scale from 0 no data,1 (bad e.g. cloud, rain, to close to land – under no conditions use this data) 2 (worst quality usable data), to 5 (best quality usable data) shall be used.</td><td>Code byte</td></tr>
<tr><td>Optional/experimental fields defined by data provider
(Section 9.24, Table 9-28)</td><td>Optional/experimental data</td><td>Defined by RDAC</td></tr>
</table>

9.3 Variable sea_surface_temperature

The variable '**sea_surface_temperature**' contains the native unmodified L2 SST of the input data file. The '**sea_surface_temperature**' variable shall be included in a L2P product with the format requirements shown in Table 9-3.

Table 9-3 CDL example description of sea_surface_temperature **variable**

Storage type definition	Variable name definition	Description	Unit
Short	**sea_surface_temperature**	Pixel sea surface temperature value	K
Example CDL Description			

```
short sea_surface_temperature(time, nj, ni) ;
  sea_surface_temperature:long_name = "sea surface skin temperature" ;
  sea_surface_temperature:standard_name="sea_surface_skin_temperature" ;
  sea_surface_temperature:units = "kelvin" ;
  sea_surface_temperature:_FillValue = -32768s ;
  sea_surface_temperature:add_offset = 273.15f ;
  sea_surface_temperature:scale_factor = 0.01f ;
  sea_surface_temperature:valid_range = -200s, 5000s ;
  sea_surface_temperature:coverage_content_type = "physicalMeasurement" ;
  sea_surface_temperature:coordinates = "lon lat" ;
  sea_surface_temperature:grid_mapping = "polar_stereographic" ;
  sea_surface_temperature:comment = "Temperature of the skin of the
ocean."
```

sea_surface_temperature:depth = "10 micrometers"
Comments
The standard_name attribute should be CF-1.7 or later compliant as described in [AD-3] Table 9-4**.** More details on standard names for SST are given in Table 7-3.

Table 9-4 GHRSST short SST names and CF-1.4 standard names for sea_surface_temperature

GHRSST name	CF-1.7 standard name definitions [AD-3]
SSTint	**sea_surface_temperature**
SSTskin	**sea_surface_skin_temperature**
SSTsubskin	**sea_surface_subskin_temperature**
SSTfnd	**sea_surface_foundation_temperature**
SSTdepth	**sea_water_temperature** Note the attribute "**depth**" should be used to indicate the depth for which the SST data are valid e.g.: **sea_surface_temperature:standard_name="sea_water_temperature";** **sea_surface_temperature:units = "kelvin" ;** **sea_surface_temperature:depth = "1 metre" ;**

9.4 Variable sst_dtime

The difference in seconds from the reference time, stored in the netCDF coordinate variable **time** (Section 8). The variable '**sst_dtime**' shall be included with the format requirements shown in Table 9-5. Note that in L2P, the storage type is short, but for L3, the storage type is long.

Table 9-5 CDL example description of sst_dtime **variable**

Storage type definition	Variable name definition	Description	Unit
short (long in L3)	**sst_dtime**	Deviation from reference time stored in the coordinate variable, **time.**	second
Example CDL Description			
short sst_dtime (time, nj, ni) ; **sst_dtime:long_name = "time difference from reference time" ;** **sst_dtime:units = "seconds" ;** **sst_dtime:_FillValue = -32768s ;** **sst_dtime:valid_range = -32767s, 32767s ;** **sst_dtime:coverage_content_type = "referenceInformation" ;** **sst_dtime:coordinates = "lon lat" ;** **sst_dtime:grid_mapping = "polar_stereographic" ;** **sst_dtime:comment = "time plus sst_dtime gives seconds after 00:00:00 UTC January 1, 1981"**			
Comments			
Pixel-by-pixel time difference from **time** variable defined by data provider. Add **sst_dtime** to reference time stored in variable **time** to get seconds since 00:00:00 UTC, 01 January 1981.			

9.5 Variable sses_bias

Providing uncertainty estimates for each SST measurement is one of the key user requirements for GHRSST L2P SST data products. Uncertainty estimates allow users to select the accuracy level suitable for their application and to make optimum use of the SST observations (e.g. in data assimilation).

The uncertainties associated with each observation in a data stream are provided as Sensor Specific Error Statistic (SSES) https://www.ghrsst.org/resources/single-sensor-error-statistic-sses/. The SSES are based on understanding the errors associated with the in-flight performance of an individual satellite instrument for the retrieval of SST from the measured radiances. The SSES are provided as a mean bias error and its associated standard deviation.

There are a variety of methods for determining SSES as they depend on the specific characteristics of each satellite instrument. Consequently, the L2P provider can define their own scheme for producing SSES that is tailored to their specific dataset. However, the SSES scheme must conform to a set of agreed SSES common principles.

The SSES common principles are maintained on the GHRSST website at https://www.ghrsst.org/resources/single-sensor-error-statistic-sses/, and have been approved by the GHRSST Science Team. The L2P provider must provide documentation that summarizes the theoretical basis of their SSES scheme, its implementation, any recommendations for users, and its conformance to the agreed SSES common principles. The SSES documentation will be maintained through the GHRSST website at https://www.ghrsst.org/resources/single-sensor-error-statistic-sses/.

The variable '**sses_bias**' is used to store SSES bias estimates and shall be included with the L2P format requirements shown in Data producers are reminded to choose appropriate scale_factors and add_offsets for their data, and to strive for scale_factors as close to 0.01 as possible without "oversaturating" the values.
Table 9-6. Data producers are reminded to choose appropriate scale_factors and add_offsets for their data, and to strive for scale_factors as close to 0.01 as possible without "oversaturating" the values.

Table 9-6 CDL example description of sses_bias **variable**

Storage type definition	Variable name definition	Description	Unit
byte	**sses_bias**	SSES bias estimate	K
Example CDL Description			
byte sses_bias (time, nj, ni) ; sses_bias:long_name = "SSES bias estimate" ; sses_bias:units = "kelvin" ; sses_bias:_FillValue = -128b ; sses_bias:add_offset = 0. ; sses_bias:scale_factor = 0.02 ; sses_bias:valid_range = -127b, 127b ; sses_bias:coverage_content_type = "auxiliaryInformation" ; sses_bias:coordinates = "lon lat" ; sses_bias:grid_mapping = "polar_stereographic" ;			

sses_bias:comment = "Bias estimate derived using the techniques described at https://www.ghrsst.org/resources/single-sensor-error-statistic-sses/"
Comments
SSES bias values are derived by the data provider according to a documented methodology. Please consult the data provider L2P documentation for details. A summary of all SSES schemes is provided at https://www.ghrsst.org/resources/single-sensor-error-statistic-sses/.

9.6 Variable sses_standard_deviation

SSES standard deviation estimates are generated by the L2P data provider and are specific to a particular satellite instrument, and must conform to the SSES common principles. The SSES common principles are maintained on the GHRSST website at https://www.ghrsst.org/resources/single-sensor-error-statistic-sses/, and have been approved by the GHRSST Science Team. The L2P provider must provide documentation that summarises the theoretical basis of their SSES scheme, its implementation, any recommendations for users, and its conformance to the agreed SSES common principles. The SSES documentation will be maintained through the GHRSST website at https://www.ghrsst.org/resources/single-sensor-error-statistic-sses/.

The variable '**sses_standard_deviation**' shall be included with the format requirements shown in Table 9-7. Data producers are reminded to choose appropriate scale_factors and add_offsets for their data, and to strive for scale_factors as close to 0.01 as possible without "oversaturating" the values.

Table 9-7 CDL example description of sses_standard_deviation **variable**

Storage type definition	Variable name definition	Definition description	Unit
byte	**sses_standard_deviation**	SSES standard deviation.	K
Example CDL Description			
byte sses_standard_deviation (time, nj, ni) ; sses_standard_deviation:long_name = "SSES standard deviation" ; sses_standard_deviation:units = "kelvin" ; sses_standard_deviation:_FillValue = -128b ; sses_standard_deviation:add_offset = 2.54. ; sses_standard_deviation:scale_factor = 0.02 ; sses_standard_deviation:valid_range = -127b, 127b ; sses_standard_deviation:coverage_content_type = "auxiliaryInformation" ; sses_standard_deviation:coordinates = "lon lat" ; sses_standard_deviation:grid_mapping = "polar_stereographic" ; sses_bias:comment = "Standard deviation estimate derived using the techniques described at https://www.ghrsst.org/resources/single-sensor-error-statistic-sses/"			
Comments			
SSES standard deviation values are derived by the data provider according to a documented methodology. Please consult the data provider L2P documentation for details. A summary of all SSES schemes is provided at https://www.ghrsst.org/resources/single-sensor-error-statistic-sses/			

9.7 Variable dt_analysis

The L2P variable **dt_analysis** is the temperature difference between an input L2 SST measurement and a reference SST L4 analysis data set. **dt_analysis** may be used to indicate potential areas of diurnal variability or gross outliers in the L2 input SST measurement data set by looking for large deviations from the previous analysis SST data. Note that **dt_analysis** is an indicator field and the temperature anomalies may be difficult to interpret in regions of high SST gradients. Furthermore, interpretation requires a good understanding of the strengths and weaknesses (e.g. space and time de-correlations) of the chosen reference L4 analysis system.

The GDS-2.1 specifies the following:

dt_analysis shall be derived using:

(Equation **9**-1) dt_analysis $= SST_{input} - L4_{SST}$

Where SST_{input} is the input satellite L2 measurement and $L4_{SST}$ is a previous day analysis from a GHRSST L4 System selected by the data provider. If a previous analysis *SSTfnd* data file is not available for use in (Equation 9-1, then a mean reference SST or climatology should be used in its place as defined in Table 9-8.

The **dt_analysis** value shall be inserted into the **dt_analysis** field of the L2P product for the pixel in question as described in Table 9-9.

Table 9-8 Reference SST data sets for use in dt_analysis **computation**

Name	Description	Reference
Use code from L4 analysis	The mean SSTfnd computed for a n- day period. This product is computed from data provider SSTfnd data products in real time each day	https://www.ghrsst.org/ghrsst-data-services/ghrsst-catalogue/
GMPE_GLOBAL	Daily, 25 km median average SST and sea ice product created using 10 operational SST analysis products from operational centres around the world	https://ghrsst-pp.metoffice.gov.uk/ostia-website/gmpe-monitoring.html

Table 9-9 CDL example description of dt_analysis **variable**

Storage type definition	Variable name definition	Description	Unit
Byte or short	**dt_analysis**	Deviation from previous day (T-1) L4 SSTfnd analysis as defined in Table 9-8 If no analysis is available, the reference mean SST climatology should be used as defined in Table 9-8	K
Example CDL Description			
byte dt_analysis (time, nj, ni) ; dt_analysis:long_name = "Deviation from last SST analysis" ; dt_analysis:units = "kelvin" ; dt_analysis:_FillValue = -128b ; dt_analysis:add_offset = 0.0f ; dt_analysis:scale_factor = 0.1f ; dt_analysis:valid_range = -127b, 127b ; dt_analysis:coverage_content_type = "auxiliaryInformation" ; dt_analysis:coordinates = "lon lat" ; dt_analysis:grid_mapping = "polar_stereographic" ; dt_analysis:reference = "UKMO-L4HRfnd-GLOB-OSTIA" ; dt_analysis:comment = “The difference between this SST and the previous day’s SST.”			
Comments			
The **reference** variable attribute should be used to specify the analysis or climatology used to compute **dt_analysis** as shown in the example above following the guidelines in Table 9-8 and 7.9.			

9.8 Variable wind_speed

The L2P variable **wind_speed** contains a best estimate of the **10m surface wind speed, ideally at the time of SST data acquisition** (although this is rarely possible). Wind speed measurements are required within the GDS as an indicator of the turbulent state of the air sea interface to interpret the relationship between satellite and subsurface SST data and assess the severity of any skin SST temperature deviation, thermal stratification and for use in diurnal variability adjustment schemes. At low wind speeds, especially in clear sky conditions, stronger diurnal variability is expected leading to higher surface layer temperature gradients and the potential for significant de-coupling of the skin/sub-skin SST from the SST at depth.

Ideally a near contemporaneous wind speed measurement from satellite sensors should be used but this is impossible for all sensors due to the limited number of satellite wind speed sensors available. As a surrogate for a measured wind speed value, analysis product estimates (e.g., from numerical weather prediction models) may be used as an indication of the surface wind speed. The GDS specifies the following rules:

> A 10m surface wind speed value assigned to each SST measurement pixel using the variable '**wind_speed**'. The following criteria shall apply:
>
> > Simultaneous microwave 10m wind speed measurements obtained from the same instrument providing the SST measurement shall be used when available to set the L2P confidence data variable **wind_speed.**
> >
> > In the absence of a simultaneous surface wind speed measurement, an analysis product estimated 10m surface wind speed shall be used to set the L2P variable **wind_speed**.
>
> The difference in time expressed in hours between the time of SST measurement and the time of wind speed data should be entered into the L2P confidence data variable **wind_speed_dtime_from_sst** as described in Section 9.9. In the case of an analysis field, this should be the central (mean) time of an integrated value. If all of the wind speeds have a single time value, as in the case of an analysis or model that gives the wind speeds at an instant in time, then the **wind_speed_dtime_from_sst** variable is not needed and instead a variable level attribute named **time_offset** is used. The attribute **time_offset** should store the difference in hours between the **wind_speed** and the reference time, stored in the variable **time**.
>
> If a single source of data is used in the L2P variable **wind_speed**, the L2P variable **source_of_wind_speed** is not required and the **wind_speed:source** attribute value is sufficient. In that case, it shall be a single source text string defined by the data provider using the text string naming best practice given in Section 7.9.
>
> If multiple sources of data are used, source information should be indicated in the L2P variable **source_of_wind_speed** as defined by the data provider and as described in detail in Section 9.10, and the **wind_speed:source** attribute shall have

the value **"source_of_wind_speed"**. In addition, the units of all sources used in the file shall be identical.

The GDS L2P variable **wind_speed** shall be included in GDS-2.1 L2P products with the format requirements shown in Table 9-10.

Table 9-10 CDL example description of wind_speed **variable**

Storage type definition	Variable name definition	Description	Unit
byte	**wind_speed**	Surface wind speed at 10m height. Resolution should be no less than 1 ms^{-1}	$m\ s^{-1}$
Example CDL Description			
byte wind_speed (time, nj, ni); **wind_speed:long_name = "10m wind speed" ;** **wind_speed:standard_name = "wind_speed" ;** **wind_speed:units = "m s-1" ;** **wind_speed:height = "10 m" ;** **wind_speed:_FillValue = -128b ;** **wind_speed:add_offset = 0.0f ;** **wind_speed:scale_factor = 1.f ;** **wind_speed:valid_range = -127b, 127b ;** **wind_speed:coverage_content_type = "auxiliaryInformation" ;** **wind_speed:time_offset = 2. ;** **wind_speed:coordinates = "lon lat" ;** **wind_speed:grid_mapping = "polar_stereographic" ;** **wind_speed:source = "ECMWF_Analysis_V2" ;** **wind_speed:comment = "These wind speeds were created by the ECMWF and represent winds at 10 metres above the sea surface"**			
Comments			
A single source of wind data is shown in this example which is reported as **wind_speed:source** = "**ECMWF_Anaylsis_V2**" the code has been defined by the data provider using the ancillary data naming rules given in Section 7.9. Since all of the wind speeds have the same time, the attribute **time_offset** is used instead of the variable **wind_speed_dtime_from_sst**.			

9.9 Variable wind_speed_dtime_from_sst

The variable **wind_speed_dtime_from_sst** reports the time difference between wind speed data and SST measurement in hours. The variable '**wind_speed_dtime_from_sst**' shall be included with the format requirements shown in Table 9-11. In the case of an analysis field, the central (mean) time of an integrated value should be used. If all of the values are the same, this variable is not required. Instead, use the variable level attribute named **time_offset** with the variable **wind_speed**.

Table 9-11 CDL example description of wind_speed_dtime_from_sst variable

Storage type definition	Variable name definition	Description	Unit
byte	**wind_speed_dtime_from_sst**	This variable reports the time difference of wind speed measurement from SST measurement in hours.	hour
Example CDL Description			
byte wind_speed_dtime_from_sst (time, nj, ni) ; wind_speed_dtime_from_sst:long_name = "time difference of wind speed measurement from sst measurement" ; wind_speed_dtime_from_sst:units = "hour" ; wind_speed_dtime_from_sst:_FillValue = -128b ; wind_speed_dtime_from_sst:add_offset = 0.0f ; wind_speed_dtime_from_sst:scale_factor = 0.1f ; wind_speed_dtime_from_sst:valid_range = -127b, 127b ; wind_speed_dtime_from_sst:coverage_content_type = "auxiliaryInformation" ; wind_speed_dtime_from_sst:coordinates = "lon lat" ; wind_speed_dtime_from_sst:grid_mapping = "polar_stereographic" ; wind_speed_dtime_from_sst:comment = “The hours between the wind speed measurement and the SST observation”			
Comment			

9.10 Variable source_of_wind_speed

The source of data used to set the L2P ancillary data variable **wind_speed** shall be indicated in the L2P variable **source_of_wind_speed** when more than one source of wind speed data is used in the L2P product. When only one source is used, this variable is not needed and the appropriate text string indicating the source is placed in the **source** attribute of the **wind_speed** variable. For multiple sources, the GDS-2.1 requires the following:

The variable in question should contain an attribute called **flag_meanings** and another one called **flag_values**. The **flag_values** attribute shall contain a comma-separated list of the numeric codes for the sources of data used whose order matches the comma-separated text strings in the **flag_meanings** attribute.

These text strings and numeric codes do not need to be unique across different data sets or even ancillary variables, but must be consistent within a given variable and clearly specified within each netCDF variable and its attributes. A best practice for naming the text strings in provided in Section 7.9.

The variable ‘**source_of_wind_speed**’ shall conform to the format requirements shown in Table 9-12.

Table 9-12 CDL example description of source_of_wind_speed **variable**

Storage type definition	Variable name definition	Description	Unit

byte	**source_of_wind_speed**	Sources of **wind_speed** values	none
Example CDL Description			
byte source_of_wind_speed (time, nj, ni) ; source_of_wind_speed:long_name = "sources of wind speed" ; source_of_wind_speed:coordinates = "lon lat" ; source_of_wind_speed:grid_mapping = "polar_stereographic" ; source_of_wind_speed:flag_meanings = "WSP-ESA-ASCAT-V2 WSP-NCEP-Analysis-V3 WSP-ECMWF-Forecast-V6" ; source_of_wind_speed:flag_values = 0b, 1b, 2b ; source_of_wind_speed:valid_range = 0b, 2b; source_of_wind_speed:coverage_content_type = "auxiliaryInformation" ; source_of_wind_speed:comment = "This variable provides a pixel by pixel description of where the wind speeds were derived from." source_of_wind_speed:_FillValue=-128b;			
Comments			
In this example, **flag_meanings** and **flag_values** contain strings and numeric codes provided by the data provider according to the best practices specified in Section 7.9.			

9.11 Variable sea_ice_fraction

Some SST data are contaminated in part or wholly by sea ice and the L2P variable **sea_ice_fraction** is used to quantify the fraction of an area contaminated with sea ice. Some input SST data streams provide a flag to indicate that the SST measurement is contaminated by sea ice (e.g., AMSR-E). The GDS-2.1 specifies the following rules:

If an input data set pixel fractional sea ice estimate exists, this should be used to in the L2P variable **sea_ice_fraction** as described Table 9-13.

Best practice suggests that one should approach the issue in the following way. If an input data set pixel sea ice flag does not exist, and the pixel is located in or close to a region that may be ice contaminated, a reference sea ice data set defined should be used to determine the value of the L2P confidence flag **sea_ice_fraction**.

If an input data set pixel sea ice ***flag*** exists (i.e. indicating sea ice but not the fractional amount of coverage), this should be used to set the L2P variable **sea_ice_fraction** to 1.

If the SST input data set includes a sea ice flag in the data stream, bit 3 of the L2P confidence data variable **l2p_flag** should be set for this pixel as described in Section 9.17.

The difference in time expressed in hours between the time of SST measurement and the time of sea ice fraction measurement should be entered into the L2P variable **sea_ice_fraction_dtime_from_sst** as described in Section 9.12. In the case of an analysis field, this should be the central (mean) time of an integrated value. . If all of the ice observations have a single time value, as in the case of an analysis or model that gives the sea ice values at an instant in time, then the **sea_ice_fraction_dtime_from_sst** variable is not needed and instead a variable level attribute named **time_offset** is used. The attribute **time_offset** should store the difference in hours between the **sea_ice_fraction** and the reference time, stored in the variable **time**.

If a single source of data is used in the L2P variable **sea_ice_fraction**, the L2P variable **source_of_sea_ice_fraction** is not required and instead the **sea_ice_fraction:source** attribute value is sufficient. It shall be a single source text string defined by the data provider using the text string naming best practice given in Section 7.9.

If multiple sources of data are used, source information should be indicated in the L2P variable **source_of_sea_ice_fraction** as defined by the data provider and as described in detail in Section 9.13, and the **sea_ice_fraction:source** attribute shall have the value **"source_of_sea_ice_fraction"**. In addition, the units of all sources used in the file shall be identical.

The variable attribute **sea_ice_fraction:sea_ice_treatment** shall specify how the sea ice information has been treated by the data provider. Valid options are: "Use unmodified (one source)", "use unmodified (multiple ice sources)", or "modified using onboard sensors"

The variable **sea_ice_fraction** will be included with the format requirements shown in Table 9-13.

Table 9-13 CDL example description of sea_ice_fraction **variable**

Storage type definition	Variable name definition	Description	Unit
byte	**sea_ice_fraction**	fractional of sea ice contamination in a given pixel. Ranges from 0 to 1.	Unit less
Example CDL Description			
byte sea_ice_fraction(time, nj, ni) ; sea_ice_fraction:long_name = "sea ice fraction" ; sea_ice_fraction:standard_name = "sea_ice_area_fraction" ; sea_ice_fraction:units = "1" ; sea_ice_fraction:_FillValue = -128b ; sea_ice_fraction:add_offset = 0.0f ; sea_ice_fraction:scale_factor = 0.01f ; sea_ice_fraction:valid_range = 0b, 100b ; sea_ice_fraction:coverage_content_type = "auxiliaryInformation" ; sea_ice_fraction:time_offset = 2. ; sea_ice_fraction:coordinates = "lon lat" ; sea_ice_fraction:grid_mapping = "polar_stereographic" ; sea_ice_fraction:source = "REMSS_AMSRE_V5" ; sea_ice_fraction:sea_ice_treatment = "Use unmodified (one source)" ; sea_ice_fraction:comment = "Fractional sea ice cover from Remote Sensing Systems V5 AMSRE ice product"			
Comments			
A single source of sea ice fraction data is shown in this example which is reported as **sea_ice_fraction:source = "REMSS_AMSRE_V5**" following the ancillary data naming conventions specified in Section 7.9. Since all of ice values have the same time, the attribute **time_offset** is used instead of the variable **sea_ice_fraction_dtime_from_sst**.			

9.12 Variable sea_ice_fraction_dtime_from_sst

The variable **sea_ice_fraction_dtime_from_sst** reports the time difference between sea ice fraction data from SST measurement in hours. The variable **sea_ice_fraction_dtime_from_sst** shall be included with the format requirements shown in Table 9-14. In the case of an analysis field, this should be the central (mean) time of an integrated value. If all of the values are the same, this variable is not required. Instead, use the variable level attribute named **time_offset** with the variable **sea_ice_fraction**. The attribute **time_offset** should store the difference in hours between the **sea_ice_fraction** and the reference time, stored in the variable **time**.

Table 9-14 CDL example description of sea_ice_fraction_dtime_from_sst **variable**

Storage type definition	Variable name definition	Description	Unit
byte	sea_ice_fraction_dtime_from_sst	This variable reports the time difference between sea ice fraction data from SST measurement in hours.	hour
Example CDL Description			
byte sea_ice_fraction_dtime_from_sst (time, nj, ni) ; sea_ice_fraction_dtime_from_sst :long_name = "time difference of sea ice fraction measurement from sst measurement" ; sea_ice_fraction_dtime_from_sst:units = "hour" ; sea_ice_fraction_dtime_from_sst:_FillValue = -128b ; sea_ice_fraction_dtime_from_sst:add_offset = 0.0f ; sea_ice_fraction_dtime_from_sst:scale_factor = 0.1f ; sea_ice_fraction_dtime_from_sst:valid_range = -127b, 127b ; sea_ice_fraction_dtime_from_sst:coverage_content_type = "auxiliaryInformation"; sea_ice_fraction_dtime_from_sst:coordinates = "lon lat" ; sea_ice_fraction_dtime_from_sst:grid_mapping = "polar_stereographic" ; sea_ice_fraction_dtime_from_sst:comment = "The hours between the sea ice measurement and the SST observation " ;			
Comment			
This variable is mandatory when multiple sources of sea_ice_fraction are used. If only one source is used, instead simply set a variable attribute **sea_ice_fraction:sea_ice_fraction_dtime_from_sst =** "difference time in hours".			

9.13 Variable source_of_sea_ice_fraction

The source of data used to set the L2P ancillary data variable **sea_ice_fraction** shall be indicated in the L2P variable **source_of_sea_ice_fraction** when more than one source of sea ice fraction data is used in the L2P product. When only one source is used, this variable is not needed and the appropriate text string indicating the source is placed in the **source** attribute of the **sea_ice_fraction** variable. For multiple sources, the GDS-2.1 requires the following:

The variable in question should contain an attribute called **flag_meanings** and another one called **flag_values**. The **flag_values** attribute shall contain a comma-separated list of the numeric codes for the sources of data used whose order matches the comma-separated text strings in the **flag_meanings** attribute.

These text strings and numeric codes do not need to be unique across different data sets or even ancillary variables, but must be consistent within a given variable and clearly specified within each netCDF variable and its attributes. A best practice for naming the text strings in provided in Section 7.9.

The variable '**source_of_sea_ice_fraction**' shall conform to the format requirements shown in Table 9-15.

Table 9-15 CDL example description of source_of_sea_ice_fraction **variable**

Storage type definition	Variable name	Description	Unit
byte	**source_of_sea_ice_fraction**	Source(s) of sea ice values	none
Example CDL Description			
byte source_of_sea_ice_fraction(time, nj, ni) ; **source_of_sea_ice_fraction:long_name = "sources of sea ice fraction";** **source_of_sea_ice_fraction:coordinates = "lon lat" ;** **source_of_sea_ice_fraction:grid_mapping = "polar_stereographic" ;** **source_of_sea_ice_fraction:flag_meanings = "ICE-NSIDC-AMSRE-V3 ICE-ECMWF-Forecast-V3" ;** **source_of_sea_ice_fraction:flag_values = 0b, 1b ;** **source_of_sea_ice_fraction:coverage_content_type = "auxiliaryInformation" ;** **source_of_sea_ice_fraction:comment = "This variable provides a pixel by pixel description of where sea ice fraction were derived from" ;** **source_of_sea_ice_fraction:_FillValue=-128b;**			
Comments			
In this example, **flag_meanings** and **flag_values** contain strings and numeric codes provided by the data provider according to the best practices specified in Section 7.9.			

9.14 Variable aerosol_dynamic_indicator

The L2P variable **aerosol_dynamic_indicator** contains an indicator of potential atmospheric aerosol contamination of infrared satellite SST data. Infrared-absorbing atmospheric aerosols are a major source of error in satellite-derived sea surface temperature retrievals. Atmospheric aerosol, such as Saharan dust outbreaks, volcanic eruptions or from coastal mega cities causes errors in the atmospheric correction of top of the atmosphere radiances when retrieving SST from infrared and visible band data sets. A systematic bias in the tropical North Atlantic Ocean and Arabian Sea due to desert dust outflows in those regions is apparent. The GDS requires the following:

An aerosol indicator (e.g., derived from satellite measurements or models) value is assigned to the L2P variable '**aerosol_dynamic_indicator**' for each corresponding infrared retrieved SST measurement pixel using data chosen by the data provider to indicate aerosol contamination. The aerosol indicator data nearest in space and time to the input pixel SST value should be used.

In the case of microwave SST measurements there is no requirement to include the **aerosol_dynamic_indicator** L2P variable as MW SST retrievals are not affected by atmospheric aerosols. However, MW SST data providers may include **aerosol_dynamic_indicator** in an L2P product.

If a single source of data is used in the L2P variable **aerosol_dynamic_indicator**, the L2P variable **source_of_adi** is not required and instead the **aerosol_dynamic_indicator:source** attribute value is sufficient. It shall be a single source text string defined by the data provider using the text string naming best practice given in Section 7.9. If all the times have the same value, then using an attribute **aerosol_dynamic_indicator:time_offset** is sufficient and the variable **adi_dtime_from_sst** is not required.

If multiple sources of ADI information are used then, the **aerosol_dynamic_indicator:source** attribute shall have the value **"source_of_adi"**. In addition, the units of all sources used in the file shall be identical.

The difference in time expressed in hours between the time of SST measurement and the time of aerosol indicator data should be entered into the L2P variable **adi_dtime_from_sst** as described in Section 9.15. In the case of an analysis field, this should be the central (mean) time of an integrated value.

If the variable '**aerosol_dynamic_indicator**' is provided in an L2P product, it shall be included with the format requirements shown in Table 9-16.

Table 9-16 CDL example description of aerosol_dynamic_indicator **variable**

Storage type definition	Variable name definition	Description	Unit
byte	**aerosol_dynamic_indicator**	Indicator of potential aerosol contamination of infrared satellite data	Provider defined

Example CDL description

```
byte aerosol_dynamic_indicator (time, nj, ni) ;
 aerosol_dynamic_indicator:long_name = "aerosol dynamic indicator" ;
 aerosol_dynamic_indicator:units = " " ;
 aerosol_dynamic_indicator:_FillValue = -128b ;
 aerosol_dynamic_indicator:add_offset = 0.0f ;
 aerosol_dynamic_indicator:scale_factor = 1.0f ;
 aerosol_dynamic_indicator:valid_range = -127b, 127b ;
 aerosol_dynamic_indicator:coverage_content_type = "auxiliaryInformation" ;

 aerosol_dynamic_indicator:time_offset = 2. ;
 aerosol_dynamic_indicator:coordinates = "lon lat" ;
 aerosol_dynamic_indicator:grid_mapping = "polar_stereographic" ;
 aerosol_dynamic_indicator:source = "NAVO_SDI_V2" ;
```

aerosol_dynamic_indicator: comment = "Estimate of the potential for aerosol contamination based on the NAVO SDI_V2 product. The units are in counts, but this is not a valid UDUNITS so the attribute units is set to a single space (" ").
Comment
A single source of **aerosol_dynamic_indicator** has been used in this example indicated using the **aerosol_dynamic_indicator:source** and are defined by the data provider using the ancillary data naming best practice given in Section 7.9. Since all of the values have the same time, the attribute **time_offset** is used instead of the variable **aerosol_sst_dtime_from_sst** to indicate the offset in hours from the reference variable **sst_dtime.**

9.15 Variable adi_dtime_from_sst

The variable **adi_dtime_from_sst** reports the time difference between aerosol indicator data from input L2 SST measurement in hours. The variable '**adi_dtime_from_sst**' shall be included in L2P products with the format requirements shown in Table 9-17. In the case of an analysis field, this should be the central (mean) time of an integrated value. If all of the values are the same, this variable is not required. Instead, use the variable level attribute named **time_offset** with the variable **aerosol_dynamic_indicator**.

Table 9-17 CDL example description of adi_dtime_from_sst **variable**

Storage type definition	Variable name definition	Description	Unit
byte	**adi_dtime_from_sst**	Time difference of aerosol dynamic indicator data from SST measurement in hours.	hour
Example CDL description			
byte adi_dtime_from_sst(time, nj, ni) ; adi_dtime_from_sst:long_name = "time difference of ADI data from sst measurement" ; adi_dtime_from_sst:units = "hour" ; adi_dtime_from_sst:_FillValue = -128b ; adi_dtime_from_sst:add_offset = 0.0f ; adi_dtime_from_sst:scale_factor = 0.1f ; adi_dtime_from_sst:valid_range = -127b, 127b ; adi_dtime_from_sst:coverage_content_type = "auxiliaryInformation" ; adi_dtime_from_sst:coordinates = "lon lat" ; adi_dtime_from_sst:grid_mapping = "polar_stereographic" ; adi_dtime_from_sst:comment = "Difference in hours between the ADI and SST data"			
Comments			

9.16 Variable source_of_adi

The source of data used to set the L2P ancillary data variable **aerosol_dynamic_indicator** shall be indicated in the L2P variable **source_of_adi** when more than one source of SSI data is used in the L2P product. When only one source is used, this variable is not needed and the appropriate text string indicating the source is placed in the **sources** attribute of the **aerosol_dynamic_indicator** variable. For multiple sources, the GDS-2.1 requires the following:

The variable in question should contain an attribute called **flag_meanings** and another one called **flag_values**. The **flag_values** attribute shall contain a comma-separated list of the numeric codes for the sources of data used whose order matches the comma-separated text strings in the **flag_meanings** attribute.

These text strings and numeric codes do not need to be unique across different data sets or even ancillary variables, but must be consistent within a given variable and clearly specified within each netCDF variable and its attributes. A best practice for naming the text strings in provided in Section 7.9.

The variable '**source_of_adi**' shall conform to the with the format requirements shown in Table 9-18.

Table 9-18 CDL example description of source_of_adi **variable**

Storage type definition	Variable name definition	Description	Unit
byte	**source_of_adi**	Sources of aerosol dynamic indicator values	none
Example CDL Description			
byte source_of_adi(time, nj, ni) ; source_of_adi:long_name = "sources of aerosol optical depth" ; source_of_adi:coordinates = "lon lat" ; source_of_adi:grid_mapping = "polar_stereographic" ; source_of_adi:flag_meanings = "no_data ADI-NAVO-SDI-V2" ; source_of_adi:flag_values = 0b, 1b ; source_of_adi:coverage_content_type = "auxiliaryInformation" ; source_of_adi:comment = "This variable provides a pixel by pixel description of where aerosol optical depth were derived from" ; source_of_adi:_FillValue=-128b;			
Comments			
In this example, **flag_meanings** and **flag_values** contain strings and numeric codes provided by the data provider according to the best practices specified in Section 7.9.			

9.17 Variable l2p_flags

The GDS-2.1 L2P variable **l2p_flags** is used to

- Specify the type of input SST data (either infrared or passive microwave instrument derived),
- Pass through native flags from the input L2 SST data set and
- Record any additional information considered important for the user of an L2P data set.

The variable **l2p_flags** is split into two sections:

- The first 6 bits of the L2P variable **l2p_flags** are generic flags that are common to all L2P data files as defined in Table 9-19,

- Bits 6-15 are defined by the L2P data provider and are specific to each L2 input data stream.

Table 9-19 Bit field definitions for the L2P variable l2p_flags

Bit	Common flags
0	Set if passive microwave data (not set is assumed to be infrared data)
1	Set if over land (not set is assumed to be ocean)
2	Set if pixel is over ice
3	Set if pixel is over a lake (if known)
4	Set if pixel is over a river (if known)
5	Reserved for future use
6-15	Defined by L2 data provider

The least significant bit (bit 0) starts on the right. The GDS-2.1 requires the following:

> The L2P variable **l2p_flags** holds Boolean (single bit) codes detailed in its **flag_meanings** and **flag_masks** attributes. It is also possible to extend these codes in an enumerated list by adding attribute **flag_values** but this increases complexity and is discouraged.
>
> The **flag_meanings**, **flag_masks**, and (optionally) **flag_values** attributes are used in the following manner:
>
>> The **flag_meanings** attribute shall contain a space-separated list of (string) descriptions for each distinct flag value. For descriptions containing multiple words, the words shall be linked by underscores.
>>
>> The **flag_masks** attribute shall contain a comma-separated list of (numeric) mask values that isolate the bit or bits that encode each flag value, whose order matches that of the **flag_meanings** values. It is recommended not to use the **_FillValue** attribute when **flag_masks** attribute is used as it is prone to misinterpretation of the bit mask.
>>
>> The **flag_values** in combination with **flag_masks** attribute shall contain a comma-separated list of masked numeric flag values, whose order matches that of the **flag_meanings** values. Not recommended (only **flag_masks** and **flag_meanings** are preferred).
>
> Bit 0 of the L2P **l2p_flags** is used to record if an input pixel SST is derived from an infrared satellite sensor or a passive microwave sensor. The GDS-2.1 specifies the following:

If an input pixel is derived from a passive microwave sensor, bit 0 of the L2P **l2p_flags** variable should be set to 1. By not setting this flag the pixel is assumed to be from an infrared sensor.

Bit 1 of the L2P **l2p_flags** variable is used to record if an input pixel is over land or ocean surfaces. The GDS specifies the following:

If an input pixel is classified as land covered bit 1 of the L2P **l2p_flags** variable should be set to equal 1. By not setting this flag the pixel is assumed to be classified as over ocean.

Bit 2 of the L2P **l2p_flags** variable is used to record if an input pixel records ice contamination. The GDS specifies the following rules:

If an input pixel is classified as ice contaminated bit 2 of the L2P **l2p_flags** variable should be set to 1..

Bit 3 of the L2P **l2p_flags** variable is used to record if an input pixel contains any part of a lake, as defined by the GHRSST definition of lakes (mask). The GDS specifies the following:

If an input pixel contains any part of a lake, as defined by the GHRSST definition of lakes (mask), bit 3 of the L2P **l2p_flags** variable should be set to 1.

Bit 4 of the L2P **l2p_flags** variable is optionally used to record if an input pixel contains any part of a river, as defined by the GHRSST definition of rivers (mask). The GDS specifies the following:

If an input pixel contains any part of a river, as defined by the GHRSST definition of rivers (mask), bit 4 of the L2P **l2p_flags** variable should be set to 1.

Flags or other information provided with the input L2 SST data should be defined and assigned to the l2p_flags variable using bits 6-15 of the L2P variable l2p_flags. It is recommended to use single bits for any information, no combination of multiple bits. If that is not possible, then an additional experimental byte field should be used instead. Definitions for bits 6-15, if used, should be given using the variable comment attribute.

The L2P variable '**l2p_flags** ' shall be included in GDS-2.1 L2P data files with the format requirements shown in Table 9-20.

Table 9-20 CDL example description of l2p_flags **variable**

Storage type definition	Variable name definition	Description	Unit

short	**l2p_flags**	The variable **l2p_flags** is used to (a) specify the type of input SST data (either infrared or passive microwave instrument derived), (b) pass through native flags from the input L2 SST data set and (c) record any additional information considered important for the user of an L2P data set.	Bit field
Example CDL Description			
short l2p_flags(time, nj, ni) ; **l2p_flags:long_name = "L2P flags" ;** **l2p_flags:coordinates = "lon lat" ;** **l2p_flags:grid_mapping = "polar_stereographic" ;** **l2p_flags:flag_meanings = "microwave land ice lake river reserved_for_future_use sun_glint SST_algorithm_A SST_algorithm_B SST_algorithm_C SST_algorithm_D";** **l2p_flags:flag_masks = 1s, 2s, 4s, 8s, 16s, 32s, 64s, 128s, 256s, 512s, 1024s ;** **l2p_flags:coverage_content_type = "auxiliaryInformation " ;** **l2p_flags:comment = "These flags are important to properly use the data"**			
Comments			
The meaning of each bit of the L2P variable **l2p_flags** shall be detailed in its **flag_meanings** and **flag_masks** attributes b0:1 = passive microwave source data; b1:1 = land surface; b2:1 = ice contamination; b3:1 = input data over lake surface; b4:1 = input data over river; b5: spare (not presently used); b6:b15 set by the data provider. In this example bit b6 flags sun glint and bits b7:b10 are used to enumerate an SST algorithm type For this variable there is no **_FillValue** attribute.			

9.18 Variable quality_level

The L2P variable '**quality_level** provides an indicator of the overall quality of an SST measurement in an L2P file. The GDS requires the following:

> The L2P variable '**quality_level**' shall use an incremental scale from 0 to 5 to provide the user with an indication of the quality of the L2P SST data. The value 0 shall be used to indicate missing data and the value 1 shall be used to indicate invalid data (e.g. cloud, rain, too close to land - under no conditions use this data). The remaining values from 2-5 are set at the discretion of the L2P provider with the proviso that the value 2 shall be used to indicate the worst quality of usable data and the value 5 shall be used to indicate the best quality usable data. The L2P provider is required to provide a description of the quality levels provided as part of the product documentation.

The L2P variable **quality_level** reflects the quality of SST data from a single sensor and does not provide an indication of the relative quality between sensors.

The L2P variable **quality_level** shall be included with the format requirements shown in Table 9-21.

Table 9-21 CDL example description of quality_level **variable**

Storage type definition	Variable name definition	Description	Unit
byte	**quality_level**	Overall indicator of SST measurement quality	none
Example CDL Description			
byte quality_level (time, nj, ni) ; quality_level:long_name = "quality level of SST pixel" ; quality_level:coordinates = "lon lat" ; quality_level:grid_mapping = "polar_stereographic" ; quality_level:_FillValue = -128b; quality_level:flag_meanings = "no_data bad_data worst_quality low_quality acceptable_quality best_quality" ; quality_level:flag_values = 0b, 1b, 2b, 3b, 4b, 5b ; quality_level:coverage_content_type = "qualityInformation" ; quality_level:comment = "These are the overall quality indicators and are used for all GHRSST SSTs"			
Comments			

9.19 Optional Variable satellite_zenith_angle

Sea surface temperature retrievals from satellite instruments degrade as the sensor zenith angle increases. Measurements made with high viewing angles relative to nadir appear to be considerably colder than they are in reality. The L2P variable **satellite_zenith_angle** contains the calculated satellite zenith angle (measured at the Earth's surface between the satellite and the zenith) for the input L2 SST based on the satellite geometry at the time of SST data acquisition.

The GDS L2P variable **satellite_zenith_angle** is an optional field that may be provided by a data provider. The following criteria shall apply:

The satellite zenith angle for each input pixel measurement should be recorded in the L2P variable **satellite_zenith_angle** having a range of 0° to +90°.

If the L2P variable **satellite_zenith_angle** is included in a L2P data product it shall conform to the format requirements shown in Table 9-22.

Table 9-22 CDL example description of satellite_zenith_angle **variable**

Storage type definition	Variable name definition	Description	Unit

Byte or short	**satellite_zenith_angle**	Calculated satellite zenith angle (measured at the Earth's surface between the satellite and the local zenith) for the input L2 SST based on the satellite geometry at the time of SST data acquisition. Ranges from 0 to 90 degrees.	degree
Example CDL Description			
byte satellite_zenith_angle(time, nj, ni) ; satellite_zenith_angle:long_name = "satellite zenith angle" ; satellite_zenith_angle:standard_name = "platform_zenith_angle" ; satellite_zenith_angle:units = "angular_degree" ; satellite_zenith_angle:_FillValue = -128b ; satellite_zenith_angle:add_offset = 0.0f ; satellite_zenith_angle:scale_factor = 1.0f ; satellite_zenith_angle:valid_range = 0b, 90b ; source_of_adi:coverage_content_type = "auxiliaryInformation" ; satellite_zenith_angle:coordinates = "lon lat" ; satellite_zenith_angle:grid_mapping = "polar_stereographic" ; satellite_zenith_angle:comment = “the satellite zenith angle at the time of the SST observations”			
Comments			

9.20 Optional Variable solar_zenith_angle

The L2P variable **solar_zenith_angle** contains the calculated solar zenith angle (the angle between the local zenith and the line of sight to the sun, measured at the Earth's surface) for the input L2 SST based on the satellite geometry at the time of SST data acquisition. Solar zenith angle is a function of time, day number and latitude.

The GDS L2P variable **solar_zenith_angle** is an optional field that may be provided by a data provider. The following criteria shall apply:

> The solar zenith angle for each input pixel measurement should be recorded in the L2P variable **solar_zenith_angle** having a range of 0° to 180°.
>
> If the L2P variable **solar_zenith_angle** is included in a L2P data product it shall conform to the format requirements shown in Table 9-23.

Table 9-23 CDL example description of solar_zenith_angle variable

Storage type definition	Variable name definition	Description	Unit
short	**solar_zenith_angle**	Calculated solar zenith angle (measured at the Earth's surface between the sun and the local zenith) for the input SST based on	degree

		the solar geometry at the time of SST data acquisition. Ranges from 0 to 180 degrees.	
Example CDL Description			
byte solar_zenith_angle(time, nj, ni) ; **solar_zenith_angle:long_name = "solar zenith angle" ;** **solar_zenith_angle:standard_name = "solar_zenith_angle" ;** **solar_zenith_angle:units = "angular_degree" ;** **solar_zenith_angle:_FillValue = -128b ;** **solar_zenith_angle:add_offset = 0.0f ;** **solar_zenith_angle:scale_factor = 1.0f ;** **solar_zenith_angle:valid_range = 0b, 180b ;** **solar_zenith_angle:coverage_content_type = "auxiliaryInformation" ;** **solar_zenith_angle:coordinates = "lon lat" ;** **solar_zenith_angle:grid_mapping = "polar_stereographic" ;** **solr_zenith_angle:comment "the solar zenith angle at the time of the SST observations"**			
Comments			

9.21 Optional Variable surface_solar_irradiance

Surface Solar Irradiance (SSI) data were originally required within the GDS 1.6 to assess the magnitude and variability of significant diurnal SST variations, for use in diurnal variability correction schemes, for use in L4 SST analysis procedures and to interpret the relationship between satellite and in situ SST data. In the GDS-2.1, it is an optional variable. Ideally a near contemporaneous SSI measurement from satellite sensors should be used but this is impossible for all areas due to the limited number of geostationary satellite sensors available. As a surrogate for a measured SSI value, analysis estimates may be used.

Surface solar Irradiance (SSI) data may be assigned to each L2P SST measurement pixel using the variable '**surface_solar_irradiance**'. The following criteria shall apply:

An integrated down-welling SSI measurement (e.g., derived from satellite measurements) should be assigned to each SST pixel value using the **surface_solar_irradiance** L2P variable. The SSI measurement nearest in space and time before the input pixel SST value should be used.

If no SSI measurement is available, an integrated SSI value derived from an analysis system nearest in space and time to the SST measurement should be used to set the value of **surface_solar_irradiance**.

The difference in time expressed in hours between the time of SST measurement and the time of surface solar irradiance data should be entered into the L2P confidence data variable **ssi_dtime_from_sst.** In the case of an analysis field, this should be the central (mean) time of an integrated value. If all of the values have the same time, the attribute **time_offset** is used instead of the variable **ssi_dtime_fraction_dtime_from_sst.** The attribute **time_offset** should store the difference in hours between the **surface_solar_irradiance** and the reference time, stored in the variable **time**.

If a single source of data is used in the L2P variable **surface_solar_irradiance**, the L2P variable **source_of_ssi** is not required and instead the **surface_solar_irradiance:source** attribute value is sufficient. It shall be a single source text string defined by the data provider using the text string naming best practice given in Section 7.9.

If multiple sources of data are used, source information should be indicated in the L2P variable **source_of_ssi** as defined by the data provider and as described in detail in Section 9.23. Then, the **surface_solar_irradiance:source** attribute shall have the value **"source_of_ssi"**.

The L2P variable '**surface_solar_irradiance**' may be included by a data provider with the format requirements shown in Table 9-24.

Table 9-24 CDL example description of surface_solar_irradiance **variable**

Storage type definition	Variable name definition	Description	Unit
byte	**surface_solar_irradiance**	Near contemporaneous integrated Surface Solar Irradiance (SSI) data.	Wm^{-2}
Example CDL Description			
byte surface_solar_irradiance(time, nj, ni) ; surface_solar_irradiance:long_name = "surface solar irradiance" ; surface_solar_irradiance:stardard_name = "solar irradiance" ; surface_solar_irradiance:units = "W m-2" ; surface_solar_irradiance:_FillValue = -128b ; surface_solar_irradiance:add_offset = 127.0f ; surface_solar_irradiance:scale_factor = -1.36f ; surface_solar_irradiance:valid_range = -127b, 127b ; surface_solar_irradiance:coverage_content_type = "auxiliaryInformation" ; surface_solar_irradiance:source = "SSI-MSG_SEVIRI-V1" ; surface_solar_irradiance:coordinates = "lon lat" ; surface_solar_irradiance:grid_mapping = "polar_stereographic" ; surface_solor_irradiance:comment = "The surface solar irradiance as close to the SST observation times as possible"			
Comments			
A single source of SSI data is shown in this example which is reported as **surface_solar_irradiance:source = "SSI-MSG_SEVIRI-V1"** The text string has been defined by the data provider using the text string naming best practice given in Section 7.9. Since all of the SSI values have the same time, the attribute **time_offset** is used instead of the variable **ssi_dtime_from_sst.**			

9.22 Optional Variable ssi_dtime_from_sst

The variable **ssi_dtime_from_sst** reports the time difference between SSI data from SST measurement in hours. The variable '**ssi_dtime_from_sst**' shall be included with the format requirements shown in Table 9-25. In the case of an analysis field, the central (mean) time of an integrated value should be used.

Table 9-25 CDL example description of ssi_dtime_from_sst **variable**

Storage type definition	Variable name definition	Description	Unit
byte	ssi_dtime_from_sst	This variable reports the time difference between SSI data from SST measurement in hours.	hour
Example CDL Description			
byte ssi_dtime_from_sst (time, nj, ni) ; ssi_dtime_from_sst:long_name = "time difference of surface solar irradiance measurement from sst measurement" ; ssi_dtime_from_sst:units = "hour" ; ssi_dtime_from_sst:_FillValue = -128b ; ssi_dtime_from_sst:add_offset = 0.0f ; ssi_dtime_from_sst:scale_factor = 0.1f ; ssi_dtime_from_sst:valid_range = -127b, 127b ; ssi_dtime_from_sst:coverage_content_type = "auxiliaryInformation" ; ssi_dtime_from_sst:coordinates = "lon lat" ; ssi_dtime_from_sst:grid_mapping = "polar_stereographic" ; ssi_dtime_from_sst:comment = "The hours between the SSI and SST data"			
Comment			

9.23 Optional Variable source_of_ssi

The source of data used to set the L2P ancillary data variable **surface_solar_irradiance** shall be indicated in the L2P variable **source_of_ssi** when more than one source of SSI data is used in the L2P product. When only one source is used, this variable is not needed and the appropriate text string indicating the source is placed in the **sources** attribute of the **surface_solar_irradiance** variable. For multiple sources, the GDS-2.1 requires the following:

The variable in question should contain an attribute called **flag_meanings** and another one called **flag_values**. The **flag_values** attribute shall contain a comma-separated list of the numeric codes for the sources of data used whose order matches the comma-separated text strings in the **flag_meanings** attribute.

These text strings and numeric codes do not need to be unique across different data sets or even ancillary variables, but must be consistent within a given variable and clearly specified within each netCDF variable and its attributes. A best practice for naming the text strings in provided in Section 7.9.

The variable '**source_of_ssi**' shall conform to the format requirements shown in Table 9-26.

Table 9-26 CDL example description of source_of_ssi **variable**

Storage type definition	Variable name	Description	Unit
byte	**source_of_ssi**	Sources of surface solar irradiance values	code

Example CDL Description
byte source_of_ssi(time, nj, ni) ; **source_of_ssi:long_name = "source_of_surface_solar_irradiance" ;** **source_of_ssi:coordinates = "lon lat" ;** **source_of_ssi:grid_mapping = "polar_stereographic" ;** **source_of_ssi:flag_meanings = "no_data SSI-MSG_SEVIRI-V1 SSI-NOAA-GOES_E-V1 SSI-NOAA-GOES_W-V1 SSI-ECMWF-V1 SSI-NCEP-V1 SSI-NAAPS-V1 spare" ;** **source_of_ssi:flag_values = 0b, 1b, 2b, 3b, 4b, 5b, 6b, 7b ;** **source_of_ssi:coverage_content_type = "auxiliaryInformation" ;** **source_of_ssi:comment = "**This variable provides a pixel by pixel description of where **surface solar irradiance** were derived from**"**
Comments
In this example, **flag_meanings** and **flag_values** contain code data provided by the data provider according to the best practices specified in Section 7.9. An example of these codes is given in Table 9-27.

Table 9-27 Example text string and numeric codes used to identify the sources of data in surface_solar_irradiance:sources and source_of_ssi

Numeric Code	Text String	Sources of surface solar irradiance Description
0	no_data	No surface solar irradiance set
1	SSI-MSG_SEVIRI-V1	SSI from Meteosat Second Generation SEVIRI instrument (EUMETSAT OSI-SAF)
2	SSI-NOAA-GOES_E-V1	GOES_E SSI data from NOAA
3	SSI-NOAA-GOES_W-V1	GOES_W SSI data from NOAA
4	SSI-ECMWF-V1	SSI data from European Centre for Medium Range Weather Forecasting
5	SSI-NCEP-V1	SSI data from NOAA's National Center for Environmental Prediction
6	SSI-NAVY-NAAPS-V1	SSI data from the US Navy Atmospheric aerosol Prediction system
7		Spare to be defined as required

9.24 Optional experimental L2P variables included by data provider

Flexibility of L2P product content is provided through the netCDF API, which allows fully self-describing fields and additional L2P variables may be included by L2P data providers if they are considered relevant for L2P users. The GDS-2.1 also permits the inclusion of R&D variables (e.g. channel radiance data sets, estimates of Chlorophyll A, fields that facilitate flagging of diurnal variability, etc.) and 32 bytes per pixel are available in total for optional/experimental variables in any combination (i.e., variables can be defined as 32 x byte, 16 x short, 3 x int + 4 x byte, etc). The use of optional/experimental variables provides a limited amount of flexibility within the GDS-2.1 for regional user requirements while maintaining an overall upper limit on

GDS-2.1 L2P products for data management groups and archive scaling. In exceptional cases a waiver on the 32 byte ceiling can be requested to extend up to 64 bytes per pixel.

The GDS-2.1 issues the following guidance on the inclusion of optional or experimental variables within L2P data products:

> The sum total of all experimental variables shall not increase L2P record size by more than 32 bytes per SST pixel. A waiver can be requested for higher amounts up to 64 bytes.
>
> CF-1.7 or later compliance should be maintained for all optional/experimental variables. Where available, a **standard_name** attribute should be used.
>
> It is permitted to use a provider defined coordinate variable associated with experimental fields but this shall be documented in data provider documentation.
>
> Time difference data (dtime values) should be provided for variables when appropriate.
>
> The source of data should be indicated: in the single source case as a variable attribute; as a dedicated variable when mixed data sources are present.
>
> Use of experimental variables requires clear documentation by the RDAC. Data providers shall provide adequate documentation that describes each variable following the CDL examples provided in this document.
>
> The variable attribute **comment** shall be used to provide a URL link to a full description of each data producer defined variable included in the L2P product.
>
> Experimental L2P variables if present in an L2P product will be included with the minimum format requirements shown in Table 9-28.
>
> Additional global variables may be declared within the L2P product.

Table 9-28 CDL template for data provider defined L2P variables

Storage type definition	Variable name definition	Description	Unit
Byte	Provide a variable name in lower case using underscore separators e.g. **my_variable**	Provide a description of **my_variable** stating content purpose and units.	Units of **my_variable**
Example CDL Description			
byte my_variable (time, nj, ni); my_variable:long_name = "estimated diurnal variability" ; my_variable:standard_name = "use_a_CF_standard_name_if_available" ;			

my_variable:units = "kelvin" ; my_variable:source = "MY-SOURCES-V1" ; my_variable:_FillValue = -128b ; my_variable:add_offset = 0.0f ; my_variable:scale_factor = 1.0f ; my_variable:valid_range = -127b, 127b ; my_variable:coordinates = "lon lat" ; my_variable:grid_mapping = "polar_stereographic" ; my_variable:coverage_content_type = "auxiliaryInformation" ; my_variable:comment = "This field is fully documented at http://www.mysite.com/my_variable-description.html"
Comments
A URL should be used to provide a live link to the documentation describing **my_variable**. CF-1.7 or later compliance should be maintained when using optional/experimental fields (particularly for the variable attribute **standard_name**.

9.25 CDL example L2P data set

The following CDL has been generated for a L2P dataset derived from the VIIRS sensor on NOAA-20 platform (https://doi.org/10.5067/GHV20-2PO28) . It includes a number of optional and experiemental variables.

```
netcdf l2p {
dimensions:
	ni = 3200 ;
	nj = 5376 ;
	time = 1 ;
variables:
	int time(time) ;
		time:comment = "seconds since 1981-01-01 00:00:00" ;
		time:long_name = "reference time of sst file" ;
		time:standard_name = "time" ;
		time:units = "seconds since 1981-01-01 00:00:00" ;
		time:calendar = "Gregorian" ;
		time:axis = "T" ;
		time:coverage_content_type = "coordinate" ;
	short sst_dtime(time, nj, ni) ;
		sst_dtime:add_offset = 0.f ;
		sst_dtime:comment = "time plus sst_dtime gives seconds since 1981-01-01 00:00:00 UTC" ;
		sst_dtime:coordinates = "lon lat" ;
		sst_dtime:long_name = "time difference from reference time" ;
		sst_dtime:scale_factor = 0.25f ;
		sst_dtime:units = "seconds" ;
		sst_dtime:valid_max = 32767s ;
		sst_dtime:valid_min = -32767s ;
		sst_dtime:_FillValue = -32768s ;
		sst_dtime:coverage_content_type = "referenceInformation" ;
	byte dt_analysis(time, nj, ni) ;
		dt_analysis:add_offset = 0.f ;
		dt_analysis:comment = "Deviation from reference SST, i.e., dt_analysis = SST - reference SST" ;
		dt_analysis:coordinates = "lon lat" ;
		dt_analysis:long_name = "deviation from SST reference" ;
		dt_analysis:source = "CMC0.1deg-CMC-L4-GLOB-v2.0" ;
		dt_analysis:scale_factor = 0.1f ;
```

```
		dt_analysis:units = "kelvin" ;
		dt_analysis:valid_max = 127b ;
		dt_analysis:valid_min = -127b ;
		dt_analysis:_FillValue = -128b ;
		dt_analysis:coverage_content_type = "qualityInformation" ;
	float lat(nj, ni) ;
		lat:comment = "Latitude of retrievals" ;
		lat:long_name = "latitude" ;
		lat:standard_name = "latitude" ;
		lat:units = "degrees_north" ;
		lat:valid_max = 90.f ;
		lat:valid_min = -90.f ;
		lat:coverage_content_type = "coordinate" ;
	float lon(nj, ni) ;
		lon:comment = "Longitude of retrievals" ;
		lon:long_name = "longitude" ;
		lon:standard_name = "longitude" ;
		lon:units = "degrees_east" ;
		lon:valid_max = 180.f ;
		lon:valid_min = -180.f ;
		lon:coverage_content_type = "coordinate" ;
	short satellite_zenith_angle(time, nj, ni) ;
		satellite_zenith_angle:add_offset = 0.f ;
		satellite_zenith_angle:comment = "satellite zenith angle" ;
		satellite_zenith_angle:coordinates = "lon lat" ;
		satellite_zenith_angle:long_name = "satellite zenith angle" ;
		satellite_zenith_angle:scale_factor = 0.01f ;
		satellite_zenith_angle:units = "degrees" ;
		satellite_zenith_angle:valid_max = 32767s ;
		satellite_zenith_angle:valid_min = -32767s ;
		satellite_zenith_angle:_FillValue = -32768s ;
		satellite_zenith_angle:coverage_content_type = "referenceInformation" ;
	short sea_surface_temperature(time, nj, ni) ;
		sea_surface_temperature:add_offset = 273.15f ;
		sea_surface_temperature:comment = "SST obtained by regression with buoy measurements,
sensitive to skin SST. Further information at (Petrenko et al., JGR, 2014; doi:10.1002/2013JD020637)" ;
		sea_surface_temperature:coordinates = "lon lat" ;
		sea_surface_temperature:long_name = "sea_surface_subskin_temperature" ;
		sea_surface_temperature:scale_factor = 0.01f ;
		sea_surface_temperature:source = "NOAA" ;
		sea_surface_temperature:units = "kelvin" ;
		sea_surface_temperature:valid_max = 32767s ;
		sea_surface_temperature:valid_min = -200s ;
		sea_surface_temperature:_FillValue = -32768s ;
		sea_surface_temperature:standard_name = "sea_surface_subskin_temperature" ;
		sea_surface_temperature:coverage_content_type = "physicalMeasurement" ;
	byte sses_bias(time, nj, ni) ;
		sses_bias:add_offset = 0.f ;
		sses_bias:comment = "Bias is derived against Piecewise Regression SST produced by local
regressions with buoys. Subtracting sses_bias from sea_surface_temperature producess more accurate SST
at the depth of buoys Further information at (Petrenko et al., JTECH, 2016; doi:10.1175/JTECH-D-15-0166.1)"
;
		sses_bias:coordinates = "lon lat" ;
		sses_bias:long_name = "SSES bias estimate" ;
		sses_bias:scale_factor = 0.016f ;
		sses_bias:units = "kelvin" ;
		sses_bias:valid_max = 127b ;
```

```
                sses_bias:valid_min = -127b ;
                sses_bias:_FillValue = -128b ;
                sses_bias:coverage_content_type = "qualityInformation" ;
        byte sses_standard_deviation(time, nj, ni) ;
                sses_standard_deviation:add_offset = 1.f ;
                sses_standard_deviation:comment = "Standard deviation of sea_surface_temperature from SST measured by drifting buoys. Further information at (Petrenko et al., JTECH, 2016; doi:10.1175/JTECH-D-15-0166.1)" ;
                sses_standard_deviation:coordinates = "lon lat" ;
                sses_standard_deviation:long_name = "SSES standard deviation" ;
                sses_standard_deviation:scale_factor = 0.01f ;
                sses_standard_deviation:units = "kelvin" ;
                sses_standard_deviation:valid_max = 127b ;
                sses_standard_deviation:valid_min = -127b ;
                sses_standard_deviation:_FillValue = -128b ;
                sses_standard_deviation:coverage_content_type = "qualityInformation" ;
        byte sea_ice_fraction(time, nj, ni) ;
                sea_ice_fraction:add_offset = 0.f ;
                sea_ice_fraction:comment = "Fractional sea ice cover from reference SST" ;
                sea_ice_fraction:coordinates = "lon lat" ;
                sea_ice_fraction:long_name = "sea ice fraction" ;
                sea_ice_fraction:scale_factor = 0.01f ;
                sea_ice_fraction:source = "CMC0.1deg-CMC-L4-GLOB-v2.0" ;
                sea_ice_fraction:standard_name = "sea_ice_area_fraction" ;
                sea_ice_fraction:units = "1" ;
                sea_ice_fraction:valid_max = 100b ;
                sea_ice_fraction:valid_min = 0b ;
                sea_ice_fraction:_FillValue = -128b ;
                sea_ice_fraction:coverage_content_type = "auxiliaryInformation" ;
        short l2p_flags(time, nj, ni) ;
                l2p_flags:comment = "L2P common flags in bits 1-6 and data provider flags (from ACSPO mask) in bits 9-16: bit01 (0=IR: 1=microwave); bit02 (0=ocean; 1=land); bit03 (0=no ice; 1=ice); bits04-08 (reserved,set to 0); bit09 (0=radiance valid; 1=invalid); bit10 (0=night; 1=day); bit11 (0=ocean; 1=land); bit12 (0=good quality data; 1=degraded quality data due to \"twilight\" region); bit13 (0=no glint; 1=glint); bit14 (0=no snow/ice; 1=snow/ice); bits15-16 (00=clear; 01=probably clear; 10=cloudy; 11=clear-sky mask undefined)" ;
                l2p_flags:coordinates = "lon lat" ;
                l2p_flags:flag_masks = 1s, 2s, 4s, 256s, 512s, 1024s, 2048s, 4096s, 8192s, -16384s ;
                l2p_flags:flag_meanings = "microwave land ice invalid day land twilight glint ice probably_clear_or_cloudy_or_undefined" ;
                l2p_flags:long_name = "L2P flags" ;
                l2p_flags:valid_max = 32767s ;
                l2p_flags:valid_min = -32768s ;
                l2p_flags:coverage_content_type = "thematicClassification" ;
        byte quality_level(time, nj, ni) ;
                quality_level:comment = "SST quality levels: 5 corresponds to clear-sky pixels and is recommended for operational applications and validation;" ;
                quality_level:coordinates = "lon lat" ;
                quality_level:flag_meanings = "missing invalid not_used not_used not_used clear" ;
                quality_level:flag_values = 0b, 1b, 2b, 3b, 4b, 5b ;
                quality_level:long_name = "quality level of SST pixel" ;
                quality_level:valid_max = 5b ;
                quality_level:valid_min = 0b ;
                quality_level:_FillValue = -128b ;
                quality_level:coverage_content_type = "qualityInformation" ;
        byte wind_speed(time, nj, ni) ;
                wind_speed:add_offset = 25.4f ;
```

```
                wind_speed:comment = "Typically represents surface winds (10 meters above the sea surface)" ;
                wind_speed:coordinates = "lon lat" ;
                wind_speed:height = "10 m" ;
                wind_speed:long_name = "wind speed" ;
                wind_speed:scale_factor = 0.2f ;
                wind_speed:standard_name = "wind_speed" ;
                wind_speed:units = "m s-1" ;
                wind_speed:valid_max = 127b ;
                wind_speed:valid_min = -127b ;
                wind_speed:_FillValue = -128b ;
                wind_speed:source = "Wind speed from MERRA-2 data" ;
                wind_speed:coverage_content_type = "auxiliaryInformation" ;
        short sst_gradient_magnitude(time, nj, ni) ;
                sst_gradient_magnitude:_FillValue = -32768s ;
                sst_gradient_magnitude:valid_min = -32767s ;
                sst_gradient_magnitude:valid_max = 32767s ;
                sst_gradient_magnitude:long_name = "SST gradient magnitude value" ;
                sst_gradient_magnitude:comment = "Gradient magnitude calculated from SST field in all grids with valid SST" ;
                sst_gradient_magnitude:coordinates = "lon lat" ;
                sst_gradient_magnitude:scale_factor = 0.001f ;
                sst_gradient_magnitude:add_offset = 0.f ;
                sst_gradient_magnitude:units = "kelvin/km" ;
                sst_gradient_magnitude:coverage_content_type = "physicalMeasurement" ;
        byte sst_front_position(time, nj, ni) ;
                sst_front_position:_FillValue = -128b ;
                sst_front_position:comment = "Binary indicator of SST front position in the valid SST clear-sky domain: 1 - SST front present, 0 - no front present" ;
                sst_front_position:coordinates = "lon lat" ;
                sst_front_position:long_name = "Binary SST front position indicator" ;
                sst_front_position:valid_min = 0b ;
                sst_front_position:valid_max = 1b ;
                sst_front_position:coverage_content_type = "image" ;

// global attributes:
                :geospatial_bounds = "POLYGON(( 64.981 51.577,  68.015 17.025,  40.270 12.847,  24.261 45.479,  64.981 51.577))" ;
                :geospatial_first_scanline_first_fov_lat = 17.02484f ;
                :geospatial_first_scanline_first_fov_lon = 68.01483f ;
                :geospatial_first_scanline_last_fov_lat = 12.8468f ;
                :geospatial_first_scanline_last_fov_lon = 40.2699f ;
                :geospatial_last_scanline_first_fov_lat = 51.57727f ;
                :geospatial_last_scanline_first_fov_lon = 64.98145f ;
                :geospatial_last_scanline_last_fov_lat = 45.47906f ;
                :geospatial_last_scanline_last_fov_lon = 24.26056f ;
                :acknowledgement = "Please acknowledge the use of these data with the following statement: These data were provided by Group for High Resolution Sea Surface Temperature (GHRSST) and the National Oceanic and Atmospheric Administration (NOAA)." ;
                :cdm_data_type = "swath" ;
                :comment = "none" ;
                :creator_email = "Alex.Ignatov@noaa.gov" ;
                :creator_name = "Alex Ignatov" ;
                :creator_url = "http://www.star.nesdis.noaa.gov" ;
                :date_created = "20220722T042120Z" ;
                :destripe = "yes (M5:1.0:f M7:1.0:f M10:1.0:f M12:1.0:b M13:1.0:b M14:1.0:b M15:1.0:b M16:1.0:b)" ;
```

```
		:easternmost_longitude = 68.01483f ;
		:file_quality_level = 3s ;
		:gds_version_id = "02.0" ;
		:geospatial_lat_resolution = 0.0067f ;
		:geospatial_lat_units = "degrees_north" ;
		:geospatial_lon_resolution = 0.0067f ;
		:geospatial_lon_units = "degrees_east" ;
		:history = "Created by Advanced Clear-Sky Processor for Oceans (ACSPO)-VIIRS at
NOAA/NESDIS/STAR." ;
		:id = "VIIRS_N20-STAR-L2P-v2.8" ;
		:institution = "NOAA/NESDIS/STAR" ;
		:keywords = "Oceans > Ocean Temperature > Sea Surface Temperature" ;
		:keywords_vocabulary = "NASA Global Change Master Directory (GCMD) Science Keywords" ;
		:license = "GHRSST protocol describes data use as free and open" ;
		:metadata_link =
"http://podaac.jpl.nasa.gov/ws/metadata/dataset/?format=iso&shortName=VIIRS_N20-STAR-L2P-v2.8" ;
		:naming_authority = "org.ghrsst" ;
		:northernmost_latitude = 51.65356f ;
		:platform = "N20" ;
		:processing_level = "L2P" ;
		:product_version = "2.80" ;
		:project = "Group for High Resolution Sea Surface Temperature" ;
		:publisher_email = "ghrsst-po@nceo.ac.uk" ;
		:publisher_name = "The GHRSST Project Office" ;
		:publisher_url = "http://www.ghrsst.org" ;
		:references = "Data convention: GHRSST Data Specification (GDS) v2.0. Algorithms: ACSPO-
VIIRS ATBD (NOAA/NESDIS/STAR)" ;
		:sensor = "VIIRS" ;
		:aggregator_version = "V1.00" ;
		:preprocessor_version = "1.15.0" ;
		:sst_luts = "LUT_VIIRS_N20_L2P_DEPTH_DAY_V01.05_20201216.txt," ;
		:source = "VIIRS-MOD-GEO-TC,VIIRS-M5-SDR,VIIRS-M7-SDR,VIIRS-M10-SDR,VIIRS-M12-
SDR,VIIRS-M15-SDR,VIIRS-M16-SDR,CMC0.1deg-CMC-L4-GLOB-v2.0,NOAA-NCEP-GFS" ;
		:southernmost_latitude = 12.8468f ;
		:spatial_resolution = "742 m at nadir" ;
		:standard_name_vocabulary = "CF Standard Name Table (v26, 08 November 2013)" ;
		:stop_time = "20220609T095000Z" ;
		:summary = "Sea surface temperature retrievals produced by NOAA/NESDIS/STAR office from
VIIRS sensor" ;
		:time_coverage_end = "20220609T095000Z" ;
		:title = "VIIRS L2P SST" ;
		:uuid = "bcc370d8-0975-11ed-82c2-b8ca3a636470" ;
		:westernmost_longitude = 24.26056f ;
		:netcdf_version_id = "4.7.4 of Nov 18 2021 15:43:53 $" ;
		:start_time = "20220609T094000Z" ;
		:time_coverage_start = "20220609T094000Z" ;
		:Conventions = "Conventions = CF-1.7, ACDD-1.3" ;
}
}
```

10 Level 3 (L3) Product Specification

10.1 Overview description of the L3 data product

GHRSST L3 data have been introduced to provide users with gridded, synthetic, and potentially adjusted SST products, bringing added value with respect to the original L2P but still allowing traceability to the original dataset. GHRSST L3 products do not use analysis or interpolation procedure to fill gaps where no observations are available. The GHRSST L3 products include:

- **Un-collated** data that represent a straightforward remapping of L2P GHRSST data granules to a space grid without combining any observations from overlapping orbits or times. Although in principle these data may or may not be adjusted to a reference sensor, in practice the un-collated L3 will normally be a remapped L2P dataset. For remapping best practices, see Section 10.31.
- **Collated** data that grid observations from a single instrument and a single platform into space and/or time bins. These data may or may not be adjusted to a reference sensor. For collating best practices see Section 10.32, and for adjustment best practices see Section 10.33.
- **Super-collated** data that combine observations from a multiple instruments into a space-time grid. In this case, the adjustment to a common reference is necessary to avoid heterogeneities in the resulting field. For best practices concerning the creation of super collated files see Section 10.34.

As a result, the format of a L3 file will be able to cope with the three kinds of L3 SST presented above. The L3 format will include the following parts:

1) **In case the L3 is un-adjusted, a mandatory section containing the original L2P information** remapped onto the grid point: the original sea surface temperature, quality level and SSES information. An optional section including the remapping condition information may also be provided. These files are essentially gridded L2P files.
2) **In case the L3 is adjusted to a reference**, the adjusted SST value must be provided, together with the local bias to the reference, the error generated by the adjustment processing, and the overall error resulting from the combination of the SSES and the adjustment processing error.
3) **In case the L3 is super-collated**, the source of SST at each pixel is mandatory.

Un-adjusted files: In the case of **un-collated or collated un-adjusted L3 files** the L3 file is derived from L2P data by a remapping process. The remapping and collating best practices are given in the Section 10.31. Their content is thus identical to that of the L2P, but complementary, optional information on the remapping conditions may be provided.

Adjusted files: Collated files may or may not be adjusted, but a super-collated file is necessarily adjusted. The super-collating and adjustment best practices are described in Sections 10.32 and 10.33. The principle governing this format is to allow traceability to the original L2P, while providing the best-adjusted SST value. A first section (in blue in Table 10-)

reproduces the original L2P SST and SSES information as in the un-adjusted version. The reference used to adjust the SST must be given in the “reference” attribute of the **adjusted_sea_surface_temperature** variable. The adjusted SST and some error information are also mandatory. This information (in yellow in Table 10-) is:

- **adjusted_standard_deviation_error**: the total error resulting from the combination of the SSES error and the adjustment procedure error, **standard_deviation_to_reference_sst**.
- **bias_to_reference_sst**: the local value of the estimated difference between the original SST and the reference SST
- **standard_deviation_to_reference_sst**: an estimate of the error resulting from the adjustment procedure. If the procedure consists of analysing a field of differences of original SST and reference SST, the **standard_deviation_to_reference_sst** will be the error of this analysis.

The GHRSST Science Team determined that 5 mandatory fields will form the core data content of a GHRSST L3 data file. In addition to global attributes and geo-location information, RDACs must produce the following within a L3 file:

- Sea Surface temperature data (SST),
- Time of SST measurement,
- Bias and Standard Deviation error estimates for SST data,
- Data quality.

There are a number of optional fields that may be used at the data provider’s discretion that will form the core data content of a GHRSST data file (table 10-1)".

For every L3 file that is generated, appropriate ISO metadata (specified in Section 12.1) must also be created and registered at the GHRSST Master Metadata Repository (MMR) system. The GHRSST L3 file contents are summarized in Table 10-1 below.

Table 10-1 Summary description of the contents within a GHRSST L3 data product

Description	Required	Relevant Section
Dimensions (e.g., i *x* j *x* k)	Mandatory	Section 8
Global attributes	Mandatory	Section 8.2
[i *x* j *x* k] geolocation data	Mandatory	Section 8.4
[i *x* j *x* k] array of SST data	Mandatory	Section 9.3
[i *x* j *x* k] array of **sst_dtime** data	Mandatory	Section 9.4
[i *x* j *x* k] array of **sses_bias** data	Mandatory	Section 9.5
[i *x* j *x* k] array of **sses_standard_deviation** data	Mandatory	Section 9.6
[i *x* j *x* k] array of **quality_level** data	Mandatory	Section 9.18
[i *x* j *x* k] array of optional/experimental data	Optional	Section 9.24

10.2 L3 data record format specification

This table provides an overview of the GHRSST L3 product pixel data record that should be created for each input data. Within GHRSST L3 data files, there are many variables that are defined identically to their L2P counterparts. In addition, there are several variables that are unique to L3. Both types are listed below in Table 10-. In the following sections, each variable within the L3 data file that is unique to L3 is described in detail.

Table 10-2 L3 SST data record content.

Variable Name (Definition Section, CDL Example)	Description	Units type
sea_surface_temperature (Section 9.3, Table 9-3)	SST measurement values from input L2 satellite data set. L2 SST data are not adjusted in any manner and are identical to the input data set. Use attribute '**sea_surface_temperature:source =** "< code from Section 7.9, **Error! Reference source not found.**>" to specify the L2 input product source.	kelvin int
sst_dtime (Section 10.4, Table 9-5)	Deviation in time of SST measurement from reference time stored in the netCDF global variable **time** (defined as the start time of granule for L3U and the centre time of the collation window for L3C and L3S). Minimum resolution should be one second.	seconds long
sses_bias (Section 9.5, Data producers are reminded to choose appropriate scale_factors and add_offsets for their data, and to strive for scale_factors as close to 0.01 as possible without "oversaturating" the values. Table 9-6)	Sensor Specific Error Statistic (SSES) bias error estimate generated by data provider The specific SSES methodology should be described in L2P documentation from the data provider. The GHRSST ST-VAL TAG will maintain a summary document of all SSES schemes at http://www.ghrsst.org/STVAL-TAG-SSES-Schemes.html	kelvin byte
sses_standard_deviation (Section 9.6, Table 9-7)	SSES standard deviation uncertainty generated by data provider. The specific SSES methodology should be described in L2P documentation from the data provider. The GHRSST ST-VAL TAG will maintain a summary document of all SSES schemes at http://www.ghrsst.org/STVAL-TAG-SSES-Schemes.html	kelvin byte

dt_analysis (Section 9.7, Table 9-9)	The difference between input SST and a GHRSST L4 SST analysis from the previous 24 hour period. The GHRSST L4 analysis chosen for a given L2P data set variable should be consistent for all L2P products as far as practically possible. If no L4 analysis is available then an alternative L4 analysis or a reference mean SST climatology may be used. If storage as *byte* does not allow the provider to offer the full precision required for this field, storage as a *short* is optionally permitted though *byte* is preferred.	kelvin byte (or short)
wind_speed (Section 9.8, Table 9-10)	10 m surface wind speed near contemporaneous to the input SST measurement from satellite or analysis. Wind speed data should be provided at a minimum resolution of 1 ms^{-1} and data producers shall use **scale_factor** and **add_offset** to scale data to an appropriate resolution (higher resolution is better). The difference in time between SST measurement and **wind_speed** data shall be recorded in the L2P variable **wind_speed_dtime_from_sst** If multiple sources of wind speed data are used, the variable **source_of_wind_speed** shall be used to indicate their source following the format requirements shown Section 7.9. Units of multiple sources of information shall be identical. If a unique source is used (this is recommended) the attribute **'wind_speed:source =** "< string defined following best practice in Section 7.9>" is considered sufficient.	ms^{-1} byte
wind_speed_dtime_from_sst (Section 9.9, Table 9-11)	Time difference of **wind_speed** data from input L2 SST measurement specified in hours. Units of multiple sources of information shall be identical.	Hours byte
source_of_wind_speed	When multiple sources of wind speed data are used in the variable **wind_speed**, the variable	Code byte

(Section 9.10, Table 9-12)	**source_of_wind_speed** shall be used to record the source of the wind speed data used. Units of multiple sources of information shall be identical. If a unique source of wind speed data is used (this is recommended) the variable attribute **'wind_speed:source =** "<string defined following best practice defined in Section 7.9>" shall be sufficient and the variable **source_of_wind_speed** Is not required.	
sea_ice_fraction (Section 9.11, Table 9-13)	Fractional Sea Ice contamination data. Ranges from 0 to 1. This field is only required if there is actually sea ice in the input L2 data set. Do not provide an array of missing data values. When multiple sources of sea ice fraction data are used in the variable **sea_ice_fraction**, the variable **source_of_sea_ice_fraction** shall be used to record the source of the sea ice fraction data used and the difference in time between SST measurement and **sea_ice_fraction** data shall be recorded in the variable **sea_ice_fraction_dtime_from_sst.** Units of multiple sources of information shall be identical. If a unique source of sea ice fraction data is used (this is recommended), the variable attribute **'sea_ice_fraction:source =** "< string defined following best practice defined in Section 7.9>" and an attribute **sea_ice_fraction:time_offset =** "difference time in hours" are considered sufficient and the variables **source_of_sea_ice_fraction** and **sea_ice_fraction_dtime_from_sst** are not required.	Percent byte
sea_ice_fraction_dtime_from_sst (Section 9.12, Table 9-14)	Time difference of **sea_ice_fraction** data from input L2 SST measurement specified in hours. This variable is mandatory when multiple sources of sea_ice_fraction are used. If only one source is used and the values all have one time, simply set a variable attribute **sea_ice_fraction:time_offset =** "difference time in hours".	Hours byte
source_of_sea_ice_fraction (Section 9.13, Table 9-15)	When multiple sources of sea ice fraction data are used in the variable **sea_ice_fraction**, the variable **source_of_sea_ice_fraction** shall be used to record the source of the sea ice fraction data used. Units of multiple sources of information shall be identical.	Code byte

	If a unique source of sea ice fraction data is used (this is recommended), the variable attribute **'sea_ice_fraction:source =** "< string defined following best practice defined in Section 7.9>" is sufficient and the variable **source_of_sea_ice_fraction** Is not needed.	
aerosol_dynamic_indicator (Section 9.14, Table 9-16)	The variable **aerosol_dynamic_indicator** (ADI) is used to indicate the presence of atmospheric aerosols that may cause errors in the atmospheric correction of infrared satellite data when retrieving SST. The variable **aerosol_dynamic_indicator** is mandatory only when the input SST data set has been derived from an infrared satellite instrument. The atmospheric aerosol data used to fill the variable **aerosol_dynamic_indicator** is chosen by the data provider as the most appropriate aerosol indicator for a given input SST data set. (e.g., SDI might be used for MSG SEVIRI, a view difference might be used for AATSR, and aerosol optical depth may be used from a model or another satellite system). When multiple sources of atmospheric aerosol indicator data are used in the variable **aerosol_dynamic_indicator** , the variable **source_of_sea_aerosol_dynamic_indicator** shall be used to record the source of the aerosol indicator data used. Units of multiple sources of information shall be identical. If a unique source of atmospheric aerosol indicator data is used (this is recommended), the variable attribute **'aerosol_dynamic_indicator:source =** "< string defined following best practice defined in Section 7.9>" is sufficient and the variable **source_of_aerosol_dynamic_indicator** Is not required. If only one source is used and the values all have one time, simply set a variable attribute **sea_ice_fraction:time_offset =** “difference time in hours”.	Scaled value byte
adi_dtime_from_sst		Hours byte

<table>
<tr>
<td>(Section 9.15, Table 9-17)</td>
<td>The time difference between the aerosol_dynamic_indicator value and SST measurement recorded in hours.</td>
<td></td>
</tr>
<tr>
<td>source_of_adi

(Section 9.16, Table 9-18)</td>
<td>When multiple sources of atmospheric aerosol indicator data are used in the variable aerosol_dynamic_indicator , the variable source_of_sea_aerosol_dynamic_indicator shall be used to record the source of the aerosol indicator data used.

If a unique source of atmospheric aerosol indicator data is used (this is recommended), the variable attribute 'aerosol_dynamic_indicator:source = "<string defined following best practice defined in Section 7.9>" is sufficient and the variable source_of_aerosol_dynamic_indicator Is not required.</td>
<td>Code byte</td>
</tr>
<tr>
<td>l2p_flags

(Section 9.17, Table 9-20)</td>
<td>The variable l2p_flags is used to (a) specify the type of input SST data (either infrared or passive microwave instrument derived), (b) pass through native flags from the input L2 SST data set and (c) record any additional information considered important for the user of an L3 data set.

The variable l2p_flags is split into two sections: the first 6 bits of the L2P variable l2p_flags are generic flags that are common to all L3 data files; bits 6-15 are defined by the L3 data provider and are specific to each L3 input data stream.

The tables below define the bit field and their meanings.

<table>
<tr><th>Bit</th><th>Common flags</th></tr>
<tr><td>0</td><td>Passive microwave data</td></tr>
<tr><td>1</td><td>Land</td></tr>
<tr><td>2</td><td>Ice</td></tr>
<tr><td>3</td><td>Lake (if known)</td></tr>
<tr><td>4</td><td>River (if known)</td></tr>
<tr><td>5</td><td>Spare</td></tr>
</table>

<table>
<tr><th>Bit</th><th>l2p_flags definition</th></tr>
<tr><td>6-15</td><td>Defined by L2 data provider and described in the flag_meanings,</td></tr>
</table>
</td>
<td>Flags int</td>
</tr>
</table>

	and **flag_masks** variable attributes. Please refer to L2P data provider documentation	
quality_level (Section 9.18, Table 9-21)	The variable **quality_level** is used to provide an overall indication of L3 data quality. Variable **quality_level** will reflect CEOS QA4EO (Quality Indicator) guidelines. An incremental scale from 0 no data, 1 (bad e.g. cloud, rain, to close to land – under no conditions use this data) 2 (worst quality usable data), to 5 (best quality usable data) shall be used.	Code byte
or_latitude (Section 10.20, Table 10-3)	Original latitude of the satellite measurement as provided in the L2P	Degree short
or_longitude (Section 10.21, Table 10-4)	Original longitude of the satellite measurement as provided in the L2P	Degree short
or_number_of_pixels (Section 10.22, Table 10-5)	Number of original pixels from the L2P contributing to the binned (space and/or time) average	Number short
sum_sst (Section 10.23, Table 10-6)	Sum of the pixel values going into the space and/or time bin	kelvin float
sum_square_sst (Section 10.24, Table 10-7)	Sum of the pixel value squares going into the space and/or time bin	$kelvin^2$ float
adjusted_sea_surface_temperature (Section 10.25, Table 10-8)	SST adjusted to the reference Mandatory for adjusted type file	kelvin short
adjusted_standard_deviation_error (Section 10.26, Table 10-9)	Total error standard deviation estimate derived from SSES and adjustment method Mandatory for adjusted type file	kelvin byte
bias_to_reference_sst (Section 10.27, Table 10-10)	Bias error derived from comparison with the reference Mandatory for adjusted type file	kelvin short
standard_deviation_to_reference_sst	Error standard deviation resulting from the bias estimation method Mandatory for adjusted type file	kelvin byte

(Section 10.28, Table 10-11)		
source_of_sst (Section 10.29, Table 10-12)	Source of SST data Mandatory for a super-collated type file	Code byte
Optional/experimental fields defined by data provider (Section 9.24, Table 9-28)	Optional/experimental data	Defined by RDAC

10.3 Variable sea_surface_temperature

Defined identically to L2P variable of the same name. See Section 9.3 for more details.

10.4 Variable sst_dtime

Defined identically to L2P variable of the same name except the storage type is long instead of short. See Section 9.4.

10.5 Variable sses_bias

Defined identically to L2P variable of the same name. See Section 9.5.

10.6 Variable sses_standard_deviation

Defined identically to L2P variable of the same name. See Section 9.6.

10.7 Variable dt_analysis

Defined identically to L2P variable of the same name. See Section 9.7.

10.8 Variable wind_speed

Defined identically to L2P variable of the same name. See Section 9.8.

10.9 Variable wind_speed_dtime_from_sst

Defined identically to L2P variable of the same name. See Section 9.9.

10.10 Variable source_of_wind_speed

Defined identically to L2P variable of the same name. See Section 9.10.

10.11 Variable sea_ice_fraction

Defined identically to L2P variable of the same name. See Section 9.11.

10.12 Variable sea_ice_fraction_dtime_from_sst

Defined identically to L2P variable of the same name. See Section 9.12.

10.13 Variable source_of_sea_ice_fraction

Defined identically to L2P variable of the same name. See Section 9.13.

10.14 Variable aerosol_dynamic_indicator

Defined identically to L2P variable of the same name. See Section 9.14.

10.15 Variable adi_dtime_from_sst

Defined identically to L2P variable of the same name. See Section 9.15.

10.16 Variable source_of_adi

Defined identically to L2P variable of the same name. See Section 9.16.

10.17 Variable l2p_flags

Defined identically to L2P variable of the same name. See Section 9.17.

10.18 Variable quality_level

Defined identically to L2P variable of the same name. See Section 9.18.

10.19 Optional or experimental L3 variables included by data provider

Defined similarly to experimental L2P variables. See Section 9.24.

10.20 Variable or_latitude

The variable '**or_latitude**' will be included either:

- As a floating point variable similarly to the grid latitude and longitude
- As a short variable with the format requirements shown in Table 10-3, if the required precision is compatible.

This variable is the original latitude of the contributing pixel in case of remapping to the nearest pixel, or the average latitude of the contributing pixels in case of averaging.

Table 10-3 CDL example description of or_latitude variable

Storage type	Name	Description	Unit
short	**or_latitude**	Original latitude of the satellite measurement	degree
CDL description			
short or_latitude(time, lat, lon) ; or_latitude:long_name = "original latitude of the SST value" ; or_latitude:standard_name = "latitude" ; or_latitude:units = "degrees_north" ; or_latitude:_FillValue = -32768s ; or_latitude:valid_range = -9000s, 9000s ; or_latitude:add_offset = 0.0f ; or_latitude:scale_factor = 0.01f ; or_latitude:comment = "Original latitude of the SST value" ;			
Comments			

10.21 Variable or_longitude

The variable '**or_longitude**' shall be included either

- As a floating point variable similarly to the grid latitude and longitude
- As a short variable with the format requirements shown in Table 10-4, if the required precision is compatible.

This variable is the original longitude of the contributing pixel in case of remapping to the nearest pixel, or the average longitude of the contributing pixels in case of averaging.

Table 10-4 CDL example description of or_longitude variable

Storage type	Name	Description	Unit
short	**or_longitude**	Original longitude of the satellite measurement	degree
CDL description			
short or_longitude(time, lat, lon) ; or_longitude:long_name = "original longitude of the SST value" ; or_longitude:standard_name = "longitude" ; or_longitude:units = "degrees_east" ; or_longitude:_FillValue = -32768s ; or_longitude:valid_range = -18000s, 18000s ; or_longitude:add_offset = 0.0f ; or_longitude:scale_factor = 0.01f ; or_longitude:comment = "Original longitude of the SST value" ;			
Comments			

10.22 Variable or_number_of_pixels

The variable '**or_number_of_pixels** ' shall be included with the format requirements shown in Table 10-5.

Table 10-5 CDL example description of or_number_of_pixels variable

Storage type	Name	Description	Unit
short	**or_number_of_pixels**	Number of pixels from the L2P contributing to the SST value	none
CDL description			
short or_number_of_pixels(time, lat, lon) ; or_number_of_pixels:long_name = "number of pixels from the L2Ps contributing to the SST value" ; or_number_of_pixels:units = "1" ; or_number_of_pixels:_FillValue = -32768s; or_number_of_pixels:valid_range = 0, 32767s ; ; or_number_of_pixels:comment = "Original number of pixels from the L2Ps contributing to the SST value" ;			

Comments
This variable records the number of original L2P pixels contributing to the SST in case of averaging during the L3 fabrication.

10.23 Variable sum_sst

The variable '**sum_sst**' shall be included with the format requirements shown in Table 10-6.

Table 10-6 CDL example description of sum_sst variable

Storage type	Name	Description	Unit
float	**sum_sst**	Sum of the pixel values going into the space and/or time bin	kelvin
CDL description			
float sum_sst(time, lat, lon) ; **sum_sst:long_name = "sum of contributing pixel sst values" ;** **sum_sst:_FillValue = -99999f ;** **sum_sst:units = "kelvin" ;** **sum_sst:valid_range = -200.0f, 200.0f;** **sum_sst:comment = "Sum of orginal contributing pixel sst values" ;**			
Comments			
This variable records the sum of the original SST values in case of averaging during the L3 fabrication.			

10.24 Variable sum_square_sst

The variable '**sum_square_sst**' shall be included with the format requirements shown in Table 10-7.

Table 10-7 CDL example description of sum_square_sst variable

Storage type	Name	Description	Unit
float	**sum_square_sst**	Sum of the pixel value squares going into the space and/or time bin	kelvin**2
CDL description			
float sum_square_sst(time, lat, lon) ; **sum_ square_sst:long_name = "sum of contributing pixel sst value squares" ;** **sum_ square_sst:standard_name = sum_of_contributing_pixel_sst_value_squares_D;** **sum_ square_sst:_FillValue = -1f ;** **sum_ square_sst:units = "kelvin2" ;** **sum_ square_sst:valid_range = 0.0f, 50000.0f;** **sum_ square_sst:comment = "Sum of contributing pixel sst value squares" ;**			
Comments			

This variable records the sum of squares of the original SST values in case of averaging during the L3 fabrication

10.25 Variable adjusted_sea_surface_temperature

The variable '**adjusted_sea_surface_temperature**' shall be included with the format requirements shown in Table 10-8. see the principles of the adjustment procedure in Section 10.33.

Table 10-8 CDL example description of adjusted_sea_surface_temperature variable

Storage type	Name	Description	Unit
short	**adjusted_sea_surface_temperature**	SST values after adjustment to the reference	kelvin
CDL description			
short adjusted_sea_surface_temperature(time, lat, lon) ; adjusted_sea_surface_temperature:long_name = "adjusted sea surface temperature" ; adjusted_sea_surface_temperature:standard_name = "sea_surface_skin_temperature, sea_surface_subskin_temperature or sea_surface_foundation_temperature " ; adjusted_sea_surface_temperature:units = "kelvin" ; adjusted_sea_surface_temperature:_FillValue = -32768s ; adjusted_sea_surface_temperature:add_offset = 273.15f ; adjusted_sea_surface_temperature:scale_factor = 0.01f ; adjusted_sea_surface_temperature:valid_range = -300s, 4500s ; adjusted_sea_surface_temperature:reference="ATS_NR_2P" ; adjusted_sea_surface_temperature:comment="Priorities: example: ATS_NR_2P, AVHRRMTA, NAR17_SST, NAR18_SST, AVHRR17_L, AVHRR_18_L, AVHRR17_L, AVHRR18_G, SEVIRI_1H_SST, GOES_12_1H_SST, AMSRE, TMI, MODIS_A, MODIS_T"			
Comments			

10.26 Variable adjusted_standard_deviation_error

The variable '**adjusted_standard_deviation_error**' shall be included with the format requirements shown in Table 10-9. This variable represents the total error associated with the **adjusted_sea_surface_temperature** variable. It represents the accumulated error of the SST production (the **sses_standard_deviation**) and the SST adjustment (**standard_deviation_to_reference_sst**).

Table 10-9 CDL example description of adjusted_standard_deviation_error variable

Storage type	Name	Description	Unit
byte	**adjusted_standard_deviation_error**	Total error standard deviation estimate derived from SSES and adjustment method	kelvin
CDL description			
byte adjusted_standard_deviation_error(time, lat, lon) ; adjusted_standard_deviation_error:long_name = "standard deviation error based on L2P SSES and adjustment method" ; adjusted_standard_deviation_error:units = "kelvin" ;			

adjusted_standard_deviation_error:_FillValue = -128b ; **adjusted_standard_deviation_error:add_offset = 1.0f ;** **adjusted_standard_deviation_error:scale_factor = 0.01f ;** **adjusted_standard_deviation_error:valid_range = -127b, 127b ;** **adjusted_standard_deviation_error:comment = "Cumulated errors of SSES and adjustment method" ;**
Comments
This represents the cumulated errors of SSES and adjustment method

10.27 Variable bias_to_reference_sst

The variable '**bias_to_reference_sst**' shall be included with the format requirements shown in Table 10-10. This quantity represents the local value of the adjustment to the reference.

Table 10-10 CDL example description of bias_to_reference_sst variable

Storage type	Name	Description	Unit
short	**bias_to_reference_sst**	Bias error derived from comparison with the reference	kelvin
CDL description			
short bias_to_reference_sst (time, lat, lon) ; **bias_to_reference_sst:long_name = "bias error derived from reference" ;** **bias_to_reference_sst:units = "kelvin" ;** **bias_to_reference_sst:_FillValue = -32768s ;** **bias_to_reference_sst:add_offset = 0.0f ;** **bias_to_reference_sst:scale_factor = 0.01f ;** **bias_to_reference_sst:valid_range = -32767s, 32767s ;** **bias_to_reference_sst:valid_max = 32767s;** **bias_to_reference_sst:comment = "Bias estimate derived from comparison between the original SST (native SSES being applied) and the reference sensor SST (original SST - reference SST)" ;**			
Comments			
This represents the bias estimate derived from comparison between the original SST (native SSES being applied) and the reference sensor SST (original SST - reference SST)			

10.28 Variable standard_deviation_to_reference_sst

The variable '**standard_deviation_to_reference_sst'** shall be included with the format requirements shown in Table 10-11.

Table 10-11 CDL example description of standard_deviation_to_reference_sst variable

Storage type	Name	Description	Unit
byte	**standard_deviation_to_reference_sst**	Error standard deviation resulting from the bias estimation method	kelvin
CDL description			
byte standard_deviation_to_reference_sst(time, lat, lon) ; **standard_deviation_to_reference_sst:long_name = "standard deviation of the reference error" ;** **standard_deviation_to_reference_sst:units = "kelvin" ;** **standard_deviation_to_reference_sst:_FillValue = -128b ;** **standard_deviation_to_reference_sst:add_offset = 1.0f ;** **standard_deviation_to_reference_sst:scale_factor = 0.01f ;**			

standard_deviation_to_reference_sst:valid_range = -127b, 127b ; **standard_deviation_to_reference_sst:comment = "This represents the error standard deviation estimate resulting from the bias estimation method" ;**
Comments
This represents the error standard deviation estimate resulting from the bias estimation method

10.29 Variable source_of_sst

In a super-collated file (L3S), the variable '**source_of_sst**' shall be included with the format requirements shown in Table 10-12.

Table 10-12 CDL description of source_of_sst variable

Storage type	Name	Description	Unit
byte	**source_of_sst**	Origin of the SST at pixel level	Code table
CDL description			
byte source_of_sst(time, lat, lon) ; **source_of_sst:long_name = "SST product origin" ;** **source_of_sst:_FillValue = -128b ;** **source_of_sst:flag_meanings = "AVHRR_SST_METOP_B-OSISAF-L2P-v1.0 VIIRS_NPP-OSPO-L2P-v2.61 VIIRS_N20-OSPO-L2P-v2.61 SLSTRA_MAR_L2P_v1.0 SLSTRB_MAR_L2P_v1.0 SEVIRI_SST-OSISAF-L3C-v1.0 GOES16-OSISAF-L3C-v1.0 ABI_G17-STAR-L3C-v2.71 SEVIRI_IO_SST-OSISAF-L3C-v1.0 AHI_H08-STAR-L3C-v2.7 AMSR2-REMSS-L2P-v8a" ;** **source_of_sst:flag_values = 70b, 20b, 21b, 80b, 81b, 41b, 52b, 53b, 42b, 85b, 60b ;**			
Comments			

10.30 Sample GHRSST L3 file (CDL header)

A complete CDL description of a L3S dataset derived from infrared VIIRS sensors on S-NPP, and NOAA-20 platforms (https://doi.org/10.5067/GHLPM-3SS28) is given below. It includes some non-standard variables and attributes.

```
netcdf l3s {
dimensions:
        time = 1 ;
        lat = 9000 ;
        lon = 18000 ;
variables:
        int time(time) ;
                time:long_name = "reference time of sst file" ;
                time:units = "seconds since 1981-01-01 00:00:00" ;
                time:comment = "seconds since 1981-01-01 00:00:00" ;
                time:standard_name = "time" ;
                time:calendar = "Gregorian" ;
                time:axis = "T" ;
                time:coverage_content_type = "coordinate" ;
        int sst_dtime(time, lat, lon) ;
                sst_dtime:long_name = "time difference from reference time" ;
```

```
		sst_dtime:units = "seconds" ;
		sst_dtime:add_offset = 0.f ;
		sst_dtime:scale_factor = 0.25f ;
		sst_dtime:valid_max = 2147483647 ;
		sst_dtime:valid_min = -2147483647 ;
		sst_dtime:_FillValue = -2147483648 ;
		sst_dtime:coordinates = "lon lat" ;
		sst_dtime:comment = "time plus sst_dtime gives seconds since 1981-01-01 00:00:00 UTC" ;
		sst_dtime:coverage_content_type = "referenceInformation" ;
	float lat(lat) ;
		lat:long_name = "latitude" ;
		lat:comment = "Latitudes for locating data" ;
		lat:units = "degrees_north" ;
		lat:axis = "Y" ;
		lat:valid_min = -90.f ;
		lat:valid_max = 90.f ;
		lat:standard_name = "latitude" ;
		lat:coverage_content_type = "coordinate" ;
	float lon(lon) ;
		lon:long_name = "longitude" ;
		lon:comment = "Longitude for locating data" ;
		lon:units = "degrees_east" ;
		lon:axis = "X" ;
		lon:valid_min = -180.f ;
		lon:valid_max = 180.f ;
		lon:standard_name = "longitude" ;
		lon:coverage_content_type = "coordinate" ;
	short sea_surface_temperature(time, lat, lon) ;
		sea_surface_temperature:add_offset = 273.15f ;
		sea_surface_temperature:comment = "SST obtained by regression with buoy measurements,
sensitive to skin SST. Further information at (Petrenko et al., JGR, 2014; doi:10.1002/2013JD020637)" ;
		sea_surface_temperature:coordinates = "lon lat" ;
		sea_surface_temperature:long_name = "sea surface sub-skin temperature" ;
		sea_surface_temperature:scale_factor = 0.01f ;
		sea_surface_temperature:source = "NOAA" ;
		sea_surface_temperature:units = "kelvin" ;
		sea_surface_temperature:valid_max = 32767s ;
		sea_surface_temperature:valid_min = -200s ;
		sea_surface_temperature:_FillValue = -32768s ;
		sea_surface_temperature:standard_name = "sea_surface_subskin_temperature" ;
		sea_surface_temperature:coverage_content_type = "physicalMeasurement" ;
		sea_surface_temperature:grid_mapping = "crs" ;
	byte sses_bias(time, lat, lon) ;
		sses_bias:long_name = "SSES bias estimate" ;
		sses_bias:units = "kelvin" ;
		sses_bias:_FillValue = -128b ;
		sses_bias:add_offset = 0.f ;
		sses_bias:scale_factor = 0.016f ;
		sses_bias:valid_min = -127b ;
		sses_bias:valid_max = 127b ;
		sses_bias:coordinates = "lon lat" ;
		sses_bias:grid_mapping = "crs" ;
		sses_bias:comment = "Bias is derived against Piecewise Regression SST produced by local
regressions with buoys. Subtracting sses_bias from sea_surface_temperature produces more accurate
estimate of SST at the depth of buoys. Further information at (Petrenko et al., JTECH, 2016;
doi:10.1175/JTECH-D-15-0166.1)" ;
		sses_bias:coverage_content_type = "qualityInformation" ;
```

```
	byte sses_standard_deviation(time, lat, lon) ;
		sses_standard_deviation:long_name = "SSES standard deviation" ;
		sses_standard_deviation:units = "kelvin" ;
		sses_standard_deviation:_FillValue = -128b ;
		sses_standard_deviation:add_offset = 1.f ;
		sses_standard_deviation:scale_factor = 0.01f ;
		sses_standard_deviation:valid_min = -127b ;
		sses_standard_deviation:valid_max = 127b ;
		sses_standard_deviation:coordinates = "lon lat" ;
		sses_standard_deviation:grid_mapping = "crs" ;
		sses_standard_deviation:comment = "Standard deviation of sea_surface_temperature from
SST measured by drifting buoys. Further information at (Petrenko et al., JTECH, 2016; doi:10.1175/JTECH-D-
15-0166.1)" ;
		sses_standard_deviation:coverage_content_type = "qualityInformation" ;
	short l3s_sst_reference(time, lat, lon) ;
		l3s_sst_reference:long_name = "l3s sea surface temperature reference" ;
		l3s_sst_reference:units = "kelvin" ;
		l3s_sst_reference:_FillValue = -32768s ;
		l3s_sst_reference:add_offset = 273.15f ;
		l3s_sst_reference:scale_factor = 0.01f ;
		l3s_sst_reference:valid_min = -32767s ;
		l3s_sst_reference:valid_max = 32767s ;
		l3s_sst_reference:source = "NOAA" ;
		l3s_sst_reference:coordinates = "lon lat" ;
		l3s_sst_reference:grid_mapping = "crs" ;
		l3s_sst_reference:comment = "Reference SST used for determining weights of L3U pixels to the
L3S output. It is a 7x7 sliding window weighted mean of sea_surface_temperature. Weights are equal to
sst_count with a maximum weight of 5. Coverage is improved compared to sea_surface_temperature, at the
cost of reduced feature resolution. This is an experimental variable and is subject to change." ;
		l3s_sst_reference:coverage_content_type = "physicalMeasurement" ;
	short dt_analysis(time, lat, lon) ;
		dt_analysis:long_name = "deviation from SST reference" ;
		dt_analysis:units = "kelvin" ;
		dt_analysis:source = "CMC0.1deg-CMC-L4-GLOB-v2.0" ;
		dt_analysis:add_offset = 0.f ;
		dt_analysis:scale_factor = 0.01f ;
		dt_analysis:valid_min = -32767s ;
		dt_analysis:valid_max = 32767s ;
		dt_analysis:_FillValue = -32768s ;
		dt_analysis:coordinates = "lon lat" ;
		dt_analysis:comment = "Deviation from reference SST, i.e., dt_analysis = SST - reference SST" ;
		dt_analysis:grid_mapping = "crs" ;
		dt_analysis:coverage_content_type = "qualityInformation" ;
	byte quality_level(time, lat, lon) ;
		quality_level:long_name = "quality level of SST pixel" ;
		quality_level:coordinates = "lon lat" ;
		quality_level:grid_mapping = "crs" ;
		quality_level:_FillValue = -128b ;
		quality_level:valid_min = 0b ;
		quality_level:valid_max = 5b ;
		quality_level:flag_meanings = "no_data bad_data not_used not_used not_used best_quality" ;
		quality_level:flag_values = 0b, 1b, 2b, 3b, 4b, 5b ;
		quality_level:comment = "SST quality levels: 5 corresponds to “clear-sky” pixels and is
recommended for operational applications and validation." ;
		quality_level:coverage_content_type = "qualityInformation" ;
	short l2p_flags(time, lat, lon) ;
		l2p_flags:long_name = "L2P flags" ;
```

```
		l2p_flags:coordinates = "lon lat" ;
		l2p_flags:valid_min = -32768s ;
		l2p_flags:valid_max = 32767s ;
		l2p_flags:flag_meanings = "microwave land ice invalid day land glint ice probably_clear_or_cloudy_or_undefined" ;
		l2p_flags:flag_masks = 1s, 2s, 4s, 256s, 512s, 1024s, 4096s, 8192s, -16384s ;
		l2p_flags:comment = "L2P common flags in bits 1-6 and data provider flags (from ACSPO mask) in bits 9-16: bit01 (0=IR: 1=microwave); bit02 (0=ocean; 1=land); bit03 (0=no ice; 1=ice); bits04-08 (reserved,set to 0); bit09 (0=radiance valid; 1=invalid); bit10 (0=night; 1=day); bit11 (0=ocean; 1=land); bit12 not used (set to 0); bit13 (0=no glint; 1=glint); bit14 (0=no snow/ice; 1=snow/ice); bits15-16 (00=clear; 01=probably clear; 10=cloudy; 11=clear-sky mask undefined)" ;
		l2p_flags:grid_mapping = "crs" ;
		l2p_flags:coverage_content_type = "thematicClassification" ;
	byte sst_count(time, lat, lon) ;
		sst_count:long_name = "Count of input L3U SST pixels" ;
		sst_count:_FillValue = -128b ;
		sst_count:valid_min = 0b ;
		sst_count:valid_max = 127b ;
		sst_count:coordinates = "lon lat" ;
		sst_count:grid_mapping = "crs" ;
		sst_count:comment = "Number of L3U pixels contributing to L3S pixel" ;
		sst_count:coverage_content_type = "referenceInformation" ;
		sst_count:units = "1" ;
	byte sst_source(time, lat, lon) ;
		sst_source:long_name = "Source of major (highest weight) contribution to sst" ;
		sst_source:coordinates = "lon lat" ;
		sst_source:_FillValue = -128b ;
		sst_source:valid_min = 0b ;
		sst_source:valid_max = 6b ;
		sst_source:flag_meanings = "viirs_npp viirs_n20 avhrr_ma avhrr_mb avhrr_mc modis_t modis_a" ;
		sst_source:flag_values = 0b, 1b, 2b, 3b, 4b, 5b, 6b ;
		sst_source:grid_mapping = "crs" ;
		sst_source:comment = "Major contributor to SST. The major contributor is defined as the platform with highest weighed l3u observation." ;
		sst_source:coverage_content_type = "referenceInformation" ;
	short satellite_zenith_angle(time, lat, lon) ;
		satellite_zenith_angle:long_name = "satellite zenith angle" ;
		satellite_zenith_angle:units = "degrees" ;
		satellite_zenith_angle:_FillValue = -32768s ;
		satellite_zenith_angle:add_offset = 0.f ;
		satellite_zenith_angle:scale_factor = 0.01f ;
		satellite_zenith_angle:valid_min = -32767s ;
		satellite_zenith_angle:valid_max = 32767s ;
		satellite_zenith_angle:coordinates = "lon lat" ;
		satellite_zenith_angle:grid_mapping = "crs" ;
		satellite_zenith_angle:comment = "Satellite zenith angle corresponding to L3U SST measurement with highest weight." ;
		satellite_zenith_angle:coverage_content_type = "referenceInformation" ;
	byte wind_speed(time, lat, lon) ;
		wind_speed:long_name = "wind speed" ;
		wind_speed:standard_name = "wind_speed" ;
		wind_speed:units = "m s-1" ;
		wind_speed:height = "10 m" ;
		wind_speed:_FillValue = -128b ;
		wind_speed:add_offset = 0.f ;
		wind_speed:scale_factor = 0.15f ;
```

```
                wind_speed:valid_min = -127b ;
                wind_speed:valid_max = 127b ;
                wind_speed:coordinates = "lon lat" ;
                wind_speed:grid_mapping = "crs" ;
                wind_speed:source = "Wind speed from MERRA-2 data" ;
                wind_speed:comment = "Typically represents surface winds (10 meters above the sea surface).
The wind speeds reported here are a weighted average of wind speeds reported in input l3u data." ;
                wind_speed:coverage_content_type = "auxiliaryInformation" ;
        int crs ;
                crs:grid_mapping_name = "latitude_longitude" ;
                crs:horizontal_datum_name = "World Geodetic System 1984" ;
                crs:reference_ellipsoid_name = "WGS84" ;
                crs:prime_meridian_name = "Greenwich" ;
                crs:long_name = "coordinate reference system" ;
        short sst_gradient_magnitude(time, lat, lon) ;
                sst_gradient_magnitude:_FillValue = -32768s ;
                sst_gradient_magnitude:valid_min = -32767s ;
                sst_gradient_magnitude:valid_max = 32767s ;
                sst_gradient_magnitude:long_name = "SST gradient magnitude value" ;
                sst_gradient_magnitude:comment = "Gradient magnitude calculated from SST field in all grids
with valid SST" ;
                sst_gradient_magnitude:coordinates = "lon lat" ;
                sst_gradient_magnitude:grid_mapping = "crs" ;
                sst_gradient_magnitude:scale_factor = 0.001f ;
                sst_gradient_magnitude:add_offset = 0.f ;
                sst_gradient_magnitude:units = "kelvin/km" ;
                sst_gradient_magnitude:coverage_content_type = "physicalMeasurement" ;
        byte sst_front_position(time, lat, lon) ;
                sst_front_position:_FillValue = -128b ;
                sst_front_position:comment = "Binary indicator of SST front position in the valid SST clear-sky
domain: 1 - SST front present, 0 - no front present" ;
                sst_front_position:coordinates = "lon lat" ;
                sst_front_position:grid_mapping = "crs" ;
                sst_front_position:long_name = "Binary SST front position indicator" ;
                sst_front_position:valid_min = 0b ;
                sst_front_position:valid_max = 1b ;
            sst_front_position:coverage_content_type = "image" ;
// global attributes:
                :collation_version = "2.2.8" ;
                  :collation_input = "20220605000000-STAR-L3U_GHRSST-SSTsubskin-VIIRS_N20-ACSPO_V2.80-
            v02.0-fv01.0.nc",…";
                :source = "See list of L3U fileSs in collation_input global attribute" ;
                :acknowledgement = "Please acknowledge the use of these data with the following statement:
These data were provided by Group for High Resolution Sea Surface Temperature (GHRSST) and the National
Oceanic and Atmospheric Administration (NOAA)." ;
                :aggregator_version = "V1.00" ;
                :cdm_data_type = "grid" ;
                :comment = "SSTs are a weighted average of the SSTs of contributing pixels. WARNING: some
applications are unable to properly handle signed byte values. If byte values > 127 are encountered, subtract
256 from this reported value." ;
                :creator_email = "Alex.Ignatov@noaa.gov" ;
                :creator_name = "Alex Ignatov" ;
                :creator_url = "http://www.star.nesdis.noaa.gov" ;
                :gds_version_id = "02.0" ;
                :geospatial_lat_resolution = 0.02f ;
                :geospatial_lat_units = "degrees_north" ;
```

```
        :geospatial_lon_resolution = 0.02f ;
        :geospatial_lon_units = "degrees_east" ;
        :history = "Created by the L2-to-L3 conversion tool, which was developed and provided by NOAA/NESDIS/STAR and CCNY. The version is 4.6.9" ;
        :institution = "NOAA/NESDIS/STAR" ;
        :keywords = "Oceans > Ocean Temperature > Sea Surface Temperature" ;
        :keywords_vocabulary = "NASA Global Change Master Directory (GCMD) Science Keywords" ;
        :license = "GHRSST protocol describes data use as free and open" ;
        :naming_authority = "org.ghrsst" ;
        :preprocessor_version = "1.15.0" ;
        :product_version = "L2 algorithm V2.80; L3 algorithm V4.6.9" ;
        :project = "Group for High Resolution Sea Surface Temperature" ;
        :publisher_email = "ghrsst-po@nceo.ac.uk" ;
        :publisher_name = "The GHRSST Project Office" ;
        :publisher_url = "http://www.ghrsst.org" ;
        :references = "Data convention: GHRSST Data Specification (GDS) v2.0. Algorithms: ACSPO-VIIRS ATBD (NOAA/NESDIS/STAR)" ;
        :spatial_resolution = "0.02 deg" ;
        :standard_name_vocabulary = "CF Standard Name Table (v26, 08 November 2013)" ;
        :Conventions = "CF-1.7, ACDD-1.3" ;
        :file_quality_level = 3 ;
        :metadata_link = "TBD" ;
        :processing_level = "L3S" ;
        :program = "GHRSST" ;
        :summary = "Sea surface temperature retrievals produced by NOAA/NESDIS/STAR office" ;
        :start_time = "20220605T000000Z" ;
        :time_coverage_start = "20220605T000000Z" ;
        :stop_time = "20220605T235959Z" ;
        :time_coverage_end = "20220605T235959Z" ;
        :date_created = "20220723T011729Z" ;
        :col_start = 0 ;
        :col_count = 18000 ;
        :row_start = 0 ;
        :row_count = 9000 ;
        :westernmost_longitude = -179.99f ;
        :easternmost_longitude = 179.99f ;
        :southernmost_latitude = -89.99f ;
        :northernmost_latitude = 89.99f ;
        :geospatial_lon_min = -179.99f ;
        :geospatial_lon_max = 179.99f ;
        :geospatial_lat_min = -89.99f ;
        :geospatial_lat_max = 89.99f ;
        :title = "ACSPO L3S LEO-PM SST" ;
        :id = "ACSPO-L3S-LEO-PM-v2.80" ;
        :sensor = "VIIRS" ;
        :instrument = "VIIRS" ;
        :platform = "NPP,N20" ;
        :netcdf_version_id = "4.7.4" ;
        :day_or_night = "day" ;
        :uuid = "f2684f93-1fad-4005-94ac-017041304ab4" ;
}
```

10.31 Best Practices for Remapping Level 2 Data to a Fixed Grid

The remapping procedure consists in remapping the original L2P in swath projection onto a fixed grid. This remapping should preserve the traceability of the SST at pixel level and keep the best quality data.

If the original and final grid resolutions are similar, the nearest pixel remapping should be adopted. To do so, either a “source to target” or a “target to source” approach may be used. The latter, target to source, which consists in scanning the target grid points to find the nearest pixel in the source, is recommended since it avoids creating holes in the remapped field.

If the original grid resolution is finer than the output grid, (Figure 10-4) an averaging procedure can be adopted. For these cases the best practice is to average the values of all pixels which overlap the product cell entirely and which have a L2P confidence record **quality_level** value equal to the highest encountered within the cell, to produce a single value.

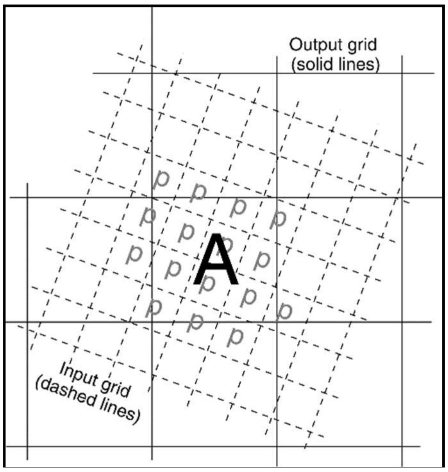

Figure 10-4: To illustrate the approach when the L3 product output grid is over-sampled by the L2P input data. All pixels labeled *p* in the input data are possible contributors to the value for new cell *A*.

The following practices are recommended by the GDS:

- 1) In the case of a smaller L2P input pixel than the grid cell size, L3 data product cell values are derived from an average of the L2P pixel which completely overlap the product cell and which have a L2P quality record **quality_level** value equal to the highest encountered within the cell, to produce a single value.
- 2) For input pixels that straddle the boundary between output grid cells, a weighting function may be applied to the input values according to the degree of coverage of the output grid cell and according to the SSES.
- 3) Only the best quality original data within a grid cell should be averaged to produce the resulting SST value, to preserve the homogeneity of the SST quality (recommendation 1 above). In the case of averaging, the number of contributors can be recorded as well as the sum of the SST values and the sum of the square values of the SST. The SSES and ancillary data (if needed, for instance if there may be more that one SSES couple of values (bias and standard deviation) by quality level) must be averaged accordingly: the **sses_bias** values are averaged similarly as the SST values, the new **sses_standard_deviation** value is the square root of the averaged squared values of the contributing **sses_standard_deviations**. The averaging should account for the nature of the original **l2p_flags**.

- 4) In the case of a larger pixel than the L3 grid cell size, 2 approaches can be adopted:
    1. The value of the L2P pixel is allocated to the grid cell the closest to the pixel centre.
    2. The output grid cell takes the value of the L2P pixel in which its centre lies. In this case **the original latitudes and longitudes of the pixel must be recorded**, to be able to detect where the original L2P pixel value has been duplicated.

If the original grid resolution is larger than the output grid (e.g., microwave instruments), as illustrated in Figure 10-5, the following practices are recommended by the GDS:

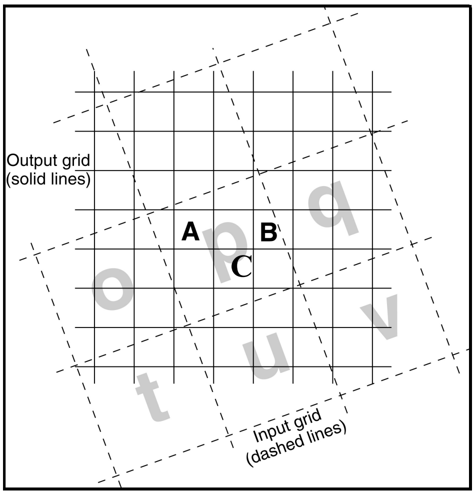

Figure 10-5: To illustrate the approach when the L3 output grid is under-sampled by the L2P data. Either Grid cell *C* is assigned the value of pixel *p*, Or grid cell *A* is assigned the value of pixel *p* and grid cell *B* is assigned the weighted average of p and q provided they both have quality flags with the same rating.

10.32 Best Practices for Collating Data from the Same Sensor and Platform

The collating procedure consists of gathering over a unique grid several orbits or slots (in the case of a geostationary satellite) of the **same sensor** on the **same platform**. This process is often known as "binning" the data. The collating procedure merges data with different times of observation.

1) For situations in which the collation is to be done for data collected within the same day, two cases are met in practice: collation of consecutive orbits in the case of data collected from polar orbiting sensors, or the merging of consecutive slots in the case of geostationary satellites. In both cases there may be multiple candidates for a grid cell.
    a. To collate observations from overlapping orbits of the polar orbiting sensors, the selection procedure should prioritize data first by using the highest available quality data. If multiple observations share the same highest quality, one of two approaches should be taken: either the observation with the minimum satellite zenith angle should be selected, or the observations should be averaged. If the minimum satellite zenith angle approach is taken, the corresponding **sses_bias** and **sses_standard_deviation** should be selected as well. If

the averaging approach is followed, the **sses_bias** and **sses_standard_deviation** should be averaged similarly (note that the new **sses_standard_deviation** value is the square root of the averaged squared values of the contributing **sses_standard_deviation** values). Also in the case of averaging, it is good practice to record the number of observations being averaged, the sum of the SST values, and the sum of the squared SST values. These values can be stored in the **or_number_pixels**, **sum_sst**, and **sum_square_sst** variables listed in Sections and 8 and 9.

b. In the case of geostationary data, the selection procedure must prioritize data showing the best quality level, and if equal, data closest to the representative time (central time) of the L3 time window. In the case of geostationary satellites, remapping is not a preliminary step to the collating procedure.

2) If averaging over multiple days, only the best quality original data within a grid cell should be averaged to produce the resulting SST value, to preserve the homogeneity of the SST quality. The number of contributors can be recorded (**or_number_pixels**) as well as the sum of the SST values (**sum_sst)** and the sum of the square values of the SST (**sum_square_sst)**. The SSES values should be averaged accordingly: the **sses_bias** values are averaged in the same manner as the SST values and the new **sses_standard_deviation** value is the square root of the averaged squared values of the contributing **sses_standard_deviation values**. The averaging should preserve the nature of the original **L2P_flags**.

10.33 Best Practices for Adjustments

Most of individual sensors show regional biases resulting in limitations of the applied algorithms. The objective of the adjustment procedure is to provide a correction to these regional biases by comparison with a “reference sensor”, supposedly free from such biases. A variety of sources can be adopted as references in the adjustment procedure, ranging from AATSR or in situ measurement to using a median of sensors approach. The adopted reference must be recorded in the **adjusted_sea_surface_temperature** variable “reference” attribute.
The adjustment procedure includes the following steps:

1. application of the SSES,
2. determination of the bias adjustment to the reference,
3. evaluation of the error of the adjustment procedure

NB: A skin to subskin conversion may be needed. In that case, please refer to the STVAL recommendations. The type of the SST variables must be recorded in the standard_names of the **sea_surface_temperature** and **adjusted_sea_surface_temperature** variables. The bias adjustment value at pixel and the error of the adjustment procedure must be recorded in the corresponding variables (mandatory).

10.34 Best Practices for Super-Collating Data from Multiple Sensors and Platforms

The building of a super-collated file takes place by merging adjusted collated L3 files from various sensors over the same grid and over the same time window. There is one input candidate file (and hence one candidate observation) per sensor. There may be multiple candidates for a given grid cell originating from different sensors. To make the selection from among the candidates, a “decision tree” or selection hierarchy should be established *a priori*. This hierarchy depends on the objective of the super-collation procedure, and may be quite different for a moderate resolution (10km) super-collated over 24h aiming to feed a foundation SST analysis and for a high resolution (2km) hourly subskin SST super-collated aiming to feed a diurnal warming analysis, for example. Because the hierarchy must be established based on the intended use of the super-collated dataset that results, it is out of the scope of this document to define any single hierarchy. However, the adopted hierarchy must be described in the **comment** attribute of the **adjusted_sea_surface_temperature** variable. In addition, it is mandatory to provide the source of the SST (**source_of_sst**) at the grid cell level.

11 Level 4 (L4) Product Specification

11.1 Overview description of the GHRSST L4 data product

L4 products are the analyzed SST products, usually derived from GHRSST L2P products. L4 data products should ideally be made available within the GHRSST R/GTS framework to the user community within 24 hours. For every L4 file that is generated, appropriate ISO metadata (specified in Section 12.1) must also be created and registered at the GHRSST Master Metadata Repository (MMR) system.

L4 products include gap-free analyzed SST data together with a number of ancillary fields that simplify interpretation and application of the SST data. Data providers are responsible for providing documentation on their analysis procedure. The common format of L4 products allows data users to code with the security that as new SST data products are brought on-line, very minimal code changes are required to make full use of new L4 product. Time previously spent on coding different I/O routines for each satellite data set can be spent working with the data to produce results.

The GHRSST Science Team determined that there will be 4 mandatory fields that form the core data content of a GHRSST L4 data file. In addition to global attributes and geo-location information, RDACs must produce the following within a L4 file:

- Sea Surface temperature data (SST)
- Error estimates for SST data
- Sea ice fraction
- Land/sea/ice flag

In addition there are a number of optional fields that may be used at the data provider's discretion.

Table 11-1 Summary description of the contents within a GHRSST L4 data product

Description	Required	Relevant section of this document
Dimensions (e.g., i *x* j x k)	Mandatory	Section 8.1
Global attributes	Mandatory	Section 8.2
[i *x* j *x* k] geolocation data	Mandatory	Section 8.4
[i *x* j x k] array of SST data	Mandatory	Section 11.3
[i *x* j x k] array of error estimates	Mandatory	Section 11.4
[i *x* j x k] array of sea ice fraction	Mandatory	Section 11.5
[i *x* j x k] array of land/sea/ice mask	Mandatory	Section 11.6
[i *x* j x k] array of optional fields	Optional	

11.2 L4 data record format specification

L4 analysed data products are derived from an analysis procedure implemented at regular intervals (daily, six-hourly or other time periods). L4 data products include SST, error statistics, sea ice fraction, land/sea/ice mask, and other optional data for each grid-cell. A six-byte experimental block is available for data providers to test new aspects of the file or information specific to the analysis system that will eventually transition into a GHRSST standard L4 analysis field once tested.

Table 11-2 describes the format of GDS L4 grid cell ancillary data that should be created for each L4 grid cell. In the following sections, each variable within the L4 data file is described in detail.

Table 11-2 L4 SST product data fields

Name	Description	Units
analysed_sst	SST from analysis system	K, scaled, short
analysis_error	Error standard deviation estimate	K, scaled, short
sea_ice_fraction	Fractional Sea Ice area concentration.	0-1 scaled byte
mask	land/ice/lake mask	Flag [8bits]
sea_ice_fraction_error	If the error estimates on the sea ice field are available, it is recommended to provide this information as an experimental field called **sea_ice_fraction_error** variable.	0-1 scaled byte
Experimental fields	Each grid cell has a 6 byte storage space available for RDACs and other users to include specific information. The policy for use of these fields is that they should make a useful contribution to the data sets and to GHRSST. Ideally experimental fields should transition into full fields once stable and agreed by the GHRSST Science Team. Use of these fields requires that a description of the content and specification is agreed with the GHRSST Data Assembly and Systems Technical Advisory Group and that GDS-2.1 variable attributes are included in the variable. See Section 8.3.	6 bytes (maximum). Defined by data providers.

11.3 Variable analysed_sst

The variable '**analysed_sst**' will be included with the format requirements shown in Table 11-3. The data provider is responsible for providing GHRSST with documentation on how the analysed SST is determined. Note that the RDAC should place **_FillValue** in pixels that fall on land.

Table 11-3 CDL example description of analysed_sst variable

Storage type	Name	Description	Unit
short	**analysed_sst**	SST values from analysis systems	kelvin
CDL example description			
short analysed_sst(time, lat, lon) ; analysed_sst:long_name = "analysed sea surface temperature" ; analysed_sst:standard_name = "sea_surface_foundation_temperature" ; analysed_sst:units = "kelvin" ; analysed_sst:_FillValue = -32768s ; analysed_sst:add_offset = 273.15f ; analysed_sst:scale_factor = 0.01f ; analysed_sst:valid_range = -300s, 4500s ; ; analysed_sst:source="AQUA_AMSRE_V5, AQUA_MODIS_V3, NOAA16_AVHRR_V4.1"; analysed_sst:comment = "This will be different for each analysis system"			

11.4 Variable analysis_error

The variable '**analysis_error**' will be included with the format requirements shown in Table 11-4. The data provider is responsible for providing GHRSST with documentation on how **analysis_error** is determined.

Table 11-4 CDL example description of analysis_error variable

Storage type	Name	Description	Unit
short	**analysis_error**	Error estimate from analysis system	kelvin
CDL example description			
short analysis_error(time, lat, lon) ; analysis_error:long_name = "estimated error standard deviation of analysed_sst" ; analysis_error:units = "kelvin" ; analysis_error:_FillValue = -32768s; analysis_error:add_offset = 0.0f ; analysis_error:scale_factor = 0.01f ; analysis_error:valid_range = 0s, 32767s; analysis_error:comment = "This will be different for each system"			

11.5 Variable sea_ice_fraction

The variable '**sea_ice_fraction**' will be included with the format requirements shown in Table 11-5. Some SST data are contaminated in part or wholly by sea ice and the L4 variable **sea_ice_fraction** is used to quantify the fraction of an area contaminated with sea ice.

If the error estimates on the sea ice field are available, it is recommended to provide this information as an experimental field called **sea_ice_fraction_error** variable.

Table 11-5 CDL example description of sea_ice_fraction variable

Storage type	Name	Description	Unit
byte	**sea_ice_fraction**	Fractional sea ice area concentration	Fraction
CDL example description			
byte sea_ice_fraction(time, lat, lon) ; **sea_ice_fraction:long_name = "sea ice area fraction" ;** **sea_ice_fraction:standard_name = "sea_ice_area_fraction" ;** **sea_ice_fraction:units = "1" ;** **sea_ice_fraction:_FillValue = -128b ;** **sea_ice_fraction:add_offset = 0.0f ;** **sea_ice_fraction:scale_factor = 0.01f ;** **sea_ice_fraction:valid_min = 0b ;** **sea_ice_fraction:valid_max = 100b ;** **sea_ice_fraction:source = "EUMETSAT SAF O&SI sea ice version 1.0" ;** **sea_ice_fraction:comment = "This will be different for each system" ;**			
Comments			
Sea Ice area fraction units are between 0 -> 1.0. Include source and version number in **sea_ice_fraction:source**.			

11.6 Variable mask

The variable '**mask**' will be included with the format requirements shown in Table 11-6.

Table 11-6 CDL example description of mask variable

Storage type	Name	Description	Unit
byte	**Mask**	land/sea/ice/lake mask	none
CDL example description			
byte mask(time, lat, lon) ; **mask:long_name = "land sea ice lake bit mask" ;** **mask:_FillValue = -128b;** **mask:flag_masks = 1b, 2b, 4b, 8b, 16b ;** **mask:flag_meanings = "water land optional_lake_surface sea_ice optional_river_surface";** **mask:source = "NAVOCEANO_landmask_v1.0 NSIDC_icemask_4.5 GSFC_MODIS_lakemask_v3.1";** **mask:comment = "Mask can be used to further filter the data";**			
Comments			
This is a land/sea/ice mask with the following bit values: Bit 0:1 = water in grid Bit 1:1 = land in grid			

Bit 2:1 = optional, lake surface in grid Bit 3:1 = sea ice Bit 4:1 = optional, river surface in grid Bits [5-7] spare Note that the lake and river surface bit values are optional. The **source** attribute should list any data products used in creating this mask. List **provider_type_of_mask_version_mask**.

11.7 Optional Variable sea_ice_fraction_error

If the error estimates on the sea ice field are available, it is recommended to provide this information as an experimental field called **sea_ice_fraction_error** variable. The data provider is responsible for providing GHRSST with documentation on how **sea_ice_fraction_error** is determined.

Table 11-7 CDL example description of sea_ice_fraction_error variable

Storage type	Name	Description	Unit
byte	**sea_ice_fraction_error**	Fractional sea ice area concentration	Fraction
CDL example description			
byte sea_ice_fraction_error(time, lat, lon) ; sea_ice_fraction_error:long_name = "sea ice area fraction error estimate" ; sea_ice_fraction_error:units = "1" ; sea_ice_fraction_error:_FillValue = -128b ; sea_ice_fraction_error:add_offset = 0.0f ; sea_ice_fraction_error:scale_factor = 0.01f ; sea_ice_fraction_error:valid_range = 0b, 100b ; sea_ice_fraction_error:source = "EUMETSAT SAF O&SI sea ice version 1.0" ; sea_ice_fraction_error:comment = "This will be different for each system" ;			

11.8 Sample GHRSST L4 file (CDL header)

A complete CDL description of a Level 4 dataset (https://doi.org/10.5067/GHM25-4FJ42) is given below:

```
netcdf l4 {
dimensions:
	time = 1 ;
	lat = 720 ;
	lon = 1440 ;
variables:
	int time(time) ;
		time:long_name = "reference time of sst field" ;
		time:standard_name = "time" ;
		time:coverage_content_type = "coordinate" ;
		time:axis = "T" ;
```

```
                time:units = "seconds since 1981-01-01 00:00:00 UTC" ;
                time:comment = "Nominal time of analyzed fields" ;
        float lat(lat) ;
                lat:long_name = "latitude" ;
                lat:standard_name = "latitude" ;
                lat:coverage_content_type = "coordinate" ;
                lat:axis = "Y" ;
                lat:units = "degrees_north" ;
                lat:valid_min = -90.f ;
                lat:valid_max = 90.f ;
                lat:comment = "geolocations inherited from the input data without correction" ;
        float lon(lon) ;
                lon:long_name = "longitude" ;
                lon:standard_name = "longitude" ;
                lon:coverage_content_type = "coordinate" ;
                lon:axis = "X" ;
                lon:units = "degrees_east" ;
                lon:valid_min = -180.f ;
                lon:valid_max = 180.f ;
                lon:comment = "geolocations inherited from the input data without correction" ;
        short analysed_sst(time, lat, lon) ;
                analysed_sst:long_name = "analysed sea surface temperature" ;
                analysed_sst:standard_name = "sea_surface_foundation_temperature" ;
                analysed_sst:coverage_content_type = "physicalMeasurement" ;
                analysed_sst:units = "kelvin" ;
                analysed_sst:_FillValue = -32768s ;
                analysed_sst:add_offset = 298.15 ;
                analysed_sst:scale_factor = 0.001 ;
                analysed_sst:valid_min = -32767s ;
                analysed_sst:valid_max = 32767s ;
                analysed_sst:comment = "\"Final\" version using Multi-Resolution Variational Analysis (MRVA)
method for interpolation" ;
                analysed_sst:coordinates = "lon lat" ;
                analysed_sst:source = "MODIS_T-JPL, MODIS_A-JPL, AVHRRMTB_G-NAVO, iQUAM-
NOAA/NESDIS, Ice_Conc-OSISAF" ;
        short analysis_error(time, lat, lon) ;
                analysis_error:long_name = "estimated error standard deviation of analysed_sst" ;
                analysis_error:coverage_content_type = "qualityInformation" ;
                analysis_error:units = "kelvin" ;
                analysis_error:_FillValue = -32768s ;
                analysis_error:add_offset = 0. ;
                analysis_error:scale_factor = 0.01 ;
                analysis_error:valid_min = 0s ;
                analysis_error:valid_max = 32767s ;
                analysis_error:comment = "uncertainty in \"analysed_sst\"" ;
                analysis_error:coordinates = "lon lat" ;
        byte mask(time, lat, lon) ;
                mask:long_name = "sea/land field composite mask" ;
                mask:coverage_content_type = "referenceInformation" ;
                mask:_FillValue = -128b ;
                mask:valid_min = 1b ;
                mask:valid_max = 31b ;
                mask:flag_masks = 1b, 2b, 4b, 8b, 16b ;
                mask:flag_meanings = "water land optional_lake_surface sea_ice optional_river_surface" ;
                mask:comment = "flag interpretation as integer values: 1=water, 2=land, 5=lake, 9=water with
ice in the grid, 13=lake with ice in the grid, 17=river" ;
                mask:coordinates = "lon lat" ;
```

```
		mask:source = "GMT \"grdlandmask\", ice flag from sea_ice_fraction data" ;
	byte sea_ice_fraction(time, lat, lon) ;
		sea_ice_fraction:long_name = "sea ice area fraction" ;
		sea_ice_fraction:standard_name = "sea_ice_area_fraction" ;
		sea_ice_fraction:coverage_content_type = "auxiliaryInformation" ;
		sea_ice_fraction:_FillValue = -128b ;
		sea_ice_fraction:add_offset = 0. ;
		sea_ice_fraction:scale_factor = 0.01 ;
		sea_ice_fraction:valid_min = 0b ;
		sea_ice_fraction:valid_max = 100b ;
		sea_ice_fraction:source = "EUMETSAT OSI-SAF, copyright EUMETSAT" ;
		sea_ice_fraction:comment = "ice fraction is a dimensionless quantity between 0 and 1; it has
been interpolated by a nearest neighbor approach." ;
		sea_ice_fraction:coordinates = "lon lat" ;
	short sst_anomaly(time, lat, lon) ;
		sst_anomaly:long_name = "SST anomaly from a seasonal SST climatology based on the MUR
data over 2003-2014 period" ;
		sst_anomaly:coverage_content_type = "auxiliaryInformation" ;
		sst_anomaly:units = "kelvin" ;
		sst_anomaly:_FillValue = -32768s ;
		sst_anomaly:add_offset = 0. ;
		sst_anomaly:scale_factor = 0.001 ;
		sst_anomaly:valid_min = -32767s ;
		sst_anomaly:valid_max = 32767s ;
		sst_anomaly:comment = "anomaly reference to the day-of-year average between 2003 and
2014" ;
		sst_anomaly:coordinates = "lon lat" ;

// global attributes:
		:Conventions = "CF-1.7, ACDD-1.3" ;
		:title = "Daily 0.25-degree MUR SST, Final product" ;
		:summary = "A low-resolution version of the MUR SST analysis, a merged, multi-sensor L4
Foundation SST analysis product from JPL." ;
		: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" ;
		:history = "created at nominal 4-day latency; replaced nrt (1-day latency) version." ;
		:source = "MODIS_T-JPL, MODIS_A-JPL, AVHRRMTB_G-NAVO, iQUAM-NOAA/NESDIS,
Ice_Conc-OSISAF" ;
		:platform = "Terra, Aqua, MetOp-B, Buoys/Ships" ;
		:instrument = "MODIS, AVHRR, in-situ" ;
		:sensor = "MODIS, AVHRR, in-situ" ;
		:processing_level = "L4" ;
		:cdm_data_type = "grid" ;
		:product_version = "04.2" ;
		:references = "Chin et al. (2017) \"Remote Sensing of Environment\", volulme 200, pages 154-
169. http://dx.doi.org/10.1016/j.rse.2017.07.029" ;
		:creator_name = "JPL MUR SST project" ;
		:creator_email = "ghrsst@podaac.jpl.nasa.gov" ;
		:creator_url = "http://mur.jpl.nasa.gov" ;
		:creator_institution = "Jet Propulsion Laboratory" ;
		:institution = "Jet Propulsion Laboratory" ;
		:project = "NASA MEaSUREs and COVERAGE" ;
		:program = "NASA Earth Science Data and Information System (ESDIS)" ;
		:southernmost_latitude = -90.f ;
		:northernmost_latitude = 90.f ;
		:westernmost_longitude = -180.f ;
```

```
		:easternmost_longitude = 180.f ;
		:geospatial_lat_min = -90.f ;
		:geospatial_lat_max = 90.f ;
		:geospatial_lon_min = -180.f ;
		:geospatial_lon_max = 180.f ;
		:geospatial_lat_units = "degrees north" ;
		:geospatial_lat_resolution = 0.25f ;
		:geospatial_lon_units = "degrees east" ;
		:geospatial_lon_resolution = 0.25f ;
		:date_created = "2022-06-12" ;
		:start_time = "20220603T090000Z" ;
		:stop_time = "20220603T090000Z" ;
		:time_coverage_start = "20220602T210000Z" ;
		:time_coverage_end = "20220603T210000Z" ;
		:time_coverage_resolution = "P1D" ;
		:license = "These data are available free of charge under data policy of JPL PO.DAAC." ;
		:id = "MUR25-JPL-L4-GLOB-v04.2" ;
		:uuid = "27665bc0-d5fc-11e1-9b23-0800200c9a66" ;
		:comment = "MUR = \"Multi-scale Ultra-high Resolution\"" ;
		:naming_authority = "org.ghrsst" ;
		:gds_version_id = "2.0" ;
		:netcdf_version_id = "04.2" ;
		:spatial_resolution = "0.25 degrees" ;
		:publisher_name = "GHRSST Project Office" ;
		:publisher_url = "https://www.ghrsst.org" ;
		:publisher_email = "gpc@ghrsst.org" ;
		:file_quality_level = 3 ;
		:metadata_link =
"http://podaac.jpl.nasa.gov/ws/metadata/dataset/?format=iso&shortName=MUR25-JPL-L4-GLOB-v04.2" ;
		:acknowledgment = "Please acknowledge the use of these data with the following statement:
These data were provided by JPL under support by NASA MEaSUREs and COVERAGE programs." ;
}
```

12 GHRSST Multi-Product Ensemble (GMPE) Product Specification

12.1 Overview description of the GMPE data product

The GMPE product is a combination of analysed L4 SST products (which in turn are derived from GHRSST L2P and L3 products). The GMPE data product is made available within the GHRSST R/GTS framework to the user community in real time within 24 hours of the L4 analyses becoming available. For every GMPE file that is generated, appropriate ISO metadata (Section 12.1) must also be created and registered at the GHRSST Master Metadata Repository (MMR) system.

The GMPE product includes gap-free ensemble median and standard deviation SST data. Each of the contributing L4 analyses is obtained through the GHRSST R/GTS framework once per day. The L4 products are interpolated onto a common 1/4˚ resolution grid and the ensemble median and standard deviation are calculated. These fields and the anomalies of each of the L4 analyses to the ensemble median are then output to a netCDF file with the format described in this Section. These fields, along with global attributes and geo-location information, form the core data content of a GMPE data file:

- Ensemble median Sea Surface Temperature (SST)
- Ensemble standard deviation SST
- Number of analyses contributing to the ensemble at each grid point
- Anomaly of each contributing analysis from the ensemble median.

In addition there are optional fields that may be used at the data provider's discretion. GMPE products also require three new dimensions not used in other GHRSST products levels. These dimensions are **fields, nv,** and **field_name_length.** The number of input L4 analysis products is used for **fields** and **field_name_length** is set to 50 to account for the length of the input L4 analysis product names. A GMPE variable, **time_bounds**, requires the dimension **nv**.

The GMPE product information is summarized in Table 12-1.

Table 12-1 Summary description of the contents within a GMPE data product

Description	Required	Relevant section of this document
Dimensions (e.g., i *x* j x k x l)	Mandatory	Section 8.1
Global attributes	Mandatory	Section 8.2
[i *x* j *x* k] geolocation data	Mandatory	Section 8.4
[i *x* j x k] array of median SST	Mandatory	Section 12.3
[i *x* j x k] array of standard deviation SST	Mandatory	Section 12.4
[i x j x k] array of number of contributing analyses	Mandatory	Section 12.5
[i *x* j x l x k] array of anomaly fields	Mandatory	Section 12.6
[I x j x k] array of optional fields	Optional	

12.2 GMPE data record format specification

GMPE data products are derived from a procedure produced at regular daily time periods. The product includes ensemble median SST, ensemble standard deviation SST, number of contributing analyses, and anomalies of each input L4 analysis to the ensemble median.

Table 12-2 L4 SST product data fields

Name	Description	Units
analysed_sst	Ensemble median SST of input L4 analyses	K, scaled, short
standard_deviation	Ensemble standard deviation of input L4 analyses	K, scaled, short
analysis_number	Number of contributing L4 analyses for each grid point	Number, byte
anomaly_fields	Differences between each of the input L4 analyses and the ensemble median SST.	K, scaled, short

12.3 Variable analysed_sst

The variable '**analysed_sst**' will be included with the format requirements shown in Table 12-3.

Table 12-3 CDL example description of analysed_sst variable

Storage type	Name	Description	Unit
short	**analysed_sst**	Ensemble median SST of input L4 analyses	kelvin
CDL example description			

```
short analysed_sst(time, lat, lon) ;
  analysed_sst:long_name = " median SST from GMPE " ;
  analysed_sst:standard_name = “sea_surface_temperature” ;
  analysed_sst:units = "kelvin" ;
  analysed_sst:_FillValue = -32768s ;
  analysed_sst:add_offset = 273.15f ;
  analysed_sst:scale_factor = 0.01f ;
  analysed_sst:valid_range = -300s, 4500s ;

  analysed_sst:comment = “Ensemble median SST of input L4 analyses” ;
  analysed_sst:source = “ABOM-L4LRfnd-GLOB-GAMSSA_28km, EUR-L4HRfnd-
GLOB-ODYSSEA, NAVO-L4HR1m-GLOB-K10_SST, NCDC-L4LRfnd-GLOB-
AVHRR_AMSRE_OI, NCDC-L4LRfnd-GLOB-AVHRR_OI, REMSS-L4HRfnd-GLOB-
amsre_OI, REMSS-L4HRfnd-GLOB-mw_ir_OI, UKMO-L4HRfnd-GLOB-OSTIA” ;
```

12.4 Variable standard_deviation

The variable '**standard_deviation'** will be included with the format requirements shown in Table 12-4. The current CF conventions don't contain a standard name for SST standard deviation, so the standard name attribute is not currently included in this variable.

Table 12-4 CDL example description of standard_deviation **variable**

Storage type	Name	Description	Unit
short	**standard_deviation**	Ensemble standard deviation of input L4 analyses	kelvin
CDL example description			
short standard_deviation (time, lat, lon) ; standard_deviation:long_name = "Standard deviation of input analyses" ; standard_deviation:units = "kelvin" ; standard_deviation:_FillValue = -32768s ; standard_deviation:add_offset = 32.0f ; standard_deviation:scale_factor = 0.001f ; standard_deviation:valid_range = -32000s, 32000s ; standard_deviation:comment = "Standard deviation of input analyses" ; standard_deviation:source = "ABOM-L4LRfnd-GLOB-GAMSSA_28km, EUR-L4HRfnd-GLOB-ODYSSEA, NAVO-L4HR1m-GLOB-K10_SST, NCDC-L4LRfnd-GLOB-AVHRR_AMSRE_OI, NCDC-L4LRfnd-GLOB-AVHRR_OI, REMSS-L4HRfnd-GLOB-amsre_OI, REMSS-L4HRfnd-GLOB-mw_ir_OI, UKMO-L4HRfnd-GLOB-OSTIA" ;			

12.5 Variable analysis_number

The variable '**analysis_number'** will be included with the format requirements shown in Table 8-4. The current CF conventions don't contain a standard name for this type of variable, so the standard name attribute is not currently included in this variable.

Table 12-4 CDL example description of analysis_number **variable**

Storage type	Name	Description	Unit
byte	**analysis_number**	Number of L4 analyses contributing to the ensemble at each grid point	Unit
CDL example description			
byte analysis_number (time, lat, lon) ; analysis_number:long_name = "Number of contributing analyses" ; analysis_number:units = " " ; analysis_number:_FillValue = -128b; analysis_number:add_offset = 0.0f ; analysis_number:scale_factor = 1.0f ; analysis_number:valid_range = -127b, 127b ; ; analysis_number:comment = "Number of contributing analyses" ;			

analysis_number:source = "ABOM-L4LRfnd-GLOB-GAMSSA_28km, EUR-L4HRfnd-GLOB-ODYSSEA, NAVO-L4HR1m-GLOB-K10_SST, NCDC-L4LRfnd-GLOB-AVHRR_AMSRE_OI, NCDC-L4LRfnd-GLOB-AVHRR_OI, REMSS-L4HRfnd-GLOB-amsre_OI, REMSS-L4HRfnd-GLOB-mw_ir_OI, UKMO-L4HRfnd-GLOB-OSTIA" ;

12.6 Variable anomaly_fields

The variable '**anomaly_fields'** will be included with the format requirements shown in Table 12-5. The current CF conventions don't contain a standard name for this type of variable, so the standard name attribute is not currently included in this variable. A new dimension, **fields**, is required for this variable to account for the number of each input L4 field going into the ensemble.

Table 12-5 CDL example description of analysis_number **variable**

Storage type	Name	Description	Unit
short	**anomaly_fields**	Difference of each input L4 field and the ensemble median.	K
CDL example description			
short anomaly_fields (time, fields, lat, lon) ; anomaly_fields:long_name = "Anomaly of input analyses from the ensemble median" ; anomaly_fields:units = "kelvin" ; anomaly_fields:_FillValue = -32768s ; anomaly_fields:add_offset = 0.0f ; anomaly_fields:scale_factor = 0.01f ; anomaly_fields:valid_range = -3000s, 3000s ; anomaly_fields:comment = "Anomaly of input analyses from the ensemble median" ; anomaly_fields:source = "ABOM-L4LRfnd-GLOB-GAMSSA_28km, EUR-L4HRfnd-GLOB-ODYSSEA, NAVO-L4HR1m-GLOB-K10_SST, NCDC-L4LRfnd-GLOB-AVHRR_AMSRE_OI, NCDC-L4LRfnd-GLOB-AVHRR_OI, REMSS-L4HRfnd-GLOB-amsre_OI, REMSS-L4HRfnd-GLOB-mw_ir_OI, UKMO-L4HRfnd-GLOB-OSTIA" ;			

12.7 Sample GMPE file (CDL header)

A complete CDL description of a GMPE data file is given below:

```
dimensions:
   lon = 1440 ;
   lat = 720 ;
   time = 1 ;
        fields = 8 ;
   field_name_length = 50;
   nv = 2 ;
variables:
```

```
long time(time) ;
        time:long_name = "reference time of sst field" ;
        time:standard_name = “time”;
        time:axis = “T”;
        time:calendar = “Gregorian”
        time:units = "seconds since 1981-01-01 00:00:00" ;
        time:comment = "Reference time of sst field" ;
float lat(lat) ;
   lat:standard_name = "latitude" ;
   lat:units = "degrees_north" ;
   lat:valid_min = -90. ;
   lat:valid_max = 90. ;
   lat:axis = “Y”;
   lat:comment = "Geographical coordinates, WGS84 datum" ;
float lon(lon) ;
   lon:standard_name = "longitude" ;
   lon:units = "degrees_east" ;
   lon:valid_min = -180. ;
   lon:valid_max = 180. ;
   lon:comment = "Geographical coordinates, WGS84 datum" ;
  lon:axis = “X”;
int time_bounds(time, nv) ;
   time_bounds:long_name = “time spanned by input L4 analyses” ;
               time_bounds:comment = “Time spanned by input L4 analyses” ;
char field_name(fields, field_name_length) ;
  fields:long_name = “name of the contributing L4 analyses” ;
  fields:units = “ “ ;
  fields:comment = “Name of the contributing L4 analyses” ;
        short analysed_sst(time, lat, lon) ;
   analysed_sst:long_name = " median SST from GMPE " ;
      analysed_sst:standard_name = “sea_surface_temperature” ;
      analysed_sst:units = "kelvin" ;
      analysed_sst:_FillValue = -32768s ;
      analysed_sst:add_offset = 273.15 ;
      analysed_sst:scale_factor = 0.01 ;
      analysed_sst:valid_min = -300s ;
      analysed_sst:valid_max = 4500s ;
      analysed_sst:comment = “Ensemble median SST of input L4 analyses” ;
      analysed_sst:source = “ABOM-L4LRfnd-GLOB-GAMSSA_28km, EUR-L4HRfnd-GLOB-ODYSSEA, NAVO-
L4HR1m-GLOB-K10_SST, NCDC-L4LRfnd-GLOB-AVHRR_AMSRE_OI, NCDC-L4LRfnd-GLOB-AVHRR_OI, REMSS-
L4HRfnd-GLOB-amsre_OI, REMSS-L4HRfnd-GLOB-mw_ir_OI, UKMO-L4HRfnd-GLOB-OSTIA” ;
        short standard_deviation (time, lat, lon) ;
   standard_deviation:long_name = "Standard deviation of input analyses" ;
   standard_deviation:units = "kelvin" ;
   standard_deviation:_FillValue = -32768s ;
   standard_deviation:add_offset = 32. ;
   standard_deviation:scale_factor = 0.001 ;
   standard_deviation:valid_min = -32000s ;
   standard_deviation:valid_max = 32000s ;
   standard_deviation:comment = “Standard deviation of input analyses” ;
  standard_deviation:source = “ABOM-L4LRfnd-GLOB-GAMSSA_28km, EUR-L4HRfnd-GLOB-ODYSSEA,
NAVO-L4HR1m-GLOB-K10_SST, NCDC-L4LRfnd-GLOB-AVHRR_AMSRE_OI, NCDC-L4LRfnd-GLOB-AVHRR_OI,
REMSS-L4HRfnd-GLOB-amsre_OI, REMSS-L4HRfnd-GLOB-mw_ir_OI, UKMO-L4HRfnd-GLOB-OSTIA” ;
```

byte analysis_number (time, lat, lon) ;
analysis_number:long_name = "Number of contributing analyses" ;
analysis_number:units = " " ;
analysis_number:_FillValue = -128b;
analysis_number:add_offset = 0. ;
analysis_number:scale_factor = 1. ;
analysis_number:valid_min = -127b ;
analysis_number:valid_max = 127b ;
analysis_number:comment = "Number of contributing analyses" ;
analysis_number:source = "ABOM-L4LRfnd-GLOB-GAMSSA_28km, EUR-L4HRfnd-GLOB-ODYSSEA, NAVO-L4HR1m-GLOB-K10_SST, NCDC-L4LRfnd-GLOB-AVHRR_AMSRE_OI, NCDC-L4LRfnd-GLOB-AVHRR_OI, REMSS-L4HRfnd-GLOB-amsre_OI, REMSS-L4HRfnd-GLOB-mw_ir_OI, UKMO-L4HRfnd-GLOB-OSTIA" ;
short anomaly_fields (time, fields, lat, lon) ;
anomaly_fields:long_name = "Anomaly of input analyses from the ensemble median" ;
anomaly_fields:units = "kelvin" ;
anomaly_fields:_FillValue = -32768s ;
anomaly_fields:add_offset = 0.0 ;
anomaly_fields:scale_factor = 0.01 ;
anomaly_fields:valid_min = -3000s ;
anomaly_fields:valid_max = 3000s ;
anomaly_fields:comment = "Anomaly of input analyses from the ensemble median" ;
anomaly_fields:source = "ABOM-L4LRfnd-GLOB-GAMSSA_28km, EUR-L4HRfnd-GLOB-ODYSSEA, NAVO-L4HR1m-GLOB-K10_SST, NCDC-L4LRfnd-GLOB-AVHRR_AMSRE_OI, NCDC-L4LRfnd-GLOB-AVHRR_OI, REMSS-L4HRfnd-GLOB-amsre_OI, REMSS-L4HRfnd-GLOB-mw_ir_OI, UKMO-L4HRfnd-GLOB-OSTIA" ;

// global attributes:
:Conventions = "CF-1.7";
:title = " GHRSST Multiproduct Ensemble (GMPE) data **";**
:summary = "A multi-product ensemble median SST for the global ocean together with anomaly fields from each ensemble member and uncertainty estimates.";
:references = "http://www.metoffice.gov.uk";
:institution = "MetOffice UK";
:history = "GMPE processor XXX.YY";
:comment = "WARNING:Some applications are unable to properly handle signed byte values. If values are encountered > 127, please substract 256 from this reported value." ;
:license = "These data are available free of charge under the GMES data policy.";
:id = " 20070503T120000-UKMO-L4LRens-GLOB-GMPE-v02.1-fv01.0.nc ";
:naming_authority = "org.ghrsst";
:product_version = "1.0";
:uuid = "B475601B-163E-4FC0-850D-14DD1EE32B7Z";
:gds_version_id = "2.1";
:necdf_version_id = "4.1";
:date_created = "20090831T120000Z" ;
:start_time = "20090830T120000Z" ;
:time_coverage_start = "20090830T120000Z" ;
:stop_time = "20090830T123000Z" ;
:time_coverage_end = "20090830T123000Z" ;
:file_quality_level=1;
:source = " OSTIA_filename.nc,rtg_filename.nc,NAVO_K10_sst_filename.nc,mgdsst_filename.nc,rssmw_filename.nc,rss

```
mwir_filename.nc,FNMOC_filename.nc,AVHRR_OI_filename.nc,ODYSSEA_filename.nc,CMC_filename.nc,GAMSSA_filename.nc";
    :platform = "Envisat, NOAA-17, NOAA-18, MetOpA, GOES12, Aqua, Terra, MTSAT1R, MSG1, TRMM" ;
    :sensor = "AATSR, AVHRR, AVHRR_GAC, SEVIRI, GOES_Imager, MODIS, TMI, ";
    :metadata_link = "http://data.nodc.noaa.gov/waf/FGDC-GHRSST_all- UKMO-L4LRens-GLOB-GMPE-v02.1-v1.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_lon_min = "-180.000" ;
    :geospatial_lon_max = "180.000" ;
    :geospatial_lat_min = "-90.000" ;
    :geospatial_lat_max = "90.000" ;
    :spatial_resolution = "0.25 degree" ;
    :geospatial_lat_units = "degrees north";
    :geospatial_lat_resolution = "0.25";
    :geospatial_lon_units = "degrees east";
    :geospatial_lon_resolution = "0.25";
    :acknowledgment = "Please acknowledge the use of these data with the following statement: These data were provided by GHRSST and the MyOcean Regional Data Assembly Centre";
    :creator_name = "MyOcean";
    :creator_email =" Francoise.Orain@meteo.fr ";
    :creator_url = " http://www.myocean.eu.org/";
    :project = "Group for High Resolution SST";
    :publisher_name = "GHRSST Project Office";
    :publisher_url ="http://www.ghrsst.org";
    :publisher_email ="ghrsst-po@nceo.ac.uk";
    :processing_level = "L4_GMPE";
    :cdm_data_type = "grid";
}
```

13 GDS-2.1 Document Management Policy

The purpose of a GDS document management Policy is to establish the framework under which official records and documents of GHRSST are created and managed. It lists the responsibilities of key actors, and articulates the principles underpinning the processes outlined in the records and document management guidelines.

The **intent** of this Policy is to ensure that the GHRSST GPO, Science Team and actors working within GHRSST have the appropriate governance and supporting structure in place to enable them to manage their records and documents in a manner that is planned, controlled, monitored, recorded and audited, using an authorized system.
This Policy states the key strategic and operational requirements for adequate recordkeeping and document management of the GDS to ensure that evidence, accountability and information about GHRSST activities are met.

The **scope** of this Policy is applicable to all people working in GHRSST and to all official records and documents, in any format and from any source. Examples include paper, electronic messages, digital documents and records, video, DVD, web-based content, plans, and maps. This Policy does not apply to public domain material.

13.1 GDS Document Management Definitions

Document:	Structured units of information recorded in any format and on any medium and managed as discrete units or objects. Some documents are records because they have participated in a business transaction, or were created to document such a transaction. Conversely, some documents are not records because they do not function as evidence of a business transaction.
Email:	The transmission of text messages and optional file attachments over a network.
ERDMS:	Electronic Records and Document Management System.
Records:	Information created, received, and maintained as evidence and information by an organization or person, in pursuance of legal obligations or in the transaction of business.
Records Management:	Field of management responsible for the efficient and systematic control of the creation, receipt, maintenance, use and disposition of records, including processes for capturing and maintaining evidence of and information about business activities and transactions in the form of records.

13.2 GDS Document Management Policy Statement

GDS records and documents created, received or used by GHRSST in the normal course of activities are the property of the GHRSST project, unless otherwise agreed. This includes reports compiled by external consultants commissioned by the GHRSST Project Office or Science Team.

GHRSST official records constitute its corporate memory, and as such are a vital asset for ongoing operations, and for providing evidence of activities and transactions. They assist the GPO and GHRSST Science Team in making better informed decisions and improving best practice by providing an accurate record of what has occurred before.

Thus GDS records are to be:

- managed in a consistent and structured manner;
- managed in accordance with best practice guidelines and procedures;
- stored in a secure manner.
- disposed of, or permanently archived appropriately;
- captured and registered using an authorized recordkeeping system

GHRSST GDS documents are to be

- created by authorized officers and managed by the GPO;
- version controlled by authorized officers.

13.3 GDS Document Management Policy Responsibility

The GHRSST Science Team is responsible for GDS Records Management and has delegated responsibility for records management to the GPO coordinator.

The Coordinator is accountable for providing assistance in the overall management of the GDS and documents, including:

- management of the GHRSST Document Management System (GHRSST Website document repository);
- providing assistance on the implementation and interpretation of the GDS Document Management;
- maintaining and developing GHRSST GDS document Management policy and promulgating this across GHRSST as a whole;
- identifying retention and disposal requirements for GHRSST records;
- providing training in GDS document management processes and the GHRSST website document repository.

13.4 GHRSST GDS Recordkeeping and Document Management System

The GHRSST recordkeeping and document management system assists people working in GHRSST to capture records, protect their integrity and authenticity, provide access through time, dispose of records no longer required by GHRSST in the conduct of its activities, and ensure records of enduring value are retained. It also facilitates the creation, version control, and authority of official corporate documents.

The GHRSST recordkeeping and document management system is managed by the GPO which provides ongoing support, development and training, so that GHRSST community responsibilities are met.

The GHRSST authorized recordkeeping and document management system is the GHRSST Project Office Web site document library (http://www.ghrsst.org).

All GHRSST actors are to use http://www.ghrsst.org to ensure that:

- GDS official records and documents are routinely captured and subjected to the relevant retention and disposal policy;
- access to records and documents is managed according to authorized access and appropriate retention times regardless of international location;
- records and documents are protected from unauthorized alteration or deletion;
- documents are version controlled as required;
- there is one authoritative and primary source of information documenting GHRSST GDS decisions and actions.

All GHRSST actors who create, receive and keep records and documents as part of their GHRSST work, should do so in accordance with these policies, procedures and standards. GHRSST actors should not undertake disposal of records without the authority of the GPO – and only in accordance with authorized disposal schedules.

13.5 GDS Document location

1. An approved and complete version of the GDS shall be stored on the GHRSST web site (http://www.ghrsst.org) under the documents -> GDS -> operational section of the web site. This version shall be the Operational version of the GDS.
2. A development version of the GDS shall be stored on the GHRSST web site (http://www.ghrsst.org) under the documents -> GDS -> development section of the web site. This version shall be the development version of the GDS
3. An archive of all GDS documents shall be stored on the GHRSST web site (http://www.ghrsst.org) under the documents -> GDS -> archive section of the web site.
4. A single zip file containing all operational documents shall be available at the GHRSST web site

13.6 GDS Document Publication

1. The GHRSST Project Office is responsible for publication of GDS operational documents.
2. A document Book Captain is responsible for the publication of development GDS documents and shall inform the GHRSST project office when new documents have been published.

13.7 GDS Document formats

1. Operational GDS documents shall be stored as pdf documents.

2. Development GDS documents shall be stored as Microsoft word documents.
3. Both word and pdf documents shall be stored in the GDS archive.

13.8 GDS Document filing

1. Documents shall be numbered using the following nomenclature suffix to be appended at the end of a filename:

   MM.mmm

   where MM is the major revision e.g. 2 and mmm is a minor revision e.g. 019. for example, the following GDS filename is valid

   GDS2.0_TechnicalSpecifications_rev02.001.doc

2. Following any change to a document, a new revision number shall be assigned to the document by the Book Captain before publication.

13.9 Document retrieval

1. Free and open access to all GDS documents shall be provided by the GHRSST web page interface.

13.10 Document security

1. GDS documents stored within the GHRSST web page are backed up by the web hosting company every night.
2. An independent backup copy of all GDS documents shall be maintained by the GHRSST Project Office.

13.11 Retention and long term archive

1. GDS documents shall be retained in perpetuity within a stewardship facility.

13.12 Document workflow

1. Each GDS document shall be owned and administered by a document Book Captain.
2. A GDS Book Captain is a central point of contact that is responsible for managing and maintaining the content of their GDS document
3. All revisions must be approved by a GDS document Book Captain.
4. All updates and revisions shall be entered into the Document change record.
5. A revised version of the GDS is the passed to the GPO coordinator for registration and document management (revision control).
6. A revised version of the GDS is the passed by the GPO to the GHRSST Data and Systems Technical Advisory Group (DAS-TAG) for review.
7. If required, the GPO may convene an external review Board to subject the revised GDS document to an independent peer review.
8. Proposed changes to the GDS, as provided by the DAS-TAG (and independent peer review if convened) are passed back to the Book Captains for implementation.
9. A final version of the GDS documents is passed back to the GPO.

10. A final version of the GDS is passed to the GHRSST Advisory council for approval.
11. The GPO publishes the GDS document on the GHRSST web site in the appropriate location of the GHRSST document library.

13.13 Document creation

1. The GHRSST Project Office, in collaboration with the GHRSST Science Team is responsible for the creation of new GDS documents.
2. The GHRSST Project Office may delegate the responsibility to create new documents to a member of the GHRSST Science Team.

Find out more about GHRSST

A complete description of GHRSST together with all project documentation can be found at the following web spaces:

Main GHRSST portal
https://www.ghrsst.org

GHRSST GDAC (rolling archive)
https://podaac.jpl.nasa.gov/ghrsst

GHRSST LTSRF (Archive)
http://ghrsst.nodc.noaa.gov

GHRSST MDB (validation)
https://www.ghrsst.org/about-ghrsst/task-teams/task-team-on-matchup-database-standards-mdb-tt/

GHRSST GMPE (L4 ensembles)
https://ghrsst-pp.metoffice.gov.uk/ostia-website/gmpe-monitoring.html

GHRSST data discovery
https://podaac.jpl.nasa.gov/ghrsst

GHRSST data visualisation (USA)
https://podaac-tools.jpl.nasa.gov/hitide/

Contact details
You can contact the International GHRSST Project Office using the details below.

The GHRRST Project Office is funded by the European Union Copernicus Programme and is hosted by the Danish Meteorological Institute, Lyngbyvej 100, 2100 Copenhagen (DK)

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