The ECCO Data Specification (ECCO) v4r4 User Guide

The "Estimating the Circulation and Climate of the Ocean" Team

3 June 2023

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The Recommended GHRSST Data Specification (GDS)

GDS 2.0 Technical Specifications

Compiled by
the GHRSST International Science Team 2010,
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2 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 2.0 is a technical specification of GHRSST products and services. It consists of a technical specification document (this volume) and a separate Interface Control Document (ICD). The GDS technical documents are supported by a User Manual and a complete description of the GHRSST ISO-19115-2 metadata model. GDS-2.0 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 2.0 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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6 Applicable Documents

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

- [AD-1] GDS 2.0 Interface control Document (ICD), Version 1.0, available from `https://www.ghrsst.org/files/download.php\?m=documents\&f=110626163621-GHRSSTGDS20ICDDraft03.doc`
- [AD-2] GHRSST Userś Guide available from `https://www.ghrsst.org/documents/q/category/userinteraction/` netCDF user manuals and tools available from `http://www.unidata.ucar.edu/packages/netcdf/`
- [AD-3] netCDF Climate and Forecast (CF) Metadata Conventions version 1.4 available from `http://cf-pcmdi.llnl.gov/documents/cf-conventions/1.4/cf-conventions-multi.html`
- [AD-4] COARDS Conventions available from `http://ferret.wrc.noaa.gov/noaa\_coop/coop\_cdf\_profile.html`
- [AD-5] UDUNITS-2 package available from `http://www.unidata.ucar.edu/software/udunits/udunits2/udunits2.html`

7 Reference Documents

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

- [RD-1] GHRSST PP Data Product User manunal (GDS1.5) `https://www.ghrsst.org/files/download.php\?m=documents\&f=GHRSST-PP-Product-UserGuide-v1.1.pdf`.
- [RD-2] Donlon, C. J., I. Robinson, K. S Casey, J. Vazquez-Cuervo, E Armstrong, O. Arino, C. Gentemann, D. May, P. LeBorgne, J. Piolle, 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 (GHRSST-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. Piolle, 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/files/download.php\?m=documents\&f=GHRSST-PP-URD-v1.7.pdf`

8 Acryonyms and abbreviation list

AA	Associate Administrator
ACDC	Architecture Configuration and Design Constraints
ADD	Architecture Definition Document
AE	Ascent Element
AES	Advanced Exploration Systems
AESB	Aeronautics and Space Engineering Board
APMC	Agency Program Management Council
ASAP	Agency (Aeronautics) Safety Assessment Panel
BAA	Broad Agency Announcement
CAD	Computer-Aided Design
CCB	Configuration Control Board
CCBD	Configuration Control Board Directive
CDM	Configuration and Data Management
CDMP	Configuration and Data Management Plan
CHP	Crew Health and Performance
CI	Configuration Item
CLPS	Commercial Lunar Payload Services
CLV	Commercial Launch Vehicle
CM	Configuration Management
CMRD	Configuration Management Receipt Desk
CMW	Change Management Workflow
CPE	Change Package Engineer
CPM	Change Package Manager
CR	Change Request
CSA	Configuration Status Accounting
CSA	Canadian Space Agency
CSCI	Computer Software Configuration Item
CY	Calendar Year
ConOps	Concept of Operations
DAA	Deputy Associate Administrator
DAC	Design Analysis Cycle
DCR	Design Certification Review
DE	Descent Element
DIMA	Distributed Integrated Modular Avionics
DM	Data Management
DOF	Degree of Freedom
DPMC	Directorate Program Management Council
DQA	Data Quality Assurance
DRD	Data Requirements Description
DSN	Deep Space Network
EAR	Export Administration Requirements
ECLSS	Environmental Control and Life Support System
ECM	Exploration Command Module
ECR	Export Control Representative
EGS	Exploration Ground Systems
ESA	European Space Agency
ESD	Exploration Systems Development
ET	Event Tracker
EUS	Exploration Upper Stage
EVA	Extra-Vehicular Activity

EVR	Extra-Vehicular Robotics
FAQ	Freqently Asked Question
FCA	Functional Configuration Audit
FOD	Flight Operations
FW	Forward Work
GAO	Government Accountability Office
GDSS	Gateway Docking System Specification
GEO	Geostationary Earth Orbit
GN&C	Guidance Navigation and Control
GPCB	Gateway Program Control Board
GSCB	Gateway Systems Engineering and Integration Con…
GVCB	Gateway Vehicle Integration Control Board
HALO	Habitation and Logistics Outpost
HCB	Human Landing Systems Control Board
HEO	Human Exploration & Operations
HEOMD	Human Exploration & Operations Mission Directorate
HHP	Human Health & Performance
HLS	Human Landing Systems
IAC	Integrated Analysis Cycle
ICD	Interface Control Document
ICE	Integrated Collaborative Environment
ICPS	Interim Cryogenic Propulsion Stage
IDS	Integrated Data System

9 Document Conventions

The following sub-sections describe the notation conventions and data storage types that are used throughout this GDS 2.0 Technical Specification. Implementation projects are expected to adhere to the nomenclature and style of the GDS 2.0 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].

9.1 Use of text types

The following text types are used throughout this document:

Table 9.1: 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.

9.2 Use of colour in tables

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

Table 9.2: 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 coordinates	`float lat(nj, ni)`

9.3 Definitions of storage types within the GDS 2.0

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

Table 9.3: 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

10 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.

The GDS Technical Specification document forms a component document of the GDS 2.0 document set, which is shown schematically in Figure 5-1 below. Other documents from the GDS 2.0 document pack that are specified in the Applicable Documents section of this document shall be consulted when using this document.

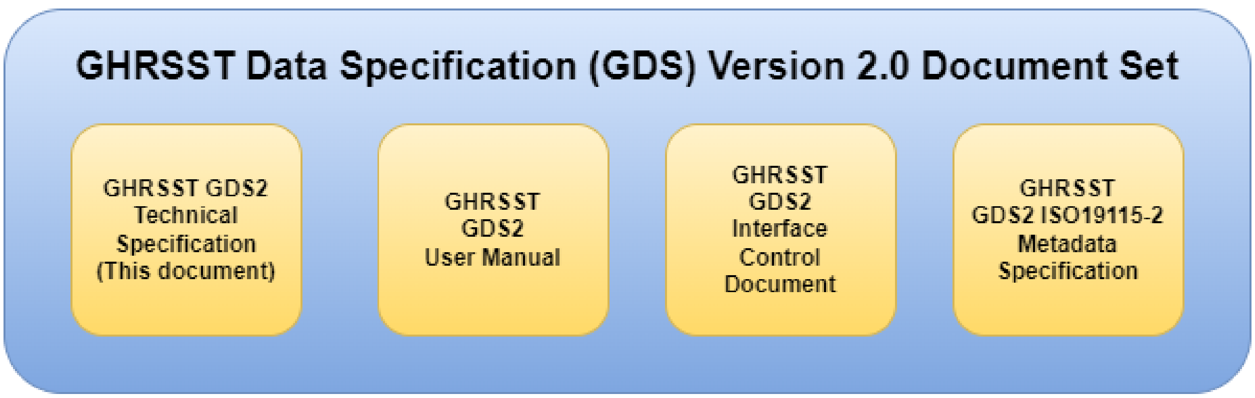

Figure 1: Schematic overview of the GHRSST Data Specification Version 2.0 document pack.

11 Overview of GHRSST and the GDS 2.0

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 2.0.

11.1 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) [RD7], [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.

11.2 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

11.3 GHRSST Organization

Over the last decade, 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 [RD-2] 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.

GHRSST data flow from numerous Regional Data Assembly Centreś (RDACs) to a Global Data Assembly Centre (GDAC) in near real time. Thirty days after observation, the data are transferred to a Long Term Stewardship and Reanalysis Facility (LTSRF). At present, RDACs from across Europe, Japan, Australia, and the United States contribute GHRSST data to the GDAC, operated by the NASA Jet Propulsion Laboratory, which in turn provides

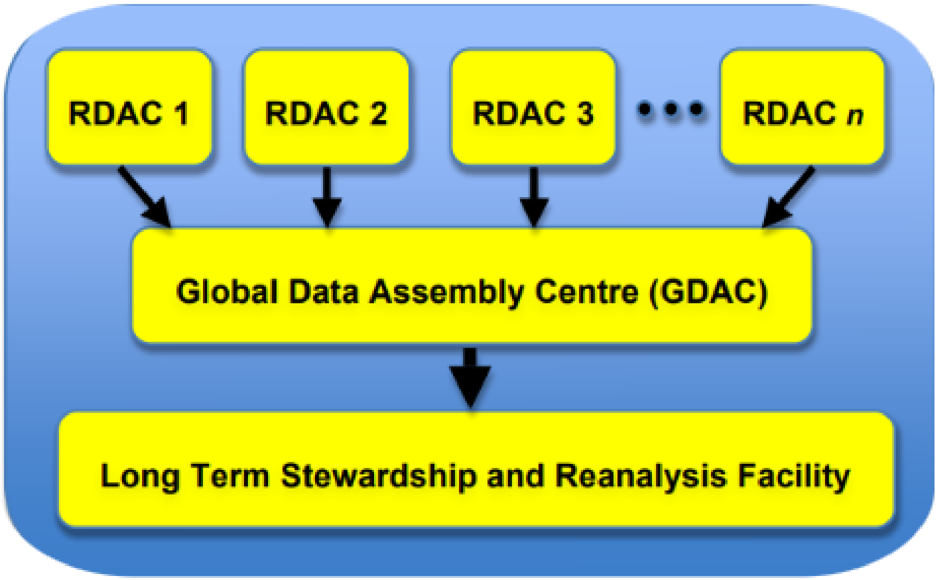

Figure 2: Schematic of the GHRSST Regional/Global Task Sharing (R/GTS) framework.

the data to the LTSRF operated by the NOAA National Oceanographic Data Center. The GHRSST R/GTS is shown schematically below in 2.

Since large-scale GHRSST data production and dissemination commenced in 2006, the GHRSST GDAC and LTSRF have combined to provide over 50,000 users more than 100 terabytes of GHRSST data. Over 28 terabytes of data are in NODCś LTSRF holdings with another approximately 10 Terabyte added each year. The detailed interactions of the R/GTS components are described in the GHRSST Interface Control Document [AD-1]. 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. A full discussion of GHRSST over the last 10 years is reported in [RD-2] and [RD-3].

11.4 Overview of the GDS 2.0

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 2011. In 2010 the Version 2 of the GDS described in this document will go into operations following a phased implementation schedule.

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 2.0 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.

12 GDS 2.0 Filenames and Supporting Conventions

Striving to achieve a flexible naming convention that maintains consistency across processing levels and better serves user needs, the GDS 2.0 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.

12.1 1 Overview of Filename Convention and Example Filenames

The filenaming convention for the GDS 2.0 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 **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 12.1: GDS 2.0 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 2.0 = "02.0".

<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.

12.1.1 L2_GHRSST Filename Example

20070503132300-NAVO-L2P_GHRSST-SSTblend-AVHRR17_L-SST_s0123_e0135-v02.0-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 2.0. The <Additional Segregator> text is "SST_s0123_e0135".

12.1.2 L3_GHRSST Filename Example

20070503110153-REMSS-L3C_GHRSST-SSTsubskin-TMI-tmi_20070503rt-v02.0-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 2.0 specifications. Its <Additional Segregator> text is "tmi_20070503rt".

12.1.3 L4_GHRSST Filename Example

20070503120000-UKMO-L4_GHRSST-SSTfnd-OSTIA-GLOB-v02.0-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 2.0 specifications and is version 1.0 of the file. The nominal time of the OSTIA analysis is 12:00:00 hours.

12.2 <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.

12.3 <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.

12.4 <RDAC>

Codes used for GHRSST Regional Data Assembly Centres (RDACs) are provided in the table below. 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.

Table 12.2: Regional Data Assembly Centre (RDAC) code table

RDAC Code	GHRSST RDAC Name
ABOM	Australian Bureau of Meteorology
CMC	Canadian Meteorological Centre
DMI	Danish Meteorological Institute
EUR	European RDAC
GOS	Gruppo di Oceanografia da Satellite
JPL	JPL Physical Oceanography Distributed Active Archive Center
JPL_OUROCEAN	JPL OurOcean Project
METNO	Norwegian Meteorological Institute
MYO	MyOcean
NAVO	Naval Oceanographic Office
NCDC	NOAA National Climatic Data Center
NEODAAS	NERC Observation Data Acquisition and Analysis Service
NOC	National Oceanography Centre, Southampton
NODC	NOAA National Oceanographic Data Center
OSDPD	NOAA Office of Satellite Data Processing and Distribution
OSISAF	EUMETSAT Ocean and Sea Ice Satellite Applications Facility
REMSS	Remote Sensing Systems, CA, USA
RSMAS	University of Miami, RSMAS
UKMO	UK Meteorological Office
UPA	United Kingdom Multi-Mission Processing and Archiving Facility
ESACCI	ESA SST Climate Change Initiative
JAXA	Japan Aerospace Exploration Agency
New codes	Please contact the GHRSST international Project Office if you require new codes to be included in future revisions of the GDS.

12.5 <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 7-3. 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).

13 GDS 2.0 Data Product File Structure

13.1 Overview of the GDS 2.0 netCDF File Format

GDS 2.0 data files preferentially use the **netCDF-4 Classic** format. However, as netCDF-4 is a relatively new format and includes a significant number of new features that may not be well supported by existing user applications and tools, the GHRSST Science Team agreed to support both netCDF-3 and netCDF-4 format data files during a transition period. At the 11th GHRSST Science Team meeting, Lima Peru, 21-25th June 2010 it was agreed that the transition period would end in 2013 at which point (subject to positive developments in the user community using netCDF-4) the use of netCDF-3 format data products will cease within the GHRSST R/GTS framework. **NetCDF-3 data products shall be delivered to the GDAC with an accompanying MMR file records as described in Section 13**. While netCDF-3 can store the metadata, it is computationally expensive to extract it from externally-compressed netCDF-3 files. 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 2.0 formatted data sets must comply with the Climate and Forecast (CF) Conventions, v1.4 [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://cfpcmdi.llnl.gov/discussion/index_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 earthbased coordinates) and time. In addition to the CF Conventions, GDS 2.0 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 2.0 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 2.0. 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 2.0 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 2.0 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.

13.2 GDS 2.0 netCDF Global Attributes

Table 8-1 below summarizes the global attributes that are mandatory for every GDS 2.0 netCDF data file. More details on the CF-mandated attributes (as indicated in the Source column) are available at: `http://cf-pcmdi.llnl.gov/documents/cf-conventions/1.4/cf-conventions.html#attribute-appendix` and information on the ACDD recommendations is available at `http://www.unidata.ucar.edu/software/netcdf-java/formats/DataDiscoveryAttConvention.html`.

Table 13.1: Mandatory global attributes for GDS 2.0 netCDF data files

Global Attribute Name	Type	Description	Source
acknowledgement	string	A place to acknowledge various types of support for the project that produced this data.	ACDD
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.)	ACDD
comment	string	Miscellaneous information about the data, not captured elsewhere. This attribute is defined in the CF Conventions.	CF, ACDD
conventions	string	A text string identifying the netCDF conventions followed (e.g., CF-1.4, 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.	ACDD
creator_name	string	The name of the person (or other creator type specified by the creator_type attribute) principally responsible for creating this data.	ACDD
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.	ACDD
date_created	string	The date on which this version of the data was created.	ACDD
easternmost_longitude	float	Decimal degrees east, range -180 to +180. This is equivalent to ACDD geospatial_lon_max.	podaac
geospatial_lat_resolution	float	Latitude Resolution in units matching geospatial_lat_units.	ACDD
geospatial_lat_units	string	Units of the latitudinal resolution. Typically "degrees_north"	ACDD
geospatial_lon_resolution	float	Longitude Resolution in units matching geospatial_lon_resolution	ACDD
geospatial_lon_units	string	Units of the longitudinal resolution. Typically "degrees_east"	ACDD
history	string	The name of the institution principally responsible for originating this data. This attribute is recommended by the CF convention.	CF, ACDD
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.	ACDD
institutions	string	The name of the institution principally responsible for originating this data. This attribute is recommended by the CF convention.	CF, ACDD
keywords	string	GCMD Science Keyword(s)	ACDD
keywords_vocabulary	string	The unique name or identifier of the vocabulary from which keywords are taken. e.g., the NASA Global Change Master Directory (GCMD) Science Keywords.	ACDD
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.	ACDD
Metadata_Conventions	string	A comma-separated list of the conventions that are followed by the dataset.	ACDD
metadata_link	string	Link to collection metadata record at archive	ACDD

Table 13.1: Mandatory global attributes for GDS 2.0 netCDF data files

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 via reverse-DNS naming convention.	ACDD
netcdf_version_id	string	Version of netCDF libraries used to create this file. For example, "4.1.1"	GDS
northernmost_latitude	float	Decimal degrees north, range -90 to +90. This is equivalent to ACDD geospatial_lat_max.	GDS
processing_level	string	A textual description of the processing (or quality control) level of the data.	ACDD & GDS
product_version	string	The product version of this data file	GDS
project	string	The name of the project(s) principally responsible for originating this data.	ACDD
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.	ACDD
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.	ACDD
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.	ACDD
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.	ACDD
source	string	Method of production of the original data.	CF
sourthernmost_latitude	float	Decimal degrees north, range -90 to +90. This is equivalent to ACDD geospatial_lat_min.	GDS
spatial_resolution	string	A string describing the approximate resolution of the product.	GDS
standard_name_vocabulary	string	The name and version of the controlled vocabulary from which variable standard names are taken.	ACDD
start_time	string	Representative date and time of the end of the granule in the ISO 8601 compliant format of "yyyymmddThhmmssZ".	GDS
stop_time	string	Representative date and time of the end of the granule in the ISO 8601 compliant format of "yyyymmddThhmmssZ".	GDS
summary	string	A paragraph describing the dataset, analogous to an abstract for a paper.	ACDD
time_coverage_end	string	Identical to stop_time. Included for increased ACDD compliance.	ACDD
time_coverage_start	string	Identical to start_time. Included for increased ACDD compliance.	ACDD
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.	CF, ACDD

Table 13.1: Mandatory global attributes for GDS 2.0 netCDF data files

uuid	string	A Universally Unique Identifier (UUID). Numerous, simple tools can be used to create a UUID, which is inserted as the value of this attribute. See http://en.wikipedia.org/wiki/Universally_Unique_Identifier for more information and tools.	GDS
westernmost_longitude	float	Decimal degrees east, range -180 to +180. This is equivalent to ACDD geospatial_lon_min.	GDS

13.3 GDS 2.0 netCDF Variable Attributes

Table 13.2: Table 8-2. Variable attributes for GDS 2.0 netCDF data files

Variable Attribute Name	Format	Description	Source
_FillValue	Must be the same as the variable type	A value used to indicate array elements containing no valid data. 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.	CF
units	string	Text description of the units, preferably S.I., and must be compatible with the Unidata UDUNITS-2 package [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.	CF, ACDD
scale_factor	Must be expressed in the unpacked data type	To be multiplied by the variable to recover the original value. Defined by the producing RDAC. Valid values within {value_min} and {valid_max} should be transformed by {scale_factor} and {add_offset}, otherwise skipped to avoid floating point errors.	CF
add_offset	Must be expressed in the unpacked data type	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.	CF
long_name	string	A free-text descriptive variable name.	CF, ACDD
valid_min	Expressed in same data type as variable	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	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

Table 13.2: Table 8-2. Variable attributes for GDS 2.0 netCDF data files

standard_name	string	Where defined, a standard and unique description of a physical quantity. For the complete list of standard name strings, see [AD-8]. {Do not} include this attribute if no {standard_name} exists.	CF, ACDD
comment	string	Miscellaneous information about the variable or the methods used to produce it.	CF
source	string	{For L2P and L3 files}: For a data variable with a single source, use the GHRSST unique string listed in Table 7-10 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 =} sources_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 commaseparated list only the sources relevant to this variable.	CF
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
axis	String	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://cfpcmdi.llnl.gov/documents/cfconventions/1.4/cfconventions.html#coordinate-types`	CF
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
coordinates	String	Identifies auxiliary coordinate variables, label variables, and alternate coordinate variables. See the section on coordinate-system in [AD3]. This attribute must be provided if the data are on a non-regular lat/lon grid (map projection or swath data).	CF
grid_mapping	String	Use this for data variables that are on a projected grid. The attribute takes a string value that is the name of another variable in the file that provides the description of the mapping via a collection of attached attributes. 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. See the section on mappings-andprojections in [AD-3]	CF
flag_mappings	String	Space-separated list of text descriptions associated in strict order with conditions set by either flag_values or flag_masks. Words within a phrase should be connected with underscores.	CF

Table 13.2: Table 8-2. Variable attributes for GDS 2.0 netCDF data files

flag_values	Must be the same as the variable type	Comma-separated array of valid, mutually exclusive variable values (required when the bit field contains enumerated values; i.e., a "list" of conditions). Used primarily for {quality_level} and "{sources_of_xxx}" variables.	CF
flag_masks	Must be the same as the variable type	Comma-separated array of valid variable masks (required when the bit field contains independent Boolean conditions; i.e., a bit "mask"). 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://cfpcmdi.llnl.gov/documents/cfconventions/1.5/ch03s05.html#id2710752` for examples), but this practice is discouraged.}	CF
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

13.4 GDS 2.0 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 2.0 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.

13.4.1 Native datasets

Hoc est casus simplex. Multae L3, L4, et GMPE comoediae, necnon quaedam geostationaria L2P comoediae, in ordinaria lat/lon tabula praebentur. In huiusmodi projectione, solum duo coordinate sunt requisitae et vectorum formis servari possunt. Longitudines debent variare ab -180 ad +180, id est ab 180 gradibus Occidentem ad 180 gradibus Orientem. Latitudines debent variare ab -90 ad +90, id est ab 90 gradibus Meridiem ad 90 gradibus Septentrionem. Non debet esse _FillValue pro latitudine et longitudine, et omnes SST pixeles debent habere validum latitudinis et longitudinis valorem.

Recommendatur ut tempus dimensionem pro Level 3 et Level 4 data prodigia ut infinita specificetur. Nota quod tempus dimensio pro L2P data est stricta definita ut tempus=1 (infinita dimensio non permittitur). Hoc strictum definitum est quia L2P data sunt swath based et geospatial informatio potest mutare per consecutive tempus slabs.

In GHRSST L3 et L4 granulis, solum unum tempus dimensio (tempus=1) est, et variabilis tempus solum unum valorem habet (secunda post 1981), sed infinitum tempus dimensionem permittit netCDF instrumenta et utilitates facile concatenare (et exempli gratia, mediare) seriem de tempore consecutive GHRSST granulis. Sequens CDL exemplum dat:

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

Pro his casibus, dimensiones et coordinae variabiles debent uti pro regulari lat/lon tabula, ut in Tabula 8-3 monstratur. Nullae specificae variabiles attributi sunt requisitae pro aliis variabilibus (ut sea_surface_temperature, ut in exemplo dat in Tabula 8-3).

Table 13.3: Example CDL description of native dataset

netcdf native example dimensions
i = 90 i_g = 90 j = 90 j_g = 90 k = 50 k_u = 50 k_l = 50 k_p1 = 51 tile = 13 time = 1 nv = 2 nb = 4
coordinates
int32 i (i) i:axis = "X" i:long_name = "grid index in x for variables at tracer and 'v' locations" i:swap_dim = "XC" i:comment = "In the Arakawa C-grid system, tracer (e.g., THETA) and 'v' variables (e.g., VVEL) have the same x coordinate on the model grid." i:coverage_content_type = "coordinate" int32 i_g (i_g) i_g:axis = "X" i_g:long_name = "grid index in x for variables at 'u' and 'g' locations" i_g:c_grid_axis_shift = "-0.5" i_g:swap_dim = "XG"

Table 13.3: Example CDL description of native dataset

```
        i_g:comment = "In the Arakawa C-grid system, 'u' (e.g., UVEL) and 'g' variables (e.g., XG) have the same x coordinate on the model grid."
        i_g:coverage_content_type = "coordinate"
    int32 j (j)
        j:axis = "Y"
        j:long_name = "grid index in y for variables at tracer and 'u' locations"
        j:swap_dim = "YC"
        j:comment = "In the Arakawa C-grid system, tracer (e.g., THETA) and 'u' variables (e.g., UVEL) have the same y coordinate on the model grid."
        j:coverage_content_type = "coordinate"
    int32 j_g (j_g)
        j_g:axis = "Y"
        j_g:long_name = "grid index in y for variables at 'v' and 'g' locations"
        j_g:c_grid_axis_shift = "-0.5"
        j_g:swap_dim = "YG"
        j_g:comment = "In the Arakawa C-grid system, 'v' (e.g., VVEL) and 'g' variables (e.g., XG) have the same y coordinate."
        j_g:coverage_content_type = "coordinate"
    int32 k (k)
        k:axis = "Z"
        k:long_name = "grid index in z for tracer variables"
        k:swap_dim = "Z"
        k:coverage_content_type = "coordinate"
    int32 k_u (k_u)
        k_u:axis = "Z"
        k_u:c_grid_axis_shift = "0.5"
        k_u:swap_dim = "Zu"
        k_u:coverage_content_type = "coordinate"
        k_u:long_name = "grid index in z corresponding to the bottom face of tracer grid cells ('w' locations)"
        k_u:comment = "First index corresponds to the bottom surface of the uppermost tracer grid cell. The use of 'u' in the variable name follows the MITgcm convention for ocean variables in which the upper (u) face of a tracer grid cell on the logical grid corresponds to the bottom face of the grid cell on the physical grid."
    int32 k_l (k_l)
        k_l:axis = "Z"
        k_l:c_grid_axis_shift = "-0.5"
        k_l:swap_dim = "Zl"
        k_l:coverage_content_type = "coordinate"
        k_l:long_name = "grid index in z corresponding to the top face of tracer grid cells ('w' locations)"
        k_l:comment = "First index corresponds to the top surface of the uppermost tracer grid cell. The use of 'l' in the variable name follows the MITgcm convention for ocean variables in which the lower (l) face of a tracer grid cell on the logical grid corresponds to the top face of the grid cell on the physical grid."
    int32 k_p1 (k_p1)
        k_p1:axis = "Z"
        k_p1:long_name = "grid index in z for variables at 'w' locations"
        k_p1:c_grid_axis_shift = "[-0.5 0.5]"
        k_p1:swap_dim = "Zp1"
        k_p1:comment = "Includes top of uppermost model tracer cell (k_p1=0) and bottom of lowermost tracer cell (k_p1=51)."
        k_p1:coverage_content_type = "coordinate"
    int32 tile (tile)
        tile:long_name = "lat-lon-cap tile index"
        tile:comment = "The ECCO V4 horizontal model grid is divided into 13 tiles of 90x90 cells for convenience."
        tile:coverage_content_type = "coordinate"
    int32 time (time)
        time:long_name = "center time of averaging period"
        time:axis = "T"
        time:bounds = "time_bnds"
        time:coverage_content_type = "coordinate"
        time:standard_name = "time"
```

Table 13.3: Example CDL description of native dataset

```
        time:units = "hours since 1992-01-01T12:00:00"
        time:calendar = "proleptic_gregorian"
    float32 XC (tile, j, i)
        XC:long_name = "longitude of tracer grid cell center"
        XC:units = "degrees_east"
        XC:coordinate = "YC XC"
        XC:bounds = "XC_bnds"
        XC:comment = "nonuniform grid spacing"
        XC:coverage_content_type = "coordinate"
        XC:standard_name = "longitude"
    float32 YC (tile, j, i)
        YC:long_name = "latitude of tracer grid cell center"
        YC:units = "degrees_north"
        YC:coordinate = "YC XC"
        YC:bounds = "YC_bnds"
        YC:comment = "nonuniform grid spacing"
        YC:coverage_content_type = "coordinate"
        YC:standard_name = "latitude"
    float32 XG (tile, j_g, i_g)
        XG:long_name = "longitude of 'southwest' corner of tracer grid cell"
        XG:units = "degrees_east"
        XG:coordinate = "YG XG"
        XG:comment = "Nonuniform grid spacing. Note: 'southwest' does not correspond to geographic orientation but is used
for convenience to describe the computational grid. See MITgcm dcoumentation for details."
        XG:coverage_content_type = "coordinate"
        XG:standard_name = "longitude"
    float32 YG (tile, j_g, i_g)
        YG:long_name = "latitude of 'southwest' corner of tracer grid cell"
        YG:units = "degrees_north"
        YG:coordinate = "YG XG"
        YG:comment = "Nonuniform grid spacing. Note: 'southwest' does not correspond to geographic orientation but is used
for convenience to describe the computational grid. See MITgcm dcoumentation for details."
        YG:coverage_content_type = "coordinate"
        YG:standard_name = "latitude"
    float32 Z (k)
        Z:long_name = "depth of tracer grid cell center"
        Z:units = "m"
        Z:positive = "up"
        Z:bounds = "Z_bnds"
        Z:comment = "Non-uniform vertical spacing."
        Z:coverage_content_type = "coordinate"
        Z:standard_name = "depth"
    float32 Zp1 (k_p1)
        Zp1:long_name = "depth of tracer grid cell interface"
        Zp1:units = "m"
        Zp1:positive = "up"
        Zp1:comment = "Contains one element more than the number of vertical layers. First element is 0m, the depth of the
upper interface of the surface grid cell. Last element is the depth of the lower interface of the deepest grid cell."
        Zp1:coverage_content_type = "coordinate"
        Zp1:standard_name = "depth"
    float32 Zu (k_u)
        Zu:units = "m"
        Zu:positive = "up"
        Zu:coverage_content_type = "coordinate"
        Zu:standard_name = "depth"
        Zu:long_name = "depth of the bottom face of tracer grid cells"
```

Table 13.3: Example CDL description of native dataset

Zu:comment = "First element is -10m, the depth of the bottom face of the first tracer grid cell. Last element is the depth of the bottom face of the deepest grid cell. The use of 'u' in the variable name follows the MITgcm convention for ocean variables in which the upper (u) face of a tracer grid cell on the logical grid corresponds to the bottom face of the grid cell on the physical grid. In other words, the logical vertical grid of MITgcm ocean variables is inverted relative to the physical vertical grid." float32 Zl (k_l) Zl:units = "m" Zl:positive = "up" Zl:coverage_content_type = "coordinate" Zl:standard_name = "depth" Zl:long_name = "depth of the top face of tracer grid cells" Zl:comment = "First element is 0m, the depth of the top face of the first tracer grid cell (ocean surface). Last element is the depth of the top face of the deepest grid cell. The use of 'l' in the variable name follows the MITgcm convention for ocean variables in which the lower (l) face of a tracer grid cell on the logical grid corresponds to the top face of the grid cell on the physical grid. In other words, the logical vertical grid of MITgcm ocean variables is inverted relative to the physical vertical grid." int32 time_bnds (time, nv) time_bnds:comment = "Start and end times of averaging period." time_bnds:coverage_content_type = "coordinate" time_bnds:long_name = "time bounds of averaging period" float32 XC_bnds (tile, j, i, nb) XC_bnds:comment = "Bounds array follows CF conventions. XC_bnds[i,j,0] = 'southwest' corner (j-1, i-1), XC_bnds[i,j,1] = 'southeast' corner (j-1, i+1), XC_bnds[i,j,2] = 'northeast' corner (j+1, i+1), XC_bnds[i,j,3] = 'northwest' corner (j+1, i-1). Note: 'southwest', 'southeast', northwest', and 'northeast' do not correspond to geographic orientation but are used for convenience to describe the computational grid. See MITgcm dcoumentation for details." XC_bnds:coverage_content_type = "coordinate" XC_bnds:long_name = "longitudes of tracer grid cell corners" float32 YC_bnds (tile, j, i, nb) YC_bnds:comment = "Bounds array follows CF conventions. YC_bnds[i,j,0] = 'southwest' corner (j-1, i-1), YC_bnds[i,j,1] = 'southeast' corner (j-1, i+1), YC_bnds[i,j,2] = 'northeast' corner (j+1, i+1), YC_bnds[i,j,3] = 'northwest' corner (j+1, i-1). Note: 'southwest', 'southeast', northwest', and 'northeast' do not correspond to geographic orientation but are used for convenience to describe the computational grid. See MITgcm dcoumentation for details." YC_bnds:coverage_content_type = "coordinate" YC_bnds:long_name = "latitudes of tracer grid cell corners" float32 Z_bnds (k, nv) Z_bnds:comment = "One pair of depths for each vertical level." Z_bnds:coverage_content_type = "coordinate" Z_bnds:long_name = "depths of tracer grid cell upper and lower interfaces"
data variables
float32 ADVx_SLT (time, k, tile, j, i_g) ADVx_SLT:_FillValue = "9.969209968386869e+36" ADVx_SLT:long_name = "Lateral advective flux of salinity in the model +x direction" ADVx_SLT:units = "1e-3 m3 s-1" ADVx_SLT:mate = "ADVy_SLT" ADVx_SLT:coverage_content_type = "modelResult" ADVx_SLT:direction = ">0 increases salinity (SALT)" ADVx_SLT:comment = "Lateral advective flux of salinity (SALT) in the +x direction through the 'u' face of the tracer cell on the native model grid. Note: in the Arakawa-C grid, horizontal flux quantities are staggered relative to the tracer cells with indexing such that +ADVx_SLT(i_g,j,k) corresponds to +x fluxes through the 'u' face of the tracer cell at (i,j,k). Also, the model +x direction does not necessarily correspond to the geographical east-west direction because the x and y axes of the model's curvilinear lat-lon-cap (llc) grid have arbitrary orientations which vary within and across tiles. Salinity defined using CF convention 'Sea water salinity is the salt content of sea water, often on the Practical Salinity Scale of 1978. However, the unqualified term 'salinity' is generic and does not necessarily imply any particular method of calculation. The units of salinity are dimensionless and the units attribute should normally be given as 1e-3 or 0.001 i.e. parts per thousand.' see https://cfconventions.org/Data/cf-standard-names/73/build/cf-standard-name-table.html" ADVx_SLT:coordinates = "Z time" ADVx_SLT:valid_min = "-181830224.0" ADVx_SLT:valid_max = "260411296.0"

Table 13.3: Example CDL description of native dataset

```
float32 DFxE_SLT (time, k, tile, j, i_g)
    DFxE_SLT:_FillValue = "9.969209968386869e+36"
    DFxE_SLT:long_name = "Lateral diffusive flux of salinity in the model +x direction"
    DFxE_SLT:units = "1e-3 m3 s-1"
    DFxE_SLT:mate = "DFyE_SLT"
    DFxE_SLT:coverage_content_type = "modelResult"
    DFxE_SLT:direction = ">0 increases salinity (SALT)"
    DFxE_SLT:comment = "Lateral diffusive flux of salinity (SALT) in the +x direction through the 'u' face of the tracer cell on the native model grid. Note: in the Arakawa-C grid, horizontal flux quantities are staggered relative to the tracer cells with indexing such that +DFxE_SLT(i_g,j,k) corresponds to +x fluxes through the 'u' face of the tracer cell at (i,j,k). Also, the model +x direction does not necessarily correspond to the geographical east-west direction because the x and y axes of the model's curvilinear lat-lon-cap (llc) grid have arbitrary orientations which vary within and across tiles. Salinity defined using CF convention 'Sea water salinity is the salt content of sea water, often on the Practical Salinity Scale of 1978. However, the unqualified term 'salinity' is generic and does not necessarily imply any particular method of calculation. The units of salinity are dimensionless and the units attribute should normally be given as 1e-3 or 0.001 i.e. parts per thousand.' see https://cfconventions.org/Data/cf-standard-names/73/build/cf-standard-name-table.html"
    DFxE_SLT:coordinates = "Z time"
    DFxE_SLT:valid_min = "-125908.03125"
    DFxE_SLT:valid_max = "192716.484375"
float32 ADVy_SLT (time, k, tile, j_g, i)
    ADVy_SLT:_FillValue = "9.969209968386869e+36"
    ADVy_SLT:long_name = "Lateral advective flux of salinity in the model +y direction"
    ADVy_SLT:units = "1e-3 m3 s-1"
    ADVy_SLT:mate = "ADVx_SLT"
    ADVy_SLT:coverage_content_type = "modelResult"
    ADVy_SLT:direction = ">0 increases salinity (SALT)"
    ADVy_SLT:comment = "Lateral advective flux of salinity (SALT) in the +y direction through the 'v' face of the tracer cell on the native model grid. Note: in the Arakawa-C grid, horizontal flux quantities are staggered relative to the tracer cells with indexing such that +ADVy_SLT(i,j_g,k) corresponds to +y fluxes through the 'v' face of the tracer cell at (i,j,k). Also, the model +y direction does not necessarily correspond to the geographical north-south direction because the x and y axes of the model's curvilinear lat-lon-cap (llc) grid have arbitrary orientations which vary within and across tiles. Salinity defined using CF convention 'Sea water salinity is the salt content of sea water, often on the Practical Salinity Scale of 1978. However, the unqualified term 'salinity' is generic and does not necessarily imply any particular method of calculation. The units of salinity are dimensionless and the units attribute should normally be given as 1e-3 or 0.001 i.e. parts per thousand.' see https://cfconventions.org/Data/cf-standard-names/73/build/cf-standard-name-table.html"
    ADVy_SLT:coordinates = "Z time"
    ADVy_SLT:valid_min = "-137905760.0"
    ADVy_SLT:valid_max = "164271664.0"
float32 DFyE_SLT (time, k, tile, j_g, i)
    DFyE_SLT:_FillValue = "9.969209968386869e+36"
    DFyE_SLT:long_name = "Lateral diffusive flux of salinity in the model +y direction"
    DFyE_SLT:units = "1e-3 m3 s-1"
    DFyE_SLT:mate = "DFxE_SLT"
    DFyE_SLT:coverage_content_type = "modelResult"
    DFyE_SLT:direction = ">0 increases salinity (SALT)"
    DFyE_SLT:comment = "Lateral diffusive flux of salinity (SALT) in the +y direction through the 'v' face of the tracer cell on the native model grid. Note: in the Arakawa-C grid, horizontal flux quantities are staggered relative to the tracer cells with indexing such that +DFyE_SLT(i,j_g,k) corresponds to +y fluxes through the 'v' face of the tracer cell at (i,j,k). Also, the model +y direction does not necessarily correspond to the geographical north-south direction because the x and y axes of the model's curvilinear lat-lon-cap (llc) grid have arbitrary orientations which vary within and across tiles. Salinity defined using CF convention 'Sea water salinity is the salt content of sea water, often on the Practical Salinity Scale of 1978. However, the unqualified term 'salinity' is generic and does not necessarily imply any particular method of calculation. The units of salinity are dimensionless and the units attribute should normally be given as 1e-3 or 0.001 i.e. parts per thousand.' see https://cfconventions.org/Data/cf-standard-names/73/build/cf-standard-name-table.html"
    DFyE_SLT:coordinates = "Z time"
    DFyE_SLT:valid_min = "-114959.2109375"
    DFyE_SLT:valid_max = "154227.140625"
```

Table 13.3: Example CDL description of native dataset

```
float32 ADVr_SLT (time, k_l, tile, j, i)
    ADVr_SLT:_FillValue = "9.969209968386869e+36"
    ADVr_SLT:long_name = "Vertical advective flux of salinity"
    ADVr_SLT:units = "1e-3 m3 s-1"
    ADVr_SLT:coverage_content_type = "modelResult"
    ADVr_SLT:direction = ">0 decreases salinity (SALT)"
    ADVr_SLT:comment = "Vertical advective flux of salinity (SALT) in the +z direction through the top 'w' face of the tracer cell on the native model grid. Note: in the Arakawa-C grid, vertical flux quantities are staggered relative to the tracer cells with indexing such that +ADVr_SLT(i,j,k_l) corresponds to upward +z fluxes through the top 'w' face of the tracer cell at (i,j,k). Salinity defined using CF convention 'Sea water salinity is the salt content of sea water, often on the Practical Salinity Scale of 1978. However, the unqualified term 'salinity' is generic and does not necessarily imply any particular method of calculation. The units of salinity are dimensionless and the units attribute should normally be given as 1e-3 or 0.001 i.e. parts per thousand.' see https://cfconventions.org/Data/cf-standard-names/73/build/cf-standard-name-table.html"
    ADVr_SLT:coordinates = "XC Zl YC time"
    ADVr_SLT:valid_min = "-324149856.0"
    ADVr_SLT:valid_max = "263294624.0"
float32 DFrE_SLT (time, k_l, tile, j, i)
    DFrE_SLT:_FillValue = "9.969209968386869e+36"
    DFrE_SLT:long_name = "Vertical diffusive flux of salinity (explicit term)"
    DFrE_SLT:units = "1e-3 m3 s-1"
    DFrE_SLT:coverage_content_type = "modelResult"
    DFrE_SLT:direction = ">0 decreases salinity (SALT)"
    DFrE_SLT:comment = "The explicit term of the vertical diffusive flux of salinity (SALT) in the +z direction through the top 'w' face of the tracer cell on the native model grid. In the ECCO V4r4 model, an implicit scheme is used to calculate vertical diffusive tracer fluxes due to background diffusivity and the Kwz component of the GM-Redi tensor (vertical flux as a function of vertical gradient) while an explicit scheme is used to calculate the vertical diffusive fluxes from the Kwx and Kwy components of the GM-Redi tensor (vertical flux as a function of horizontal gradient). Both implicit and explicit components of vertical diffusive flux of salinity are provided. Note: in the Arakawa-C grid, vertical flux quantities are staggered relative to the tracer cells with indexing such that +DFrE_SLT(i,j,k_l) corresponds to upward +z fluxes through the top 'w' face of the tracer cell at (i,j,k). Salinity defined using CF convention 'Sea water salinity is the salt content of sea water, often on the Practical Salinity Scale of 1978. However, the unqualified term 'salinity' is generic and does not necessarily imply any particular method of calculation. The units of salinity are dimensionless and the units attribute should normally be given as 1e-3 or 0.001 i.e. parts per thousand.' see https://cfconventions.org/Data/cf-standard-names/73/build/cf-standard-name-table.html"
    DFrE_SLT:coordinates = "XC Zl YC time"
    DFrE_SLT:valid_min = "-1074719.375"
    DFrE_SLT:valid_max = "471215.75"
float32 DFrI_SLT (time, k_l, tile, j, i)
    DFrI_SLT:_FillValue = "9.969209968386869e+36"
    DFrI_SLT:long_name = "Vertical diffusive flux of salinity (implicit term)"
    DFrI_SLT:units = "1e-3 m3 s-1"
    DFrI_SLT:coverage_content_type = "modelResult"
    DFrI_SLT:direction = ">0 decreases salinity (SALT)"
    DFrI_SLT:comment = "The implicit term of the vertical diffusive flux of salinity (SALT) in the +z direction through the top 'w' face of the tracer cell on the native model grid. In the ECCO V4r4 model, an implicit scheme is used to calculate vertical diffusive tracer fluxes due to background diffusivity and the Kwz component of the GM-Redi tensor (vertical flux as a function of vertical gradient) while an explicit scheme is used to calculate the vertical diffusive fluxes from the Kwx and Kwy components of the GM-Redi tensor (vertical flux as a function of horizontal gradient). Both implicit and explicit components of vertical diffusive flux of salinity are provided. Note: in the Arakawa-C grid, vertical flux quantities are staggered relative to the tracer cells with indexing such that +DFrI_SLT(i,j,k_l) corresponds to upward +z fluxes through the top face 'w' of the tracer cell at (i,j,k). Salinity defined using CF convention 'Sea water salinity is the salt content of sea water, often on the Practical Salinity Scale of 1978. However, the unqualified term 'salinity' is generic and does not necessarily imply any particular method of calculation. The units of salinity are dimensionless and the units attribute should normally be given as 1e-3 or 0.001 i.e. parts per thousand.' see https://cfconventions.org/Data/cf-standard-names/73/build/cf-standard-name-table.html"
    DFrI_SLT:coordinates = "XC Zl YC time"
    DFrI_SLT:valid_min = "-30609048.0"
    DFrI_SLT:valid_max = "3197643.0"
float32 oceSPtnd (time, k, tile, j, i)
```

Table 13.3: Example CDL description of native dataset

oceSPtnd:_FillValue = "9.969209968386869e+36"
oceSPtnd:long_name = "Salt tendency due to the vertical transport of salt in high-salinity brine plumes"
oceSPtnd:units = "g m-2 s-1"
oceSPtnd:coverage_content_type = "modelResult"
oceSPtnd:direction = ">0 increases salinity (SALT)"
oceSPtnd:comment = "Salt tendency due to the vertical transport of salt in high-salinity brine plumes. Note: units are grams of salt per square meter per second, not salinity per square meter per second."
oceSPtnd:coordinates = "XC Z YC time"
oceSPtnd:valid_min = "0.0"
oceSPtnd:valid_max = "0.021119138225913048"

13.4.2 Latlon datasets

Hoc est casus simplex. Multae L3, L4, et GMPE comoediae, necnon quaedam geostationaria L2P comoediae, in ordinaria lat/lon tabula praebentur. In huiusmodi projectione, solum duo coordinate sunt requisitae et vectorum formis servari possunt. Longitudines debent variare ab -180 ad +180, id est ab 180 gradibus Occidentem ad 180 gradibus Orientem. Latitudines debent variare ab -90 ad +90, id est ab 90 gradibus Meridiem ad 90 gradibus Septentrionem. Non debet esse _FillValue pro latitudine et longitudine, et omnes SST pixeles debent habere validum latitudinis et longitudinis valorem.

Recommendatur ut tempus dimensionem pro Level 3 et Level 4 data prodigia ut infinita specificetur. Nota quod tempus dimensio pro L2P data est stricta definita ut tempus=1 (infinita dimensio non permittitur). Hoc strictum definitum est quia L2P data sunt swath based et geospatial informatio potest mutare per consecutive tempus slabs.

In GHRSST L3 et L4 granulis, solum unum tempus dimensio (tempus=1) est, et variabilis tempus solum unum valorem habet (secunda post 1981), sed infinitum tempus dimensionem permittit netCDF instrumenta et utilitates facile concatenare (et exempli gratia, mediare) seriem de tempore consecutive GHRSST granulis. Sequens CDL exemplum dat:

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

Pro his casibus, dimensiones et coordinae variabiles debent uti pro regulari lat/lon tabula, ut in Tabula 8-3 monstratur. Nullae specificae variabiles attributi sunt requisitae pro aliis variabilibus (ut sea_surface_temperature, ut in exemplo dat in Tabula 8-3).

Table 13.4: Example CDL description of latlon dataset

netcdf latlon example dimensions
time = 1 latitude = 360 longitude = 720 nv = 2
coordinates
int32 time (time) time:axis = "T" time:bounds = "time_bnds" time:coverage_content_type = "coordinate" time:long_name = "center time of averaging period" time:standard_name = "time" time:units = "hours since 1992-01-01T12:00:00"

Table 13.4: Example CDL description of latlon dataset

```
        time:calendar = "proleptic_gregorian"
    float32 latitude (latitude)
        latitude:axis = "Y"
        latitude:bounds = "latitude_bnds"
        latitude:comment = "uniform grid spacing from -89.75 to 89.75 by 0.5"
        latitude:coverage_content_type = "coordinate"
        latitude:long_name = "latitude at grid cell center"
        latitude:standard_name = "latitude"
        latitude:units = "degrees_north"
    float32 longitude (longitude)
        longitude:axis = "X"
        longitude:bounds = "longitude_bnds"
        longitude:comment = "uniform grid spacing from -179.75 to 179.75 by 0.5"
        longitude:coverage_content_type = "coordinate"
        longitude:long_name = "longitude at grid cell center"
        longitude:standard_name = "longitude"
        longitude:units = "degrees_east"
    int32 time_bnds (time, nv)
        time_bnds:comment = "Start and end times of averaging period."
        time_bnds:coverage_content_type = "coordinate"
        time_bnds:long_name = "time bounds of averaging period"
    float32 latitude_bnds (latitude, nv)
        latitude_bnds:coverage_content_type = "coordinate"
        latitude_bnds:long_name = "latitude bounds grid cells"
    float32 longitude_bnds (longitude, nv)
        longitude_bnds:coverage_content_type = "coordinate"
        longitude_bnds:long_name = "longitude bounds grid cells"
data variables
    float32 EXFhl (time, latitude, longitude)
        EXFhl:_FillValue = "9.969209968386869e+36"
        EXFhl:coverage_content_type = "modelResult"
        EXFhl:direction = ">0 increases potential temperature (THETA)"
        EXFhl:long_name = "Open ocean air-sea latent heat flux"
        EXFhl:standard_name = "surface_downward_latent_heat_flux"
        EXFhl:units = "W m-2"
        EXFhl:comment = "Air-sea latent heat flux per unit area of open water (not covered by sea-ice). Note: calculated from the bulk formula following Large and Yeager (2004) NCAR/TN-460+STR."
        EXFhl:coordinates = "time"
        EXFhl:valid_min = "-1772.513671875"
        EXFhl:valid_max = "273.9528503417969"
    float32 EXFhs (time, latitude, longitude)
        EXFhs:_FillValue = "9.969209968386869e+36"
        EXFhs:coverage_content_type = "modelResult"
        EXFhs:direction = ">0 increases potential temperature (THETA)"
        EXFhs:long_name = "Open ocean air-sea sensible heat flux"
        EXFhs:standard_name = "surface_downward_sensible_heat_flux"
        EXFhs:units = "W m-2"
        EXFhs:comment = "Air-sea sensible heat flux per unit area of open water (not covered by sea-ice). Note: calculated from the bulk formula following Large and Yeager (2004) NCAR/TN-460+STR."
        EXFhs:coordinates = "time"
        EXFhs:valid_min = "-2478.766357421875"
        EXFhs:valid_max = "357.0105895996094"
    float32 EXFlwdn (time, latitude, longitude)
        EXFlwdn:_FillValue = "9.969209968386869e+36"
        EXFlwdn:coverage_content_type = "modelResult"
        EXFlwdn:direction = ">0 increases potential temperature (THETA)"
        EXFlwdn:long_name = "Downward longwave radiative flux"
```

Table 13.4: Example CDL description of latlon dataset

```
        EXFlwdn:standard_name = "surface_downwelling_longwave_flux_in_air"
        EXFlwdn:units = "W m-2"
        EXFlwdn:comment = "Downward longwave radiative flux. Note: sum of ERA-Interim downward longwave radiation and the control adjustment from ocean state estimation."
        EXFlwdn:coordinates = "time"
        EXFlwdn:valid_min = "4.188045501708984"
        EXFlwdn:valid_max = "513.3919067382812"
    float32 EXFswdn (time, latitude, longitude)
        EXFswdn:_FillValue = "9.969209968386869e+36"
        EXFswdn:coverage_content_type = "modelResult"
        EXFswdn:direction = ">0 increases potential temperature (THETA)"
        EXFswdn:long_name = "Downwelling shortwave radiative flux"
        EXFswdn:standard_name = "surface_downwelling_shortwave_flux_in_air"
        EXFswdn:units = "W m-2"
        EXFswdn:comment = "Downward shortwave radiative flux. Note: sum of ERA-Interim downward shortwave radiation and the control adjustment from ocean state estimation."
        EXFswdn:coordinates = "time"
        EXFswdn:valid_min = "-224.63368225097656"
        EXFswdn:valid_max = "707.345947265625"
    float32 EXFqnet (time, latitude, longitude)
        EXFqnet:_FillValue = "9.969209968386869e+36"
        EXFqnet:coverage_content_type = "modelResult"
        EXFqnet:direction = ">0 increases potential temperature (THETA)"
        EXFqnet:long_name = "Open ocean net air-sea heat flux"
        EXFqnet:units = "W m-2"
        EXFqnet:comment = "Net air-sea heat flux (turbulent and radiative) per unit area of open water (not covered by sea-ice). Note: net upward heat flux over open water, calculated as EXFlwnet+EXFswnet-EXFlh-EXFhs."
        EXFqnet:coordinates = "time"
        EXFqnet:valid_min = "-687.8736572265625"
        EXFqnet:valid_max = "3408.977783203125"
    float32 oceQnet (time, latitude, longitude)
        oceQnet:_FillValue = "9.969209968386869e+36"
        oceQnet:coverage_content_type = "modelResult"
        oceQnet:direction = ">0 increases potential temperature (THETA)"
        oceQnet:long_name = "Net heat flux into the ocean surface"
        oceQnet:standard_name = "surface_downward_heat_flux_in_sea_water"
        oceQnet:units = "W m-2"
        oceQnet:comment = "Net heat flux into the ocean surface from all processes: air-sea turbulent and radiative fluxes and turbulent and conductive fluxes between the ocean and sea-ice and snow. Note: oceQnet does not include the change in ocean heat content due to changing ocean ocean mass (oceFWflx). Mass fluxes from evaporation, precipitation, and runoff (EXFempmr) happen at the same temperature as the ocean surface temperature. Consequently, EmPmR does not change ocean surface temperature. Conversely, mass fluxes due to sea-ice thickening/thinning and snow melt in the model are assumed to happen at a fixed 0C. Consequently, mass fluxes due to phase changes between seawater and sea-ice and snow induce a heat flux when the ocean surface temperaure is not 0C. The variable TFLUX does include the change in ocean heat content due to changing ocean mass."
        oceQnet:coordinates = "time"
        oceQnet:valid_min = "-1708.8460693359375"
        oceQnet:valid_max = "675.3716430664062"
    float32 SIatmQnt (time, latitude, longitude)
        SIatmQnt:_FillValue = "9.969209968386869e+36"
        SIatmQnt:coverage_content_type = "modelResult"
        SIatmQnt:direction = ">0 upward, decreases ocean temperature"
        SIatmQnt:long_name = "Net upward heat flux to the atmosphere"
        SIatmQnt:standard_name = "surface_upward_heat_flux_in_air"
        SIatmQnt:units = "W m-2"
```

Table 13.4: Example CDL description of latlon dataset

```
        SIatmQnt:comment = "Net upward heat flux to the atmosphere across open water and sea-ice or snow surfaces. Note: nonzero SIatmQnt may not be associated with a change in ocean potential temperature due to sea-ice growth or melting. To calculate total ocean heat content changes use the variable TFLUX which also accounts for changing ocean mass (e.g. oceFWflx)."
        SIatmQnt:coordinates = "time"
        SIatmQnt:valid_min = "-756.0607299804688"
        SIatmQnt:valid_max = "1704.7703857421875"
    float32 TFLUX (time, latitude, longitude)
        TFLUX:_FillValue = "9.969209968386869e+36"
        TFLUX:coverage_content_type = "modelResult"
        TFLUX:direction = ">0 increases potential temperature (THETA)"
        TFLUX:long_name = "Rate of change of ocean heat content per m2 accounting for mass fluxes."
        TFLUX:units = "W m-2"
        TFLUX:comment = "The rate of change of ocean heat content due to heat fluxes across the liquid surface and the addition or removal of mass. . Note: the global area integral of TFLUX and geothermal flux (geothermalFlux.bin) matches the time-derivative of ocean heat content (J/s). Unlike oceQnet, TFLUX includes the contribution to the ocean heat content from changing ocean mass (e.g. from oceFWflx)."
        TFLUX:coordinates = "time"
        TFLUX:valid_min = "-1713.51220703125"
        TFLUX:valid_max = "870.3130493164062"
    float32 EXFswnet (time, latitude, longitude)
        EXFswnet:_FillValue = "9.969209968386869e+36"
        EXFswnet:coverage_content_type = "modelResult"
        EXFswnet:direction = ">0 increases potential temperature (THETA)"
        EXFswnet:long_name = "Open ocean net shortwave radiative flux"
        EXFswnet:standard_name = "surface_net_downward_shortwave_flux"
        EXFswnet:units = "W m-2"
        EXFswnet:comment = "Net shortwave radiative flux per unit area of open water (not covered by sea-ice). Note: net shortwave radiation over open water calculated from downward shortwave flux (EXFswdn) and ocean surface albdeo."
        EXFswnet:coordinates = "time"
        EXFswnet:valid_min = "-655.6171264648438"
        EXFswnet:valid_max = "193.89297485351562"
    float32 EXFlwnet (time, latitude, longitude)
        EXFlwnet:_FillValue = "9.969209968386869e+36"
        EXFlwnet:coverage_content_type = "modelResult"
        EXFlwnet:direction = ">0 increases potential temperature (THETA)"
        EXFlwnet:long_name = "Net open ocean longwave radiative flux"
        EXFlwnet:standard_name = "surface_net_downward_longwave_flux"
        EXFlwnet:units = "W m-2"
        EXFlwnet:comment = "Net longwave radiative flux per unit area of open water (not covered by sea-ice). Note: net longwave radiation over open water calculated from downward longwave radiation (EXFlwdn) and upward longwave radiation from ocean and sea-ice thermal emission (Stefan-Boltzman law)."
        EXFlwnet:coordinates = "time"
        EXFlwnet:valid_min = "-144.3661346435547"
        EXFlwnet:valid_max = "293.4114990234375"
    float32 oceQsw (time, latitude, longitude)
        oceQsw:_FillValue = "9.969209968386869e+36"
        oceQsw:coverage_content_type = "modelResult"
        oceQsw:direction = ">0 increases potential temperature (THETA)"
        oceQsw:long_name = "Net shortwave radiative flux across the ocean surface"
        oceQsw:units = "W m-2"
        oceQsw:comment = "Net shortwave radiative flux across the ocean surface. Note: Shortwave radiation penetrates below the surface grid cell."
        oceQsw:coordinates = "time"
        oceQsw:valid_min = "-134.39808654785156"
        oceQsw:valid_max = "655.6171264648438"
    float32 SIaaflux (time, latitude, longitude)
```

Table 13.4: Example CDL description of latlon dataset

SIaaflux:_FillValue = "9.969209968386869e+36"
SIaaflux:coverage_content_type = "modelResult"
SIaaflux:direction = ">0 decrease potential temperature (THETA)"
SIaaflux:long_name = "Conservative ocean and sea-ice advective heat flux adjustment"
SIaaflux:units = "W m-2"
SIaaflux:comment = "Heat flux associated with the temperature difference between sea surface temperature and sea-ice (assume 0 degree C in the model). Note: heat flux needed to melt/freeze sea-ice at 0 degC to sea water at the ocean surface (at sea surface temperature), excluding the latent heat of fusion."
SIaaflux:coordinates = "time"
SIaaflux:valid_min = "-16.214622497558594"
SIaaflux:valid_max = "50.35451889038086"

13.4.3 1D datasets

Hoc est casus simplex. Multae L3, L4, et GMPE comoediae, necnon quaedam geostationaria L2P comoediae, in ordinaria lat/lon tabula praebentur. In huiusmodi projectione, solum duo coordinate sunt requisitae et vectorum formis servari possunt. Longitudines debent variare ab -180 ad +180, id est ab 180 gradibus Occidentem ad 180 gradibus Orientem. Latitudines debent variare ab -90 ad +90, id est ab 90 gradibus Meridiem ad 90 gradibus Septentrionem. Non debet esse _FillValue pro latitudine et longitudine, et omnes SST pixeles debent habere validum latitudinis et longitudinis valorem.

Recommendatur ut tempus dimensionem pro Level 3 et Level 4 data prodigia ut infinita specificetur. Nota quod tempus dimensio pro L2P data est stricta definita ut tempus=1 (infinita dimensio non permittitur). Hoc strictum definitum est quia L2P data sunt swath based et geospatial informatio potest mutare per consecutive tempus slabs.

In GHRSST L3 et L4 granulis, solum unum tempus dimensio (tempus=1) est, et variabilis tempus solum unum valorem habet (secunda post 1981), sed infinitum tempus dimensionem permittit netCDF instrumenta et utilitates facile concatenare (et exempli gratia, mediare) seriem de tempore consecutive GHRSST granulis. Sequens CDL exemplum dat:

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

Pro his casibus, dimensiones et coordinae variabiles debent uti pro regulari lat/lon tabula, ut in Tabula 8-3 monstratur. Nullae specificae variabiles attributi sunt requisitae pro aliis variabilibus (ut sea_surface_temperature, ut in exemplo dat in Tabula 8-3).

Table 13.5: Example CDL description of 1D dataset

netcdf 1D example dimensions
time = 227904
coordinates
int32 time (time) time:axis = "T" time:comment = "" time:coverage_content_type = "coordinate" time:long_name = "snapshot time" time:standard_name = "time" time:units = "hours since 1992-01-01T12:00:00" time:calendar = "proleptic_gregorian"
data variables

Table 13.5: Example CDL description of 1D dataset

```
float64 Pa_global (time)
    Pa_global:_FillValue = "9.969209968386869e+36"
    Pa_global:coverage_content_type = "modelResult"
    Pa_global:long_name = "Global mean atmospheric surface pressure over the ocean and sea-ice"
    Pa_global:standard_name = "air_pressure_at_sea_level"
    Pa_global:units = "N m-2"
    Pa_global:valid_min = "100873.14755283327"
    Pa_global:valid_max = "101257.45252296235"
    Pa_global:coordinates = "time"
```

14 Native Dataset Coordinate Variables

14.1 Overview of the Native Dataset Coordinate Variables

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Vivamus at enim eget nisi ultrices facilisis a et purus. Sed tincidunt scelerisque ligula, in vehicula dui venenatis at. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Curabitur consequat commodo nunc, nec lacinia quam feugiat vel. Integer bibendum lectus sit amet quam elementum, ut pretium quam malesuada. Cras fermentum venenatis augue, id commodo libero facilisis nec. Quisque euismod, odio vitae dapibus convallis, justo enim iaculis metus, vel interdum elit nisi vel lectus. Fusce tempor elit in semper condimentum. Ut quis dui eget purus cursus interdum eu ac elit.'

14.2 Native coordinates NetCDF GRID_GEOMETRY_ECCO

Table 14.1: Variables in the dataset GRID_GEOMETRY_ECCO

Dataset:	GRID_GEOMETRY_ECCO
Field:	XC
Field:	YC
Field:	XG
Field:	YG
Field:	CS
Field:	SN
Field:	rA
Field:	dxG
Field:	dyG
Field:	Depth
Field:	rAz
Field:	dxC
Field:	dyC
Field:	rAw
Field:	rAs
Field:	hFacC
Field:	hFacW
Field:	hFacS
Field:	maskC
Field:	maskW
Field:	maskS

14.2.1 Native coordinates Variable XC

Table 14.2: CDL description of GRID_GEOMETRY_ECCO's XC variable

Storage Type	Variable Name	Description	Unit
float32	XC	longitude of tracer grid cell center	degrees_east
CDL Description			
float32 XC(tile, j, i) XC: long_name = longitude of tracer grid cell center XC: units = degrees_east XC: coordinate = YC XC XC: bounds = XC_bnds XC: coverage_content_type = coordinate XC: standard_name = longitude			
Comments			
nonuniform grid spacing			

../images/plots/native_plots_coords/Geometry_Parameters_for_th

Figure 3:
Dataset: GRID_GEOMETRY_ECCO
Variable: XC

14.2.2 Native coordinates Variable YC

Table 14.3: CDL description of GRID_GEOMETRY_ECCO's YC variable

Storage Type	Variable Name	Description	Unit
float32	YC	latitude of tracer grid cell center	degrees_north
CDL Description			
float32 YC(tile, j, i) YC: long_name = latitude of tracer grid cell center YC: units = degrees_north YC: coordinate = YC XC YC: bounds = YC_bnds YC: coverage_content_type = coordinate YC: standard_name = latitude			
Comments			
nonuniform grid spacing			

../images/plots/native_plots_coords/Geometry_Parameters_for_th

Figure 4:
Dataset: GRID_GEOMETRY_ECCO
Variable: YC

14.2.3 Native coordinates Variable XG

Table 14.4: CDL description of GRID_GEOMETRY_ECCO's XG variable

<table>
<tr><th>Storage Type</th><th>Variable Name</th><th>Description</th><th>Unit</th></tr>
<tr><td>float32</td><td>XG</td><td>longitude of 'southwest' corner of tracer grid cell</td><td>degrees_east</td></tr>
<tr><th colspan="4">CDL Description</th></tr>
<tr><td colspan="4">float32 XG(tile, j_g, i_g)
XG: long_name = "longitude of southwest corner of tracer grid cell"
XG: units = degrees_east
XG: coordinate = YG XG
XG: coverage_content_type = coordinate
XG: standard_name = longitude</td></tr>
<tr><th colspan="4">Comments</th></tr>
<tr><td colspan="4">Nonuniform grid spacing. Note: 'southwest' does not correspond to geographic orientation but is used for convenience to describe the computational grid. See MITgcm dcoumentation for details.</td></tr>
</table>

../images/plots/native_plots_coords/Geometry_Parameters_for_th

Figure 5:
Dataset: GRID_GEOMETRY_ECCO
Variable: XG

14.2.4 Native coordinates Variable YG

Table 14.5: CDL description of GRID_GEOMETRY_ECCO's YG variable

Storage Type	Variable Name	Description	Unit
float32	YG	latitude of 'southwest' corner of tracer grid cell	degrees_north
CDL Description			
float32 YG(tile, j_g, i_g) YG: long_name = "latitude of southwest corner of tracer grid cell" YG: units = degrees_north YG: coordinates = YG XG YG: coverage_content_type = coordinate YG: standard_name = latitude			
Comments			
Nonuniform grid spacing. Note: 'southwest' does not correspond to geographic orientation but is used for convenience to describe the computational grid. See MITgcm dcoumentation for details.			

../images/plots/native_plots_coords/Geometry_Parameters_for_th

Figure 6:
Dataset: GRID_GEOMETRY_ECCO
Variable: YG

14.2.5 Native coordinates Variable CS

Table 14.6: CDL description of GRID_GEOMETRY_ECCO's CS variable

<table>
<tr><th>Storage Type</th><th>Variable Name</th><th>Description</th><th>Unit</th></tr>
<tr><td>float32</td><td>CS</td><td>cosine of tracer grid cell orientation vs geographical north</td><td>1</td></tr>
<tr><th colspan="4">CDL Description</th></tr>
<tr><td colspan="4">float32 CS(tile, j, i)
CS: _FillValue = 9.96921e+36
CS: long_name = cosine of tracer grid cell orientation vs geographical north
CS: units = 1
CS: coordinate = YC XC
CS: coverage_content_type = modelResult
CS: coordinates = YC XC</td></tr>
<tr><th colspan="4">Comments</th></tr>
<tr><td colspan="4">CS and SN are required to calculate the geographic (meridional, zonal) components of vectors on the curvilinear model grid. Note: for vector R with components R_x and R_y: R_{east} = CS R_x - SN R_y. R_{north} = SN R_x + CS R_y</td></tr>
</table>

../images/plots/native_plots_coords/Geometry_Parameters_for_th

Figure 7:
Dataset: GRID_GEOMETRY_ECCO
Variable: CS

14.2.6 Native coordinates Variable SN

Table 14.7: CDL description of GRID_GEOMETRY_ECCO's SN variable

Storage Type	Variable Name	Description	Unit
float32	SN	sine of tracer grid cell orientation vs geographical north	1
CDL Description			
float32 SN(tile, j, i) SN: _FillValue = 9.96921e+36 SN: long_name = sine of tracer grid cell orientation vs geographical north SN: units = 1 SN: coordinate = YC XC SN: coverage_content_type = modelResult SN: coordinates = YC XC			
Comments			
CS and SN are required to calculate the geographic (meridional, zonal) components of vectors on the curvilinear model grid. Note: for vector R with components R_x and R_y in local grid directions x and y, the geographical eastward component R_{east} = CS R_x - SN R_y. The geographical northward component R_{north} = SN R_x + CS R_y.			

../images/plots/native_plots_coords/Geometry_Parameters_for_th

Figure 8:
Dataset: GRID_GEOMETRY_ECCO
Variable: SN

14.2.7 Native coordinates Variable rA

Table 14.8: CDL description of GRID_GEOMETRY_ECCO's rA variable

Storage Type	Variable Name	Description	Unit
float32	rA	area of tracer grid cell	m2
CDL Description			
float32 rA(tile, j, i) rA: _FillValue = 9.96921e+36 rA: long_name = area of tracer grid cell rA: units = m2 rA: coordinate = YC XC rA: coverage_content_type = modelResult rA: standard_name = cell_area rA: coordinates = YC XC			
Comments			
N/A			

../images/plots/native_plots_coords/Geometry_Parameters_for_th

Figure 9:
Dataset: GRID_GEOMETRY_ECCO
Variable: rA

14.2.8 Native coordinates Variable dxG

Table 14.9: CDL description of GRID_GEOMETRY_ECCO's dxG variable

Storage Type	Variable Name	Description	Unit
float32	dxG	distance between 'southwest' and 'southeast' corners of the tracer grid cell	m
CDL Description			
float32 dxG(tile, j_g, i) dxG: _FillValue = 9.96921e+36 dxG: long_name = "distance between southwest and southeast corners of the tracer grid cell" dxG: units = m dxG: coordinate = YG XC dxG: coverage_content_type = modelResult			
Comments			
Alternatively, the length of 'south' side of tracer grid cell. Note: 'south', 'southwest', and 'southeast' do not correspond to geographic orientation but are used for convenience to describe the computational grid. See MITgcm documentation for details.			

../images/plots/native_plots_coords/Geometry_Parameters_for_th

Figure 10:
Dataset: GRID_GEOMETRY_ECCO
Variable: dxG

14.2.9 Native coordinates Variable dyG

Table 14.10: CDL description of GRID_GEOMETRY_ECCO's dyG variable

Storage Type	Variable Name	Description	Unit
float32	dyG	distance between 'southwest' and 'northwest' corners of the tracer grid cell	m
CDL Description			
float32 dyG(tile, j, i_g) dyG: _FillValue = 9.96921e+36 dyG: long_name = "distance between southwest and northwest corners of the tracer grid cell" dyG: units = m dyG: coordinate = YC XG dyG: coverage_content_type = modelResult			
Comments			
Alternatively, the length of 'west' side of tracer grid cell. Note: 'west, 'southwest', and 'northwest' do not correspond to geographic orientation but are used for convenience to describe the computational grid. See MITgcm documentation for details.			

../images/plots/native_plots_coords/Geometry_Parameters_for_th

Figure 11:
Dataset: GRID_GEOMETRY_ECCO
Variable: dyG

14.2.10 Native coordinates Variable Depth

Table 14.11: CDL description of GRID_GEOMETRY_ECCO's Depth variable

Storage Type	Variable Name	Description	Unit
float32	Depth	model seafloor depth below ocean surface at rest	m
CDL Description			
float32 Depth(tile, j, i) Depth: _FillValue = 9.96921e+36 Depth: long_name = model seafloor depth below ocean surface at rest Depth: units = m Depth: coordinate = XC YC Depth: coverage_content_type = modelResult Depth: standard_name = sea_floor_depth_below_geoid Depth: coordinates = YC XC			
Comments			
Model sea surface height (SSH) of 0m corresponds to an ocean surface at rest relative to the geoid. Depth corresponds to seafloor depth below geoid. Note: the MITgcm used by ECCO V4r4 implements 'partial cells' so the actual model seafloor depth may differ from the seafloor depth provided by the input bathymetry file.			

../images/plots/native_plots_coords/Geometry_Parameters_for_th

Figure 12:
Dataset: GRID_GEOMETRY_ECCO
Variable: Depth

14.2.11 Native coordinates Variable rAz

Table 14.12: CDL description of GRID_GEOMETRY_ECCO's rAz variable

Storage Type	Variable Name	Description	Unit
float32	rAz	area of vorticity 'g' grid cell	m2
CDL Description			
float32 rAz(tile, j_g, i_g) rAz: _FillValue = 9.96921e+36 rAz: long_name = "area of vorticity g grid cell" rAz: units = m2 rAz: coordinate = YG XG rAz: coverage_content_type = modelResult rAz: standard_name = cell_area rAz: coordinates = YG XG			
Comments			
Vorticity cells are staggered in space relative to tracer cells, nominally situated on tracer cell corners. Vorticity cell (i,j) is located at the 'southwest' corner of tracer grid cell (i, j). Note: 'southwest' does not correspond to geographic orientation but is used for convenience to describe the computational grid. See MITgcm documentation for details.			

../images/plots/native_plots_coords/Geometry_Parameters_for_th

Figure 13:
Dataset: GRID_GEOMETRY_ECCO
Variable: rAz

14.2.12 Native coordinates Variable dxC

Table 14.13: CDL description of GRID_GEOMETRY_ECCO's dxC variable

<table>
<tr><th>Storage Type</th><th>Variable Name</th><th>Description</th><th>Unit</th></tr>
<tr><td>float32</td><td>dxC</td><td>distance between centers of adjacent tracer grid cells in the 'x' direction</td><td>m</td></tr>
<tr><th colspan="4">CDL Description</th></tr>
<tr><td colspan="4">float32 dxC(tile, j, i_g)
dxC: _FillValue = 9.96921e+36
dxC: long_name = "distance between centers of adjacent tracer grid cells in the x direction"
dxC: units = m
dxC: coordinate = YC XG
dxC: coverage_content_type = modelResult</td></tr>
<tr><th colspan="4">Comments</th></tr>
<tr><td colspan="4">Alternatively, the length of 'north' side of vorticity grid cells. Note: 'north' does not correspond to geographic orientation but is used for convenience to describe the computational grid. See MITgcm documentation for details.</td></tr>
</table>

../images/plots/native_plots_coords/Geometry_Parameters_for_th

Figure 14:
Dataset: GRID_GEOMETRY_ECCO
Variable: dxC

14.2.13 Native coordinates Variable dyC

Table 14.14: CDL description of GRID_GEOMETRY_ECCO's dyC variable

Storage Type	Variable Name	Description	Unit
float32	dyC	distance between centers of adjacent tracer grid cells in the 'y' direction	m
CDL Description			
float32 dyC(tile, j_g, i) dyC: _FillValue = 9.96921e+36 dyC: long_name = "distance between centers of adjacent tracer grid cells in the y direction" dyC: units = m dyC: coordinate = YG XC dyC: coverage_content_type = modelResult			
Comments			
Alternatively, the length of 'east' side of vorticity grid cells. Note: 'east' does not correspond to geographic orientation but is used for convenience to describe the computational grid. See MITgcm documentation for details.			

../images/plots/native_plots_coords/Geometry_Parameters_for_th

Figure 15:
Dataset: GRID_GEOMETRY_ECCO
Variable: dyC

14.2.14 Native coordinates Variable rAw

Table 14.15: CDL description of GRID_GEOMETRY_ECCO's rAw variable

Storage Type	Variable Name	Description	Unit
float32	rAw	area of 'v' grid cell	m2
CDL Description			
float32 rAw(tile, j, i_g) rAw: _FillValue = 9.96921e+36 rAw: long_name = "area of v grid cell" rAw: units = m2 rAw: coordinate = YG XC rAw: coverage_content_type = modelResult rAw: standard_name = cell_area			
Comments			
Model 'v' grid cells are staggered in space between adjacent tracer grid cells in the 'x' direction. 'v' grid cell (i,j) is situated at the 'west' edge of tracer grid cell (i, j). Note: 'west' does not correspond to geographic orientation but is used for convenience to describe the computational grid. See MITgcm documentation for details.			

../images/plots/native_plots_coords/Geometry_Parameters_for_th

**Figure 16:
Dataset: GRID_GEOMETRY_ECCO
Variable: rAw**

14.2.15 Native coordinates Variable rAs

Table 14.16: CDL description of GRID_GEOMETRY_ECCO's rAs variable

Storage Type	Variable Name	Description	Unit
float32	rAs	area of 'u' grid cell	m2
CDL Description			
float32 rAs(tile, j_g, i) rAs: _FillValue = 9.96921e+36 rAs: long_name = "area of u grid cell" rAs: units = m2 rAs: coordinates = YG XC rAs: coverage_content_type = modelResult rAs: standard_name = cell_area			
Comments			
Model 'u' grid cells are staggered in space between adjacent tracer grid cells in the 'y' direction. 'u' grid cell (i,j) is situated at the 'south' edge of tracer grid cell (i, j). Note: 'south' does not correspond to geographic orientation but is used for convenience to describe the computational grid. See MITgcm documentation for details.			

`../images/plots/native_plots_coords/Geometry_Parameters_for_th`

Figure 17:
Dataset: GRID_GEOMETRY_ECCO
Variable: rAs

14.2.16 Native coordinates Variable hFacC

Table 14.17: CDL description of GRID_GEOMETRY_ECCO's hFacC variable

Storage Type	Variable Name	Description	Unit
float32	hFacC	vertical open fraction of tracer grid cell	1
CDL Description			
float32 hFacC(k, tile, j, i) hFacC: _FillValue = 9.96921e+36 hFacC: long_name = vertical open fraction of tracer grid cell hFacC: coverage_content_type = modelResult hFacC: units = 1 hFacC: coordinates = Z YC XC			
Comments			
Tracer grid cells may be fractionally closed in the vertical. The open vertical fraction is hFacC. The model allows for partially-filled cells to represent topographic variations more smoothly (hFacC < 1). Completely closed (dry) tracer grid cells have hFacC = 0. Note: the model z* coordinate system allows hFacC to vary through time. A time-invariant hFacC field is provided for reference.			

../images/plots/native_plots_coords/Geometry_Parameters_for_th

Figure 18:
Dataset: GRID_GEOMETRY_ECCO
Variable: hFacC

14.2.17 Native coordinates Variable hFacW

Table 14.18: CDL description of GRID_GEOMETRY_ECCO's hFacW variable

Storage Type	Variable Name	Description	Unit
float32	hFacW	vertical open fraction of tracer grid cell 'west' face	1
CDL Description			
float32 hFacW(k, tile, j, i_g) hFacW: _FillValue = 9.96921e+36 hFacW: long_name = "vertical open fraction of tracer grid cell west face" hFacW: coverage_content_type = modelResult hFacW: units = 1 hFacW: coordinates = Z			
Comments			
The 'west' face of tracer grid cells may be fractionally closed in the vertical. The open vertical fraction is hFacW. The model allows for partially-filled cells for smoother representation of seafloor topography. Tracer grid cells adjacent in the 'x' direction that are partially closed in the vertical have hFacW < 1. The model z* coordinate system used by the model permits hFacC, and therefore hFacW, to vary through time. A time-invariant hFacW field is provided for reference. Note: The term 'west' does not correspond to geographic orientation but is used for convenience to describe the computational grid. See MITgcm documentation for details.			

../images/plots/native_plots_coords/Geometry_Parameters_for_th

Figure 19:
Dataset: GRID_GEOMETRY_ECCO
Variable: hFacW

14.2.18 Native coordinates Variable hFacS

Table 14.19: CDL description of GRID_GEOMETRY_ECCO's hFacS variable

Storage Type	Variable Name	Description	Unit
float32	hFacS	vertical open fraction of tracer grid cell 'south' face	1
CDL Description			
float32 hFacS(k, tile, j_g, i) hFacS: _FillValue = 9.96921e+36 hFacS: long_name = "vertical open fraction of tracer grid cell south face" hFacS: coverage_content_type = modelResult hFacS: units = 1 hFacS: coordinates = Z			
Comments			
The 'south' face of tracer grid cells may be fractionally closed in the vertical. The open vertical fraction is hFacS. The model allows for partially-filled cells for smoother representation of seafloor topography. Tracer grid cells adjacent in the 'y' direction that are partially closed in the vertical have hFacS < 1. The model z* coordinate system used by the model permits hFacC, and therefore hFacS, to vary through time. A time-invariant hFacS field is provided for reference. Note: The term 'south' does not correspond to geographic orientation but is used for convenience to describe the computational grid. See MITgcm documentation for details.			

../images/plots/native_plots_coords/Geometry_Parameters_for_th

Figure 20:
Dataset: GRID_GEOMETRY_ECCO
Variable: hFacS

14.2.19 Native coordinates Variable maskC

Table 14.20: CDL description of GRID_GEOMETRY_ECCO's maskC variable

Storage Type	Variable Name	Description	Unit
bool	maskC	wet/dry boolean mask for tracer grid cell	N/A
CDL Description			
bool maskC(k, tile, j, i) maskC: _FillValue = 1 maskC: long_name = wet/dry boolean mask for tracer grid cell maskC: coverage_content_type = modelResult maskC: coordinates = Z YC XC			
Comments			
True for tracer grid cells with nonzero open vertical fraction (hFacC > 0), otherwise False. Although hFacC can vary though time, cells will never close if starting open and will never open if starting closed: hFacC(i,j,k,t) > 0 for all t, if hFacC(i,j,k,t=0) and hFacC(i,j,k,t) = 0 for all t, if hFacC(i,j,k,t=0) = 0. Therefore, maskC is time invariant.			

../images/plots/native_plots_coords/Geometry_Parameters_for_th

Figure 21:
Dataset: GRID_GEOMETRY_ECCO
Variable: maskC

14.2.20 Native coordinates Variable maskW

Table 14.21: CDL description of GRID_GEOMETRY_ECCO's maskW variable

Storage Type	Variable Name	Description	Unit
bool	maskW	wet/dry boolean mask for 'west' face of tracer grid cell	N/A
CDL Description			
bool maskW(k, tile, j, i_g) maskW: _FillValue = 1 maskW: long_name = "wet/dry boolean mask for west face of tracer grid cell" maskW: coverage_content_type = modelResult maskW: coordinates = Z			
Comments			
True for grid cells with nonzero open vertical fraction along their 'west' face (hFacW > 0), otherwise False. Although hFacW can vary though time, cells will never close if starting open and will never open if starting closed: hFacW(i,j,k,t) > 0 for all t, if hFacW(i,j,k,t=0) and hFacW(i,j,k,t) = 0 for all t, if hFacW(i,j,k,t=0) = 0. Therefore, maskW is time invariant. Note:			

../images/plots/native_plots_coords/Geometry_Parameters_for_th

Figure 22:
Dataset: GRID_GEOMETRY_ECCO
Variable: maskW

14.2.21 Native coordinates Variable maskS

Table 14.22: CDL description of GRID_GEOMETRY_ECCO's maskS variable

Storage Type	Variable Name	Description	Unit
bool	maskS	wet/dry boolean mask for 'south' face of tracer grid cell	N/A
CDL Description			
bool maskS(k, tile, j_g, i) maskS: _FillValue = 1 maskS: long_name = "wet/dry boolean mask for south face of tracer grid cell" maskS: coverage_content_type = modelResult maskS: coordinates = Z			
Comments			
True for grid cells with nonzero open vertical fraction along their 'south' face (hFacS > 0), otherwise False. Although hFacS can vary though time, cells will never close if starting open and will never open if starting closed: hFacS(i,j,k,t) > 0 for all t, if hFacS(i,j,k,t=0) and hFacS(i,j,k,t) = 0 for all t, if hFacS(i,j,k,t=0) = 0. Therefore, maskS is time invariant. Note:			

../images/plots/native_plots_coords/Geometry_Parameters_for_th

Figure 23:
Dataset: GRID_GEOMETRY_ECCO
Variable: maskS

15 Native Dataset Groupings

15.1 Overview of the Native Dataset Groupings

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Vivamus at enim eget nisi ultrices facilisis a et purus. Sed tincidunt scelerisque ligula, in vehicula dui venenatis at. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Curabitur consequat commodo nunc, nec lacinia quam feugiat vel. Integer bibendum lectus sit amet quam elementum, ut pretium quam malesuada. Cras fermentum venenatis augue, id commodo libero facilisis nec. Quisque euismod, odio vitae dapibus convallis, justo enim iaculis metus, vel interdum elit nisi vel lectus. Fusce tempor elit in semper condimentum. Ut quis dui eget purus cursus interdum eu ac elit.'

15.2 Native NetCDF ATM_SURFACE_TEMP_HUM_WIND_PRES

Table 15.1: Variables in the dataset ATM_SURFACE_TEMP_HUM_WIND_PRES

Dataset:	**ATM_SURFACE_TEMP_HUM_WIND_PRES**
Field:	EXFatemp
Field:	EXFaqh
Field:	EXFuwind
Field:	EXFvwind
Field:	EXFwspee
Field:	EXFpress

15.2.1 Native Variable EXFaqh

Table 15.2: CDL description of ATM_SURFACE_TEMP_HUM_WIND_PRES's EXFaqh variable

Storage Type	Variable Name	Description	Unit
float32	EXFaqh	Atmosphere surface (2 m) specific humidity	kg kg-1
CDL Description			
float32 EXFaqh(time, tile, j, i) EXFaqh: _FillValue = 9.96921e+36 EXFaqh: long_name = Atmosphere surface (2 m) specific humidity EXFaqh: units = kg kg: 1 EXFaqh: coverage_content_type = modelResult EXFaqh: standard_name = surface_specific_humidity EXFaqh: coordinates = time XC YC EXFaqh: valid_min = : 0.0014020215021446347 EXFaqh: valid_max = 0.03014513850212097			
Comments			
Surface (2 m) specific humidity over open water. Note: sum of ERA-Interim surface specific humidity and the control adjustment from ocean state estimation.			

../images/plots/native_plots/Atmosphere_Surface_Temperature_Hu

Figure 24:
Dataset: ATM_SURFACE_TEMP_HUM_WIND_PRES
Variable: EXFaqh

15.2.2 Native Variable EXFatemp

Table 15.3: CDL description of ATM_SURFACE_TEMP_HUM_WIND_PRES's EXFatemp variable

Storage Type	Variable Name	Description	Unit
float32	EXFatemp	Atmosphere surface (2 m) air temperature	degree_K
CDL Description			
float32 EXFatemp(time, tile, j, i) EXFatemp: _FillValue = 9.96921e+36 EXFatemp: long_name = Atmosphere surface (2 m) air temperature EXFatemp: units = degree_K EXFatemp: coverage_content_type = modelResult EXFatemp: standard_name = air_temperature EXFatemp: coordinates = time XC YC EXFatemp: valid_min = 195.37054443359375 EXFatemp: valid_max = 312.8451232910156			
Comments			
Surface (2 m) air temperature over open water. Note: sum of ERA-Interim surface air temperature and the control adjustment from ocean state estimation.			

../images/plots/native_plots/Atmosphere_Surface_Temperature_Hu

Figure 25:
Dataset: ATM_SURFACE_TEMP_HUM_WIND_PRES
Variable: EXFatemp

15.2.3 Native Variable EXFpress

Table 15.4: CDL description of ATM_SURFACE_TEMP_HUM_WIND_PRES's EXFpress variable

Storage Type	Variable Name	Description	Unit
float32	EXFpress	Atmosphere surface pressure	N m-2
CDL Description			
float32 EXFpress(time, tile, j, i) EXFpress: _FillValue = 9.96921e+36 EXFpress: long_name = Atmosphere surface pressure EXFpress: units = N m: 2 EXFpress: coverage_content_type = modelResult EXFpress: standard_name = surface_air_pressure EXFpress: coordinates = time XC YC EXFpress: valid_min = 92044.171875 EXFpress: valid_max = 106314.7734375			
Comments			
Atmospheric pressure field at sea level. Note: ERA-Interim atmospheric pressure, with air tides removed using a variety of methods. Not adjusted by the ocean state estimation.			

../images/plots/native_plots/Atmosphere_Surface_Temperature_Hu

Figure 26:
Dataset: ATM_SURFACE_TEMP_HUM_WIND_PRES
Variable: EXFpress

15.2.4 Native Variable EXFuwind

Table 15.5: CDL description of ATM_SURFACE_TEMP_HUM_WIND_PRES's EXFuwind variable

Storage Type	Variable Name	Description	Unit
float32	EXFuwind	Wind speed at 10m in the model +x direction	m s-1
CDL Description			
float32 EXFuwind(time, tile, j, i) EXFuwind: _FillValue = 9.96921e+36 EXFuwind: long_name = Wind speed at 10m in the model +x direction EXFuwind: units = m s: 1 EXFuwind: coverage_content_type = modelResult EXFuwind: standard_name = x_wind EXFuwind: coordinates = time XC YC EXFuwind: valid_min = : 34.528900146484375 EXFuwind: valid_max = 29.92486572265625			
Comments			
Wind speed at 10m in the +x direction at the tracer cell on the native model grid. Note: ECCO v4r4 is forced with wind stress (see EXFtaux) not vector winds converted to wind stress using bulk formulae. EXFuwind is calculated by converting wind stress to vector wind using bulk formulae.			

../images/plots/native_plots/Atmosphere_Surface_Temperature_Hu

Figure 27:
Dataset: ATM_SURFACE_TEMP_HUM_WIND_PRES
Variable: EXFuwind

15.2.5 Native Variable EXFvwind

Table 15.6: CDL description of ATM_SURFACE_TEMP_HUM_WIND_PRES's EXFvwind variable

Storage Type	Variable Name	Description	Unit
float32	EXFvwind	Wind speed at 10m in the model +y direction	m s-1

CDL Description

```
float32 EXFvwind(time, tile, j, i)
    EXFvwind: _FillValue = 9.96921e+36
    EXFvwind: long_name = Wind speed at 10m in the model +y direction
    EXFvwind: units = m s: 1
    EXFvwind: coverage_content_type = modelResult
    EXFvwind: standard_name = y_wind
    EXFvwind: coordinates = time XC YC
    EXFvwind: valid_min = : 27.9254093170166
    EXFvwind: valid_max = 45.065101623535156
```

Comments

Wind speed at 10m in the +y direction at the tracer cell on the native model grid. Note: ECCO v4r4 is forced with wind stress (see EXFtauy) not vector winds converted to wind stress using bulk formulae. EXFvwind is calculated by converting wind stress to vector wind using bulk formulae.

../images/plots/native_plots/Atmosphere_Surface_Temperature_Hu

Figure 28:
Dataset: ATM_SURFACE_TEMP_HUM_WIND_PRES
Variable: EXFvwind

15.2.6 Native Variable EXFwspee

Table 15.7: CDL description of ATM_SURFACE_TEMP_HUM_WIND_PRES's EXFwspee variable

<table>
<tr><th>Storage Type</th><th>Variable Name</th><th>Description</th><th>Unit</th></tr>
<tr><td>float32</td><td>EXFwspee</td><td>Wind speed</td><td>m s-1</td></tr>
<tr><th colspan="4">CDL Description</th></tr>
<tr><td colspan="4">float32 EXFwspee(time, tile, j, i)
EXFwspee: _FillValue = 9.96921e+36
EXFwspee: long_name = Wind speed
EXFwspee: units = m s: 1
EXFwspee: coverage_content_type = modelResult
EXFwspee: standard_name = wind_speed
EXFwspee: coordinates = time XC YC
EXFwspee: valid_min = 0.27271032333374023
EXFwspee: valid_max = 45.87086486816406</td></tr>
<tr><th colspan="4">Comments</th></tr>
<tr><td colspan="4">10-m wind speed magnitude (>= 0) over open water. Only used for the calculation of air-sea fluxes using bulk formulae. Note: not adjusted by the ocean state estimation and not necesarily consistent with EXFuwind and EXFvwind because EXFuwind and EXFvwind are calculated from EXFtaux and EXFtauy using bulk formulae. EXFwspee != sqrt(EXFuwind**2 + EXFvwind**2.</td></tr>
</table>

../images/plots/native_plots/Atmosphere_Surface_Temperature_Hu

Figure 29:
Dataset: ATM_SURFACE_TEMP_HUM_WIND_PRES
Variable: EXFwspee

15.3 Native NetCDF OCEAN_3D_MIXING_COEFFS

Table 15.8: Variables in the dataset OCEAN_3D_MIXING_COEFFS_ECCO

Dataset:	**OCEAN_3D_MIXING_COEFFS_ECCO**
Field:	DIFFKR
Field:	KAPGM
Field:	KAPREDI

15.3.1 Native Variable DIFFKR

Table 15.9: CDL description of OCEAN_3D_MIXING_COEFFS's DIFFKR variable

Storage Type	Variable Name	Description	Unit
float32	DIFFKR	Vertical diffusivity	m2 s-1
CDL Description			
float32 DIFFKR(k, tile, j, i) DIFFKR: _FillValue = 9.96921e+36 DIFFKR: coverage_content_type = modelResult DIFFKR: long_name = Vertical diffusivity DIFFKR: units = m2 s: 1 DIFFKR: valid_min = 1e: 06 DIFFKR: valid_max = 0.0001854995 DIFFKR: coordinates = Z XC YC			
Comments			
Background vertical diffusion coefficient for temperature and salinity. Total vertical diffusivity includes background diffusivity plus contributions from the GGL90 vertical mixing and the Gent-McWilliams/Redi parameterizations. Note: DIFFKR is a model control variable and has been optimized from a spatially-invariant first-guess value of 1e-5 m2 s-1.			

../images/plots/native_plots/Ocean_3D_Gent-Mcwilliams_Redi_and

Figure 30:
Dataset: OCEAN_3D_MIXING_COEFFS
Variable: DIFFKR

15.3.2 Native Variable KAPGM

Table 15.10: CDL description of OCEAN_3D_MIXING_COEFFS's KAPGM variable

Storage Type	Variable Name	Description	Unit
float32	KAPGM	Gent-McWilliams diffusivity	m2 s-1
CDL Description			
float32 KAPGM(k, tile, j, i) KAPGM: _FillValue = 9.96921e+36 KAPGM: coverage_content_type = modelResult KAPGM: long_name = Gent: McWilliams diffusivity KAPGM: units = m2 s: 1 KAPGM: valid_min = 100.0 KAPGM: valid_max = 10000.0 KAPGM: coordinates = Z XC YC			
Comments			
Gent-McWilliams diffusivity coefficient as described in Gent and McWilliams (1990, JPO). Note: KAPGM is a model control variable and has been optimized from a spatially invariant first guess of 1e3 m2 s-1.			

../images/plots/native_plots/Ocean_3D_Gent-Mcwilliams_Redi_and

Figure 31:
Dataset: OCEAN_3D_MIXING_COEFFS
Variable: KAPGM

15.3.3 Native Variable KAPREDI

Table 15.11: CDL description of OCEAN_3D_MIXING_COEFFS's KAPREDI variable

Storage Type	Variable Name	Description	Unit
float32	KAPREDI	Along-isopycnal diffusivity	m2 s-1
CDL Description			
float32 KAPREDI(k, tile, j, i) KAPREDI: _FillValue = 9.96921e+36 KAPREDI: coverage_content_type = modelResult KAPREDI: long_name = Along: isopycnal diffusivity KAPREDI: units = m2 s: 1 KAPREDI: valid_min = 100.0 KAPREDI: valid_max = 10000.0 KAPREDI: coordinates = Z XC YC			
Comments			
Redi along-isopycnal diffusivity coefficient as described in Redi (1982, JPO). Note: KAPREDI is a model control variable and has been optimized from a spatially invariant first guess of 1e3 m2 s-1.			

../images/plots/native_plots/Ocean_3D_Gent-Mcwilliams_Redi_and

Figure 32:
Dataset: OCEAN_3D_MIXING_COEFFS
Variable: KAPREDI

15.4 Native NetCDF OCEAN_3D_MOMENTUM_TEND

Table 15.12: Variables in the dataset OCEAN_3D_MOMENTUM_TEND

Dataset:	**OCEAN_3D_MOMENTUM_TEND**
Field:	Um_dPHdx
Field:	Vm_dPHdy

15.4.1 Native Variable Um_dPHdx

Table 15.13: CDL description of OCEAN_3D_MOMENTUM_TEND's Um_dPHdx variable

Storage Type	Variable Name	Description	Unit
float32	Um_dPHdx	Momentum tendency in the model +x direction	m s-2
CDL Description			
float32 Um_dPHdx(time, k, tile, j, i_g) Um_dPHdx: _FillValue = 9.96921e+36 Um_dPHdx: long_name = Momentum tendency in the model +x direction Um_dPHdx: units = m s: 2 Um_dPHdx: mate = Vm_dPHdy Um_dPHdx: coverage_content_type = modelResult Um_dPHdx: coordinates = time Z Um_dPHdx: valid_min = : 0.0010651482734829187 Um_dPHdx: valid_max = 0.0011411579325795174			
Comments			
Momentum tendency in the +x direction due to the hydrostatic pressure gradient at the 'u' face of the native model grid cell . Note: the model +x direction does not necessarily correspond to the geographical east-west direction because the x and y axes of the model's curvilinear lat-lon-cap (llc) grid have arbitrary orientations which vary within and across tiles.			

../images/plots/native_plots/Ocean_Three-Dimensional_Momentum_

Figure 33:
Dataset: OCEAN_3D_MOMENTUM_TEND
Variable: Um_dPHdx

15.4.2 Native Variable Vm_dPHdy

Table 15.14: CDL description of OCEAN_3D_MOMENTUM_TEND's Vm_dPHdy variable

Storage Type	Variable Name	Description	Unit
float32	Vm_dPHdy	Momentum tendency in the model +y direction	m s-2
CDL Description			
float32 Vm_dPHdy(time, k, tile, j_g, i) Vm_dPHdy: _FillValue = 9.96921e+36 Vm_dPHdy: long_name = Momentum tendency in the model +y direction Vm_dPHdy: units = m s: 2 Vm_dPHdy: mate = Um_dPHdx Vm_dPHdy: coverage_content_type = modelResult Vm_dPHdy: coordinates = time Z Vm_dPHdy: valid_min = : 0.0015932790702208877 Vm_dPHdy: valid_max = 0.0008858146029524505			
Comments			
Momentum tendency in the +y direction due to the hydrostatic pressure gradient at the 'v' face of the native model grid cell . Note: the model +y direction does not necessarily correspond to the geographical north-south direction because the x and y axes of the model's curvilinear lat-lon-cap (llc) grid have arbitrary orientations which vary within and across tiles.			

../images/plots/native_plots/Ocean_Three-Dimensional_Momentum_

Figure 34:
Dataset: OCEAN_3D_MOMENTUM_TEND
Variable: Vm_dPHdy

15.5 Native NetCDF OCEAN_3D_SALINITY_FLUX

Table 15.15: Variables in the dataset OCEAN_3D_SALINITY_FLUX

Dataset:	**OCEAN_3D_SALINITY_FLUX**
Field:	ADVx_SLT
Field:	DFxE_SLT
Field:	ADVy_SLT
Field:	DFyE_SLT
Field:	ADVr_SLT
Field:	DFrE_SLT
Field:	DFrI_SLT
Field:	oceSPtnd

15.5.1 Native Variable ADVr_SLT

Table 15.16: CDL description of OCEAN_3D_SALINITY_FLUX's ADVr_SLT variable

<table>
<tr><th>Storage Type</th><th>Variable Name</th><th>Description</th><th>Unit</th></tr>
<tr><td>float32</td><td>ADVr_SLT</td><td>Vertical advective flux of salinity</td><td>1e-3 m3 s-1</td></tr>
<tr><th colspan="4">CDL Description</th></tr>
<tr><td colspan="4">float32 ADVr_SLT(time, k_l, tile, j, i)
ADVr_SLT: _FillValue = 9.96921e+36
ADVr_SLT: long_name = Vertical advective flux of salinity
ADVr_SLT: units = 1e: 3 m3 s: 1
ADVr_SLT: coverage_content_type = modelResult
ADVr_SLT: direction = >0 decreases salinity (SALT)
ADVr_SLT: coordinates = XC Zl YC time
ADVr_SLT: valid_min = : 324149856.0
ADVr_SLT: valid_max = 263294624.0</td></tr>
<tr><th colspan="4">Comments</th></tr>
<tr><td colspan="4">Vertical advective flux of salinity (SALT) in the +z direction through the top 'w' face of the tracer cell on the native model grid. Note: in the Arakawa-C grid, vertical flux quantities are staggered relative to the tracer cells with indexing such that +ADVr_SLT(i,j,k_l) corresponds to upward +z fluxes through the top 'w' face of the tracer cell at (i,j,k). Salinity defined using CF convention 'Sea water salinity is the salt content of sea water, often on the Practical Salinity Scale of 1978. However, the unqualified term 'salinity' is generic and does not necessarily imply any particular method of calculation. The units of salinity are dimensionless and the units attribute should normally be given as 1e-3 or 0.001 i.e. parts per thousand.' see https://cfconventions.org/Data/cf-standard-names/73/build/cf-standard-name-table.html</td></tr>
</table>

../images/plots/native_plots/Ocean_Three-Dimensional_Salinity_

Figure 35:
Dataset: OCEAN_3D_SALINITY_FLUX
Variable: ADVr_SLT

15.5.2 Native Variable ADVx_SLT

Table 15.17: CDL description of OCEAN_3D_SALINITY_FLUX's ADVx_SLT variable

Storage Type	Variable Name	Description	Unit
float32	ADVx_SLT	Lateral advective flux of salinity in the model +x direction	1e-3 m3 s-1
CDL Description			
float32 ADVx_SLT(time, k, tile, j, i_g) ADVx_SLT: _FillValue = 9.96921e+36 ADVx_SLT: long_name = Lateral advective flux of salinity in the model +x direction ADVx_SLT: units = 1e: 3 m3 s: 1 ADVx_SLT: mate = ADVy_SLT ADVx_SLT: coverage_content_type = modelResult ADVx_SLT: direction = >0 increases salinity (SALT) ADVx_SLT: coordinates = Z time ADVx_SLT: valid_min = : 181830224.0 ADVx_SLT: valid_max = 260411296.0			
Comments			
Lateral advective flux of salinity (SALT) in the +x direction through the 'u' face of the tracer cell on the native model grid. Note: in the Arakawa-C grid, horizontal flux quantities are staggered relative to the tracer cells with indexing such that +ADVx_SLT(i_g,j,k) corresponds to +x fluxes through the 'u' face of the tracer cell at (i,j,k). Also, the model +x direction does not necessarily correspond to the geographical east-west direction because the x and y axes of the model's curvilinear lat-lon-cap (llc) grid have arbitrary orientations which vary within and across tiles. Salinity defined using CF convention 'Sea water salinity is the salt content of sea water, often on the Practical Salinity Scale of 1978. However, the unqualified term 'salinity' is generic and does not necessarily imply any particular method of calculation. The units of salinity are dimensionless and the units attribute should normally be given as 1e-3 or 0.001 i.e. parts per thousand.' see https://cfconventions.org/Data/cf-standard-names/73/build/cf-standard-name-table.html			

../images/plots/native_plots/Ocean_Three-Dimensional_Salinity_

**Figure 36:
Dataset: OCEAN_3D_SALINITY_FLUX
Variable: ADVx_SLT**

15.5.3 Native Variable ADVy_SLT

Table 15.18: CDL description of OCEAN_3D_SALINITY_FLUX's ADVy_SLT variable

Storage Type	Variable Name	Description	Unit
float32	ADVy_SLT	Lateral advective flux of salinity in the model +y direction	1e-3 m3 s-1

CDL Description

```
float32 ADVy_SLT(time, k, tile, j_g, i)
    ADVy_SLT: _FillValue = 9.96921e+36
    ADVy_SLT: long_name = Lateral advective flux of salinity in the model +y direction
    ADVy_SLT: units = 1e: 3 m3 s: 1
    ADVy_SLT: mate = ADVx_SLT
    ADVy_SLT: coverage_content_type = modelResult
    ADVy_SLT: direction = >0 increases salinity (SALT)
    ADVy_SLT: coordinates = Z time
    ADVy_SLT: valid_min = : 137905760.0
    ADVy_SLT: valid_max = 164271664.0
```

Comments

Lateral advective flux of salinity (SALT) in the +y direction through the 'v' face of the tracer cell on the native model grid. Note: in the Arakawa-C grid, horizontal flux quantities are staggered relative to the tracer cells with indexing such that +ADVy_SLT(i,j_g,k) corresponds to +y fluxes through the 'v' face of the tracer cell at (i,j,k). Also, the model +y direction does not necessarily correspond to the geographical north-south direction because the x and y axes of the model's curvilinear lat-lon-cap (llc) grid have arbitrary orientations which vary within and across tiles. Salinity defined using CF convention 'Sea water salinity is the salt content of sea water, often on the Practical Salinity Scale of 1978. However, the unqualified term 'salinity' is generic and does not necessarily imply any particular method of calculation. The units of salinity are dimensionless and the units attribute should normally be given as 1e-3 or 0.001 i.e. parts per thousand.' see https://cfconventions.org/Data/cf-standard-names/73/build/cf-standard-name-table.html

../images/plots/native_plots/Ocean_Three-Dimensional_Salinity_

Figure 37:
Dataset: OCEAN_3D_SALINITY_FLUX
Variable: ADVy_SLT

15.5.4 Native Variable DFrE_SLT

Table 15.19: CDL description of OCEAN_3D_SALINITY_FLUX's DFrE_SLT variable

Storage Type	Variable Name	Description	Unit
float32	DFrE_SLT	Vertical diffusive flux of salinity (explicit term)	1e-3 m3 s-1

CDL Description

float32 DFrE_SLT(time, k_l, tile, j, i)
    DFrE_SLT: _FillValue = 9.96921e+36
    DFrE_SLT: long_name = Vertical diffusive flux of salinity (explicit term)
    DFrE_SLT: units = 1e: 3 m3 s: 1
    DFrE_SLT: coverage_content_type = modelResult
    DFrE_SLT: direction = >0 decreases salinity (SALT)
    DFrE_SLT: coordinates = XC Zl YC time
    DFrE_SLT: valid_min = : 1074719.375
    DFrE_SLT: valid_max = 471215.75

Comments

The explicit term of the vertical diffusive flux of salinity (SALT) in the +z direction through the top 'w' face of the tracer cell on the native model grid. In the ECCO V4r4 model, an implicit scheme is used to calculate vertical diffusive tracer fluxes due to background diffusivity and the Kwz component of the GM-Redi tensor (vertical flux as a function of vertical gradient) while an explicit scheme is used to calculate the vertical diffusive fluxes from the Kwx and Kwy components of the GM-Redi tensor (vertical flux as a function of horizontal gradient). Both implicit and explicit components of vertical diffusive flux of salinity are provided. Note: in the Arakawa-C grid, vertical flux quantities are staggered relative to the tracer cells with indexing such that +DFrE_SLT(i,j,k_l) corresponds to upward +z fluxes through the top 'w' face of the tracer cell at (i,j,k). Salinity defined using CF convention 'Sea water salinity is the salt content of sea water, often on the Practical Salinity Scale of 1978. However, the unqualified term 'salinity' is generic and does not necessarily imply any particular method of calculation. The units of salinity are dimensionless and the units attribute should normally be given as 1e-3 or 0.001 i.e. parts per thousand.' see https://cfconventions.org/Data/cf-standard-names/73/build/cf-standard-name-table.html

../images/plots/native_plots/Ocean_Three-Dimensional_Salinity_

Figure 38:
Dataset: OCEAN_3D_SALINITY_FLUX
Variable: DFrE_SLT

15.5.5 Native Variable DFrI_SLT

Table 15.20: CDL description of OCEAN_3D_SALINITY_FLUX's DFrI_SLT variable

Storage Type	Variable Name	Description	Unit
float32	DFrI_SLT	Vertical diffusive flux of salinity (implicit term)	1e-3 m3 s-1
CDL Description			
float32 DFrI_SLT(time, k_l, tile, j, i) DFrI_SLT: _FillValue = 9.96921e+36 DFrI_SLT: long_name = Vertical diffusive flux of salinity (implicit term) DFrI_SLT: units = 1e: 3 m3 s: 1 DFrI_SLT: coverage_content_type = modelResult DFrI_SLT: direction = >0 decreases salinity (SALT) DFrI_SLT: coordinates = XC Zl YC time DFrI_SLT: valid_min = : 30609048.0 DFrI_SLT: valid_max = 3197643.0			
Comments			
The implicit term of the vertical diffusive flux of salinity (SALT) in the +z direction through the top 'w' face of the tracer cell on the native model grid. In the ECCO V4r4 model, an implicit scheme is used to calculate vertical diffusive tracer fluxes due to background diffusivity and the Kwz component of the GM-Redi tensor (vertical flux as a function of vertical gradient) while an explicit scheme is used to calculate the vertical diffusive fluxes from the Kwx and Kwy components of the GM-Redi tensor (vertical flux as a function of horizontal gradient). Both implicit and explicit components of vertical diffusive flux of salinity are provided. Note: in the Arakawa-C grid, vertical flux quantities are staggered relative to the tracer cells with indexing such that +DFrI_SLT(i,j,k_l) corresponds to upward +z fluxes through the top face 'w' of the tracer cell at (i,j,k). Salinity defined using CF convention 'Sea water salinity is the salt content of sea water, often on the Practical Salinity Scale of 1978. However, the unqualified term 'salinity' is generic and does not necessarily imply any particular method of calculation. The units of salinity are dimensionless and the units attribute should normally be given as 1e-3 or 0.001 i.e. parts per thousand.' see https://cfconventions.org/Data/cf-standard-names/73/build/cf-standard-name-table.html			

../images/plots/native_plots/Ocean_Three-Dimensional_Salinity_

Figure 39:
Dataset: OCEAN_3D_SALINITY_FLUX
Variable: DFrI_SLT

15.5.6 Native Variable DFxE_SLT

Table 15.21: CDL description of OCEAN_3D_SALINITY_FLUX's DFxE_SLT variable

Storage Type	Variable Name	Description	Unit
float32	DFxE_SLT	Lateral diffusive flux of salinity in the model +x direction	1e-3 m3 s-1
CDL Description			
float32 DFxE_SLT(time, k, tile, j, i_g) DFxE_SLT: _FillValue = 9.96921e+36 DFxE_SLT: long_name = Lateral diffusive flux of salinity in the model +x direction DFxE_SLT: units = 1e: 3 m3 s: 1 DFxE_SLT: mate = DFyE_SLT DFxE_SLT: coverage_content_type = modelResult DFxE_SLT: direction = >0 increases salinity (SALT) DFxE_SLT: coordinates = Z time DFxE_SLT: valid_min = : 125908.03125 DFxE_SLT: valid_max = 192716.484375			
Comments			
Lateral diffusive flux of salinity (SALT) in the +x direction through the 'u' face of the tracer cell on the native model grid. Note: in the Arakawa-C grid, horizontal flux quantities are staggered relative to the tracer cells with indexing such that +DFxE_SLT(i_g,j,k) corresponds to +x fluxes through the 'u' face of the tracer cell at (i,j,k). Also, the model +x direction does not necessarily correspond to the geographical east-west direction because the x and y axes of the model's curvilinear lat-lon-cap (llc) grid have arbitrary orientations which vary within and across tiles. Salinity defined using CF convention 'Sea water salinity is the salt content of sea water, often on the Practical Salinity Scale of 1978. However, the unqualified term 'salinity' is generic and does not necessarily imply any particular method of calculation. The units of salinity are dimensionless and the units attribute should normally be given as 1e-3 or 0.001 i.e. parts per thousand.' see https://cfconventions.org/Data/cf-standard-names/73/build/cf-standard-name-table.html			

../images/plots/native_plots/Ocean_Three-Dimensional_Salinity_

Figure 40:
Dataset: OCEAN_3D_SALINITY_FLUX
Variable: DFxE_SLT

15.5.7 Native Variable DFyE_SLT

Table 15.22: CDL description of OCEAN_3D_SALINITY_FLUX's DFyE_SLT variable

Storage Type	Variable Name	Description	Unit
float32	DFyE_SLT	Lateral diffusive flux of salinity in the model +y direction	1e-3 m3 s-1
CDL Description			
float32 DFyE_SLT(time, k, tile, j_g, i) DFyE_SLT: _FillValue = 9.96921e+36 DFyE_SLT: long_name = Lateral diffusive flux of salinity in the model +y direction DFyE_SLT: units = 1e: 3 m3 s: 1 DFyE_SLT: mate = DFxE_SLT DFyE_SLT: coverage_content_type = modelResult DFyE_SLT: direction = >0 increases salinity (SALT) DFyE_SLT: coordinates = Z time DFyE_SLT: valid_min = : 114959.2109375 DFyE_SLT: valid_max = 154227.140625			
Comments			
Lateral diffusive flux of salinity (SALT) in the +y direction through the 'v' face of the tracer cell on the native model grid. Note: in the Arakawa-C grid, horizontal flux quantities are staggered relative to the tracer cells with indexing such that +DFyE_SLT(i,j_g,k) corresponds to +y fluxes through the 'v' face of the tracer cell at (i,j,k). Also, the model +y direction does not necessarily correspond to the geographical north-south direction because the x and y axes of the model's curvilinear lat-lon-cap (llc) grid have arbitrary orientations which vary within and across tiles. Salinity defined using CF convention 'Sea water salinity is the salt content of sea water, often on the Practical Salinity Scale of 1978. However, the unqualified term 'salinity' is generic and does not necessarily imply any particular method of calculation. The units of salinity are dimensionless and the units attribute should normally be given as 1e-3 or 0.001 i.e. parts per thousand.' see https://cfconventions.org/Data/cf-standard-names/73/build/cf-standard-name-table.html			

../images/plots/native_plots/Ocean_Three-Dimensional_Salinity_

Figure 41:
Dataset: OCEAN_3D_SALINITY_FLUX
Variable: DFyE_SLT

15.5.8 Native Variable oceSPtnd

Table 15.23: CDL description of OCEAN_3D_SALINITY_FLUX's oceSPtnd variable

Storage Type	Variable Name	Description	Unit
float32	oceSPtnd	Salt tendency due to the vertical transport of salt in high-salinity brine plumes	g m-2 s-1

CDL Description

```
float32 oceSPtnd(time, k, tile, j, i)
    oceSPtnd: _FillValue = 9.96921e+36
    oceSPtnd: long_name = Salt tendency due to the vertical transport of salt in high: salinity brine plumes
    oceSPtnd: units = g m: 2 s: 1
    oceSPtnd: coverage_content_type = modelResult
    oceSPtnd: direction = >0 increases salinity (SALT)
    oceSPtnd: coordinates = XC Z YC time
    oceSPtnd: valid_min = 0.0
    oceSPtnd: valid_max = 0.021119138225913048
```

Comments

Salt tendency due to the vertical transport of salt in high-salinity brine plumes. Note: units are grams of salt per square meter per second, not salinity per square meter per second.

../images/plots/native_plots/Ocean_Three-Dimensional_Salinity_

Figure 42:
Dataset: OCEAN_3D_SALINITY_FLUX
Variable: oceSPtnd

15.6 Native NetCDF OCEAN_3D_TEMPERATURE_FLUX

Table 15.24: Variables in the dataset OCEAN_3D_TEMPERATURE_FLUX

Dataset:	**OCEAN_3D_TEMPERATURE_FLUX**
Field:	ADVx_TH
Field:	DFxE_TH
Field:	ADVy_TH
Field:	DFyE_TH
Field:	ADVr_TH
Field:	DFrE_TH
Field:	DFrI_TH

15.6.1 Native Variable ADVr_TH

Table 15.25: CDL description of OCEAN_3D_TEMPERATURE_FLUX's ADVr_TH variable

<table>
<tr><th>Storage Type</th><th>Variable Name</th><th>Description</th><th>Unit</th></tr>
<tr><td>float32</td><td>ADVr_TH</td><td>Vertical advective flux of potential temperature</td><td>degree_C m3 s-1</td></tr>
<tr><th colspan="4">CDL Description</th></tr>
<tr><td colspan="4">float32 ADVr_TH(time, k_l, tile, j, i)
ADVr_TH: _FillValue = 9.96921e+36
ADVr_TH: long_name = Vertical advective flux of potential temperature
ADVr_TH: units = degree_C m3 s: 1
ADVr_TH: coverage_content_type = modelResult
ADVr_TH: direction = >0 decreases potential temperature (THETA)
ADVr_TH: coordinates = XC YC time Zl
ADVr_TH: valid_min = : 125094904.0
ADVr_TH: valid_max = 179459344.0</td></tr>
<tr><th colspan="4">Comments</th></tr>
<tr><td colspan="4">Vertical advective flux of potential temperature (THETA) in the +z direction through the top 'w' face of the tracer cell on the native model grid. Note: in the Arakawa-C grid, vertical flux quantities are staggered relative to the tracer cells with indexing such that +ADVr_TH(i,j,k_l) corresponds to upward +z fluxes through the top 'w' face of the tracer cell at (i,j,k)</td></tr>
</table>

../images/plots/native_plots/Ocean_Three-Dimensional_Potential

Figure 43:
Dataset: OCEAN_3D_TEMPERATURE_FLUX
Variable: ADVr_TH

15.6.2 Native Variable ADVx_TH

Table 15.26: CDL description of OCEAN_3D_TEMPERATURE_FLUX's ADVx_TH variable

Storage Type	Variable Name	Description	Unit
float32	ADVx_TH	Lateral advective flux of potential temperature in the model +x direction	degree_C m3 s-1
CDL Description			
float32 ADVx_TH(time, k, tile, j, i_g) ADVx_TH: _FillValue = 9.96921e+36 ADVx_TH: long_name = Lateral advective flux of potential temperature in the model +x direction ADVx_TH: units = degree_C m3 s: 1 ADVx_TH: mate = ADVy_TH ADVx_TH: coverage_content_type = modelResult ADVx_TH: direction = >0 increases potential temperature (THETA) ADVx_TH: coordinates = time Z ADVx_TH: valid_min = : 38210700.0 ADVx_TH: valid_max = 38049636.0			
Comments			
Lateral advective flux of potential temperature (THETA) in the +x direction through the 'u' face of the tracer cell on the native model grid. Note: in the Arakawa-C grid, horizontal flux quantities are staggered relative to the tracer cells with indexing such that +ADVx_TH(i_g,j,k) corresponds to +x fluxes through the 'u' face of the tracer cell at (i,j,k). Also, the model +x direction does not necessarily correspond to the geographical east-west direction because the x and y axes of the model's lat-lon-cap (llc) curvilinear lat-lon-cap (llc) grid have arbitrary orientations which vary within and across tiles.			

../images/plots/native_plots/Ocean_Three-Dimensional_Potential

Figure 44:
Dataset: OCEAN_3D_TEMPERATURE_FLUX
Variable: ADVx_TH

15.6.3 Native Variable ADVy_TH

Table 15.27: CDL description of OCEAN_3D_TEMPERATURE_FLUX's ADVy_TH variable

Storage Type	Variable Name	Description	Unit
float32	ADVy_TH	Lateral advective flux of potential temperature in the model +y direction	degree_C m3 s-1

CDL Description

float32 ADVy_TH(time, k, tile, j_g, i)
ADVy_TH: _FillValue = 9.96921e+36
ADVy_TH: long_name = Lateral advective flux of potential temperature in the model +y direction
ADVy_TH: units = degree_C m3 s: 1
ADVy_TH: mate = ADVx_TH
ADVy_TH: coverage_content_type = modelResult
ADVy_TH: direction = >0 increases potential temperature (THETA)
ADVy_TH: coordinates = time Z
ADVy_TH: valid_min = : 43909120.0
ADVy_TH: valid_max = 56347884.0

Comments

Lateral advective flux of potential temperature (THETA) in the +y direction through the 'v' face of the tracer cell on the native model grid. Note: in the Arakawa-C grid, horizontal flux quantities are staggered relative to the tracer cells with indexing such that +ADVy_TH(i,j_g,k) corresponds to +y fluxes through the 'v' face of the tracer cell at (i,j,k). Also, the model +y direction does not necessarily correspond to the geographical north-south direction because the x and y axes of the model's curvilinear lat-lon-cap (llc) grid have arbitrary orientations which vary within and across tiles.

../images/plots/native_plots/Ocean_Three-Dimensional_Potential

Figure 45:
Dataset: OCEAN_3D_TEMPERATURE_FLUX
Variable: ADVy_TH

15.6.4 Native Variable DFrE_TH

Table 15.28: CDL description of OCEAN_3D_TEMPERATURE_FLUX's DFrE_TH variable

Storage Type	Variable Name	Description	Unit
float32	DFrE_TH	Vertical diffusive flux of potential temperature (explicit term)	degree_C m3 s-1
CDL Description			
float32 DFrE_TH(time, k_l, tile, j, i) DFrE_TH: _FillValue = 9.96921e+36 DFrE_TH: long_name = Vertical diffusive flux of potential temperature (explicit term) DFrE_TH: units = degree_C m3 s: 1 DFrE_TH: coverage_content_type = modelResult DFrE_TH: direction = >0 decreases potential temperature (THETA) DFrE_TH: coordinates = XC YC time Zl DFrE_TH: valid_min = : 2632379.75 DFrE_TH: valid_max = 2659875.25			
Comments			
The explicit term of the vertical diffusive flux of potential temperature (THETA) in the +z direction through the top 'w' face of the tracer cell on the native model grid. In the ECCO V4r4 model, an implicit scheme is used to calculate vertical diffusive tracer fluxes due to background diffusivity and the Kwz component of the GM-Redi tensor (vertical flux as a function of vertical gradient) while an explicit scheme is used to calculate the vertical diffusive fluxes from the Kwx and Kwy components of the GM-Redi tensor (vertical flux as a function of horizontal gradient). Both implicit and explicit components of vertical diffusive flux of potential temperature are provided. Note: in the Arakawa-C grid, vertical flux quantities are staggered relative to the tracer cells with indexing such that +DFrE_TH(i,j,k_l) corresponds to upward +z fluxes through the top 'w' face of the tracer cell at (i,j,k).			

../images/plots/native_plots/Ocean_Three-Dimensional_Potential

Figure 46:
Dataset: OCEAN_3D_TEMPERATURE_FLUX
Variable: DFrE_TH

15.6.5 Native Variable DFrI_TH

Table 15.29: CDL description of OCEAN_3D_TEMPERATURE_FLUX's DFrI_TH variable

Storage Type	Variable Name	Description	Unit
float32	DFrI_TH	Vertical diffusive flux of potential temperature (implicit term)	degree_C m3 s-1
CDL Description			
float32 DFrI_TH(time, k_l, tile, j, i) DFrI_TH: _FillValue = 9.96921e+36 DFrI_TH: long_name = Vertical diffusive flux of potential temperature (implicit term) DFrI_TH: units = degree_C m3 s: 1 DFrI_TH: coverage_content_type = modelResult DFrI_TH: direction = >0 decreases potential temperature (THETA) DFrI_TH: coordinates = XC YC time Zl DFrI_TH: valid_min = : 104210688.0 DFrI_TH: valid_max = 23574302.0			
Comments			
The implicit term of the vertical diffusive flux of potential temperature (THETA) in the +z direction through the top 'w' face of the tracer cell on the native model grid. In the ECCO V4r4 model, an implicit scheme is used to calculate vertical diffusive tracer fluxes due to background diffusivity and the Kwz component of the GM-Redi tensor (vertical flux as a function of vertical gradient) while an explicit scheme is used to calculate the vertical diffusive fluxes from the Kwx and Kwy components of the GM-Redi tensor (vertical flux as a function of horizontal gradient). Both implicit and explicit components of vertical diffusive flux of potential temperature are provided. Note: in the Arakawa-C grid, vertical flux quantities are staggered relative to the tracer cells with indexing such that +DFrI_TH(i,j,k_l) corresponds to upward +z fluxes through the top 'w' face of the tracer cell at (i,j,k)			

../images/plots/native_plots/Ocean_Three-Dimensional_Potential

Figure 47:
Dataset: OCEAN_3D_TEMPERATURE_FLUX
Variable: DFrI_TH

15.6.6 Native Variable DFxE_TH

Table 15.30: CDL description of OCEAN_3D_TEMPERATURE_FLUX's DFxE_TH variable

Storage Type	Variable Name	Description	Unit
float32	DFxE_TH	Lateral diffusive flux of potential temperature in the model +x direction	degree_C m3 s-1
CDL Description			
float32 DFxE_TH(time, k, tile, j, i_g) DFxE_TH: _FillValue = 9.96921e+36 DFxE_TH: long_name = Lateral diffusive flux of potential temperature in the model +x direction DFxE_TH: units = degree_C m3 s: 1 DFxE_TH: mate = DFyE_TH DFxE_TH: coverage_content_type = modelResult DFxE_TH: direction = >0 increases potential temperature (THETA) DFxE_TH: coordinates = time Z DFxE_TH: valid_min = : 582494.125 DFxE_TH: valid_max = 698695.75			
Comments			
Lateral diffusive flux of potential temperature (THETA) in the +x direction through the 'u' face of the tracer cell on the native model grid. Note: in the Arakawa-C grid, horizontal flux quantities are staggered relative to the tracer cells with indexing such that +DFxE_TH(i_g,j,k) corresponds to +x fluxes through the 'u' face of the tracer cell at (i,j,k). Also, the model +x direction does not necessarily correspond to the geographical east-west direction because the x and y axes of the model's curvilinear lat-lon-cap (llc) grid have arbitrary orientations which vary within and across tiles.			

../images/plots/native_plots/Ocean_Three-Dimensional_Potential

Figure 48:
Dataset: OCEAN_3D_TEMPERATURE_FLUX
Variable: DFxE_TH

15.6.7 Native Variable DFyE_TH

Table 15.31: CDL description of OCEAN_3D_TEMPERATURE_FLUX's DFyE_TH variable

Storage Type	Variable Name	Description	Unit
float32	DFyE_TH	Lateral diffusive flux of potential temperature in the model +y direction.	degree_C m3 s-1

CDL Description

float32 DFyE_TH(time, k, tile, j_g, i)
DFyE_TH: _FillValue = 9.96921e+36
DFyE_TH: long_name = Lateral diffusive flux of potential temperature in the model +y direction.
DFyE_TH: units = degree_C m3 s: 1
DFyE_TH: mate = DFxE_TH
DFyE_TH: coverage_content_type = modelResult
DFyE_TH: direction = >0 increases potential temperature (THETA)
DFyE_TH: coordinates = time Z
DFyE_TH: valid_min = : 421044.78125
DFyE_TH: valid_max = 1053781.25

Comments

Lateral diffusive flux of potential temperature (THETA) in the +y direction through the 'v' face of the tracer cell on the native model grid. Note: in the Arakawa-C grid, horizontal flux quantities are staggered relative to the tracer cells with indexing such that +DFyE_TH(i,j_g,k) corresponds to +y fluxes through the 'v' face of the tracer cell at (i,j,k). Also, the model +y direction does not necessarily correspond to the geographical north-south direction because the x and y axes of the model's curvilinear lat-lon-cap (llc) grid have arbitrary orientations which vary within and across tiles.

../images/plots/native_plots/Ocean_Three-Dimensional_Potential

Figure 49:
Dataset: OCEAN_3D_TEMPERATURE_FLUX
Variable: DFyE_TH

15.7 Native NetCDF OCEAN_3D_VOLUME_FLUX

Table 15.32: Variables in the dataset OCEAN_3D_VOLUME_FLUX

Dataset:	**OCEAN_3D_VOLUME_FLUX**
Field:	UVELMASS
Field:	VVELMASS
Field:	WVELMASS

15.7.1 Native Variable UVELMASS

Table 15.33: CDL description of OCEAN_3D_VOLUME_FLUX's UVELMASS variable

Storage Type	Variable Name	Description	Unit
float32	UVELMASS	Horizontal velocity in the model +x direction per unit area of the grid cell 'u' face	m s-1
CDL Description			
float32 UVELMASS(time, k, tile, j, i_g) UVELMASS: _FillValue = 9.96921e+36 UVELMASS: long_name = "Horizontal velocity in the model +x direction per unit area of the grid cell u face" UVELMASS: units = m s: 1 UVELMASS: mate = VVELMASS UVELMASS: coverage_content_type = modelResult UVELMASS: direction = >0 increases volume UVELMASS: coordinates = Z time UVELMASS: valid_min = : 2.115365505218506 UVELMASS: valid_max = 2.0377726554870605			
Comments			
Horizontal velocity in the model +x direction averaged over the area of the tracer grid cell 'u' face on the native model grid ('u' grid cell face area = drF dyG). Accounts for partial cells (hFacW < 1) and for time-varying grid cell thickness (z* coordinate system). Volume flux in +x = UVELMASS drF dyG. Note: in the Arakawa-C grid, horizontal velocities are staggered relative to the tracer cells with indexing such that +UVELMASS(i,j,k) corresponds to +x fluxes through the 'u' face of the tracer cell at (i,j,k). UVELMASS can be used for volume flux calculations because it accounts for the grid cell thicknesses variations in the +x direction (hFacW) with time (z* coordinate system). Also, the model +x direction does not necessarily correspond to the geographical east-west direction because the x and y axes of the model's curvilinear lat-lon-cap (llc) grid have arbitrary orientations which vary within and across tiles. See VVELMASS and WVELMASS			

../images/plots/native_plots/Ocean_Three-Dimensional_Volume_Fl

Figure 50:
Dataset: OCEAN_3D_VOLUME_FLUX
Variable: UVELMASS

15.7.2 Native Variable VVELMASS

Table 15.34: CDL description of OCEAN_3D_VOLUME_FLUX's VVELMASS variable

Storage Type	Variable Name	Description	Unit
float32	VVELMASS	Horizontal velocity in the model +y direction per unit area of the grid cell 'v' face	m s-1 m3 m-3
CDL Description			
float32 VVELMASS(time, k, tile, j_g, i) VVELMASS: _FillValue = 9.96921e+36 VVELMASS: long_name = "Horizontal velocity in the model +y direction per unit area of the grid cell v face" VVELMASS: units = m s: 1 m3 m: 3 VVELMASS: mate = UVELMASS VVELMASS: coverage_content_type = modelResult VVELMASS: direction = >0 increases volume VVELMASS: coordinates = Z time VVELMASS: valid_min = : 1.7897182703018188 VVELMASS: valid_max = 1.9216758012771606			
Comments			
Horizontal velocity in the model +y direction averaged over the area of the tracer grid cell 'v' face on the native model grid ('v' grid cell face area = drF dxG). Accounts for partial cells (hFacS < 1) and for time-varying grid cell thickness (z* coordinate system). Volume flux in +y = VVELMASS drF dxG. Note: in the Arakawa-C grid, horizontal velocities are staggered relative to the tracer cells with indexing such that +VVELMASS(i,j,k) corresponds to +y fluxes through the 'v' face of the tracer cell at (i,j,k). VVELMASS can be used for volume flux calculations because it accounts for grid cell thicknesses variations in the +y direction (hFacS) with time (z* coordinate system). Also, the model +y direction does not necessarily correspond to the geographical north-south direction because the x and y axes of the model's curvilinear lat-lon-cap (llc) grid have arbitrary orientations which vary within and across tiles. See UVELMASS and WVELMASS.			

../images/plots/native_plots/Ocean_Three-Dimensional_Volume_Fl

Figure 51:
Dataset: OCEAN_3D_VOLUME_FLUX
Variable: VVELMASS

15.7.3 Native Variable WVELMASS

Table 15.35: CDL description of OCEAN_3D_VOLUME_FLUX's WVELMASS variable

<table>
<tr><th>Storage Type</th><th>Variable Name</th><th>Description</th><th>Unit</th></tr>
<tr><td>float32</td><td>WVELMASS</td><td>Grid cell face-averaged vertical velocity in the model +z direction.</td><td>m s-1</td></tr>
<tr><th colspan="4">CDL Description</th></tr>
<tr><td colspan="4">float32 WVELMASS(time, k_l, tile, j, i)
WVELMASS: _FillValue = 9.96921e+36
WVELMASS: long_name = Grid cell face: averaged vertical velocity in the model +z direction.
WVELMASS: units = m s: 1
WVELMASS: coverage_content_type = modelResult
WVELMASS: direction = >0 decreases volume
WVELMASS: standard_name = upward_sea_water_velocity
WVELMASS: coordinates = YC Zl time XC
WVELMASS: valid_min = : 0.0023150660563260317
WVELMASS: valid_max = 0.0016380994347855449</td></tr>
<tr><th colspan="4">Comments</th></tr>
<tr><td colspan="4">Vertical velocity in the +z direction at the top 'w' face of the tracer cell on the native model grid. Volume flux in +z = WVELMASS drA. Note: in the Arakawa-C grid, vertical velocities are staggered relative to the tracer cells with indexing such that +WVELMASS(i,j,k) corresponds to upward +z motion through the top 'w' face of the tracer cell at (i,j,k). Unlike UVELMASS and VVELMASS, WVELMASS is not scaled by a time-varying open water fraction because the open water fraction of the 'w' face is always 1, thus WVELMASS is identical to WVEL.</td></tr>
</table>

../images/plots/native_plots/Ocean_Three-Dimensional_Volume_Fl

Figure 52:
Dataset: OCEAN_3D_VOLUME_FLUX
Variable: WVELMASS

15.8 Native NetCDF OCEAN_AND_ICE_SURFACE_FW_FLUX

Table 15.36: Variables in the dataset OCEAN_AND_ICE_SURFACE_FW_FLUX

Dataset:	**OCEAN_AND_ICE_SURFACE_FW_FLUX**
Field:	EXFpreci
Field:	EXFevap
Field:	EXFroff
Field:	SIsnPrcp
Field:	EXFempmr
Field:	oceFWflx
Field:	SIatmFW
Field:	SFLUX
Field:	SIacSubl
Field:	SIrsSubl
Field:	SIfwThru

15.8.1 Native Variable EXFempmr

Table 15.37: CDL description of OCEAN_AND_ICE_SURFACE_FW_FLUX's EXFempmr variable

Storage Type	Variable Name	Description	Unit
float32	EXFempmr	Open ocean net surface freshwater flux from precipitation, evaporation, and runoff	m s-1

CDL Description

float32 EXFempmr(time, tile, j, i)
EXFempmr: _FillValue = 9.96921e+36
EXFempmr: long_name = Open ocean net surface freshwater flux from precipitation
evaporation
and runoff
EXFempmr: units = m s: 1
EXFempmr: coverage_content_type = modelResult
EXFempmr: direction = >0 increases salinity (SALT)
EXFempmr: coordinates = YC XC time
EXFempmr: valid_min = : 8.299433829961345e: 06
EXFempmr: valid_max = 5.400421514423215e: 07

Comments

Net surface freshwater flux from precipitation, evaporation, and runoff per unit area in open water (not covered by sea-ice). Excludes freshwater fluxes involving sea-ice and snow. Note: calculated as EXFevap-EXFpreci-EXFroff.

../images/plots/native_plots/Ocean_and_Sea-Ice_Surface_Freshwa

Figure 53:
Dataset: OCEAN_AND_ICE_SURFACE_FW_FLUX
Variable: EXFempmr

15.8.2 Native Variable EXFevap

Table 15.38: CDL description of OCEAN_AND_ICE_SURFACE_FW_FLUX's EXFevap variable

Storage Type	Variable Name	Description	Unit
float32	EXFevap	Open ocean evaporation rate	m s-1
CDL Description			
float32 EXFevap(time, tile, j, i) EXFevap: _FillValue = 9.96921e+36 EXFevap: long_name = Open ocean evaporation rate EXFevap: units = m s: 1 EXFevap: coverage_content_type = modelResult EXFevap: direction = >0 increases salinity (SALT) EXFevap: standard_name = lwe_water_evaporation_rate EXFevap: coordinates = YC XC time EXFevap: valid_min = : 1.0958113705328287e: 07 EXFevap: valid_max = 7.090054623404285e: 07			
Comments			
Evaporation rate per unit area of open water (not covered by sea-ice). Note: calculated using the bulk formula following Large and Yeager (2004) NCAR/TN-460+STR.			

../images/plots/native_plots/Ocean_and_Sea-Ice_Surface_Freshwa

Figure 54:
Dataset: OCEAN_AND_ICE_SURFACE_FW_FLUX
Variable: EXFevap

15.8.3 Native Variable EXFpreci

Table 15.39: CDL description of OCEAN_AND_ICE_SURFACE_FW_FLUX's EXFpreci variable

Storage Type	Variable Name	Description	Unit
float32	EXFpreci	Precipitation rate	m s-1
CDL Description			
float32 EXFpreci(time, tile, j, i) EXFpreci: _FillValue = 9.96921e+36 EXFpreci: long_name = Precipitation rate EXFpreci: units = m s: 1 EXFpreci: coverage_content_type = modelResult EXFpreci: direction = >0 increases salinity (SALT) EXFpreci: standard_name = lwe_precipitation_rate EXFpreci: coordinates = YC XC time EXFpreci: valid_min = : 1.4860395936011628e: 07 EXFpreci: valid_max = 8.317776519106701e: 06			
Comments			
Precipitation rate. Note: sum of ERA-Interim precipitation and the control adjustment from ocean state estimation.			

../images/plots/native_plots/Ocean_and_Sea-Ice_Surface_Freshwa

Figure 55:
Dataset: OCEAN_AND_ICE_SURFACE_FW_FLUX
Variable: EXFpreci

15.8.4 Native Variable EXFroff

Table 15.40: CDL description of OCEAN_AND_ICE_SURFACE_FW_FLUX's EXFroff variable

<table>
<tr><th>Storage Type</th><th>Variable Name</th><th>Description</th><th>Unit</th></tr>
<tr><td>float32</td><td>EXFroff</td><td>River runoff</td><td>m s-1</td></tr>
<tr><th colspan="4">CDL Description</th></tr>
<tr><td colspan="4">float32 EXFroff(time, tile, j, i)
EXFroff: _FillValue = 9.96921e+36
EXFroff: long_name = River runoff
EXFroff: units = m s: 1
EXFroff: coverage_content_type = modelResult
EXFroff: direction = >0 increases salinity (SALT)
EXFroff: standard_name = surface_runoff_flux
EXFroff: coordinates = YC XC time
EXFroff: valid_min = 0.0
EXFroff: valid_max = 4.185612397122895e: 06</td></tr>
<tr><th colspan="4">Comments</th></tr>
<tr><td colspan="4">River runoff freshwater flux. Note: not adjusted by the optimization.</td></tr>
</table>

../images/plots/native_plots/Ocean_and_Sea-Ice_Surface_Freshwa

Figure 56:
Dataset: OCEAN_AND_ICE_SURFACE_FW_FLUX
Variable: EXFroff

15.8.5 Native Variable SFLUX

Table 15.41: CDL description of OCEAN_AND_ICE_SURFACE_FW_FLUX's SFLUX variable

Storage Type	Variable Name	Description	Unit
float32	SFLUX	Rate of change of total ocean salinity per m2 accounting for mass fluxes.	g m-2 s-1
CDL Description			
float32 SFLUX(time, tile, j, i) SFLUX: _FillValue = 9.96921e+36 SFLUX: long_name = Rate of change of total ocean salinity per m2 accounting for mass fluxes. SFLUX: units = g m: 2 s: 1 SFLUX: coverage_content_type = modelResult SFLUX: direction = >0 increases salinity (SALT) SFLUX: coordinates = YC XC time SFLUX: valid_min = : 0.07353577762842178 SFLUX: valid_max = 0.010607733391225338			
Comments			
The rate of change of total ocean salinity due to freshwater fluxes across the liquid surface and the addition or removal of mass. Note: the global area integral of SFLUX matches the time-derivative of total ocean salinity (psu s-1). Unlike oceFWflx, SFLUX includes the contribution to the total ocean salinity from changing ocean mass (e.g. from the addition or removal of freshwater in oceFWflx).			

../images/plots/native_plots/Ocean_and_Sea-Ice_Surface_Freshwa

Figure 57:
Dataset: OCEAN_AND_ICE_SURFACE_FW_FLUX
Variable: SFLUX

15.8.6 Native Variable SIacSubl

Table 15.42: CDL description of OCEAN_AND_ICE_SURFACE_FW_FLUX's SIacSubl variable

Storage Type	Variable Name	Description	Unit
float32	SIacSubl	Freshwater flux to the atmosphere due to sublimation-deposition of snow or ice	kg m-2 s-1
CDL Description			
float32 SIacSubl(time, tile, j, i) SIacSubl: _FillValue = 9.96921e+36 SIacSubl: long_name = Freshwater flux to the atmosphere due to sublimation: deposition of snow or ice SIacSubl: units = kg m: 2 s: 1 SIacSubl: coverage_content_type = modelResult SIacSubl: direction = >0 decreases snow or sea: ice thickness (HSNOW or HEFF) SIacSubl: standard_name = water_sublimation_flux SIacSubl: coordinates = YC XC time SIacSubl: valid_min = 0.0 SIacSubl: valid_max = 8.154580427799374e: 05			
Comments			
Freshwater flux to the atmosphere due to sublimation-deposition of snow or ice. Positive values imply sublimation from ice/snow to vapor, negative values imply deposition from atmospheric moisture			

../images/plots/native_plots/Ocean_and_Sea-Ice_Surface_Freshwa

Figure 58:
Dataset: OCEAN_AND_ICE_SURFACE_FW_FLUX
Variable: SIacSubl

15.8.7 Native Variable SIatmFW

Table 15.43: CDL description of OCEAN_AND_ICE_SURFACE_FW_FLUX's SIatmFW variable

Storage Type	Variable Name	Description	Unit
float32	SIatmFW	Net freshwater flux into the open ocean, sea-ice, and snow	kg m-2 s-1

CDL Description

float32 SIatmFW(time, tile, j, i)
    SIatmFW: _FillValue = 9.96921e+36
    SIatmFW: long_name = Net freshwater flux into the open ocean
sea: ice
and snow
    SIatmFW: units = kg m: 2 s: 1
    SIatmFW: coverage_content_type = modelResult
    SIatmFW: direction = >0 decreases salinity (SALT)
    SIatmFW: standard_name = surface_downward_water_flux
    SIatmFW: coordinates = YC XC time
    SIatmFW: valid_min = : 0.00043017856660299003
    SIatmFW: valid_max = 0.008299433626234531

Comments

Net freshwater flux into the combined liquid ocean, sea-ice, and snow reservoirs from the atmosphere and runoff. Note: freshwater fluxes BETWEEN the liquid ocean and sea-ice or snow reservoirs do not contribute to SIatmFW. SIatmFW counts all fluxes to/from the atmosphere that change the TOTAL freshwater stored in the combined liquid ocean, sea-ice, and snow reservoirs.

../images/plots/native_plots/Ocean_and_Sea-Ice_Surface_Freshwa

Figure 59:
Dataset: OCEAN_AND_ICE_SURFACE_FW_FLUX
Variable: SIatmFW

15.8.8 Native Variable SIfwThru

Table 15.44: CDL description of OCEAN_AND_ICE_SURFACE_FW_FLUX's SIfwThru variable

Storage Type	Variable Name	Description	Unit
float32	SIfwThru	Precipitation through sea-ice	kg m-2 s-1
CDL Description			
float32 SIfwThru(time, tile, j, i) SIfwThru: _FillValue = 9.96921e+36 SIfwThru: long_name = Precipitation through sea: ice SIfwThru: units = kg m: 2 s: 1 SIfwThru: coverage_content_type = modelResult SIfwThru: direction = >0 increases ocean volume SIfwThru: coordinates = YC XC time SIfwThru: valid_min = : 1.695218452368863e: 05 SIfwThru: valid_max = 0.0010632629273459315			
Comments			
Precipitation over sea-ice covered regions reaching ocean through sea-ice. Note: Precipitation over sea-ice covered regions that directly reaches ocean through the sea-ice. It is not due to melt of sea-ice/snow.			

../images/plots/native_plots/Ocean_and_Sea-Ice_Surface_Freshwa

Figure 60:
Dataset: OCEAN_AND_ICE_SURFACE_FW_FLUX
Variable: SIfwThru

15.8.9 Native Variable SIrsSubl

Table 15.45: CDL description of OCEAN_AND_ICE_SURFACE_FW_FLUX's SIrsSubl variable

Storage Type	Variable Name	Description	Unit
float32	SIrsSubl	Residual sublimation freshwater flux	kg m-2 s-1
CDL Description			
float32 SIrsSubl(time, tile, j, i) SIrsSubl: _FillValue = 9.96921e+36 SIrsSubl: long_name = Residual sublimation freshwater flux SIrsSubl: units = kg m: 2 s: 1 SIrsSubl: coverage_content_type = modelResult SIrsSubl: direction = >0 decreases ocean volume SIrsSubl: coordinates = YC XC time SIrsSubl: valid_min = : 0.0001067528864950873 SIrsSubl: valid_max = 8.640533451398369e: 06			
Comments			
Residual freshwater flux by sublimation to remove water from or add water to ocean. When implied sublimation freshwater flux SIacSubl is larger than availabe sea-ice/snow, SIrsSubl is positive and water is removed from ocean. Note: freshwater flux by sublimation that is to remove water from the ocean when it is positive.			

../images/plots/native_plots/Ocean_and_Sea-Ice_Surface_Freshwa

Figure 61:
Dataset: OCEAN_AND_ICE_SURFACE_FW_FLUX
Variable: SIrsSubl

15.8.10 Native Variable SIsnPrcp

Table 15.46: CDL description of OCEAN_AND_ICE_SURFACE_FW_FLUX's SIsnPrcp variable

Storage Type	Variable Name	Description	Unit
float32	SIsnPrcp	Snow precipitation on sea-ice	kg m-2 s-1

CDL Description

```
float32 SIsnPrcp(time, tile, j, i)
    SIsnPrcp: _FillValue = 9.96921e+36
    SIsnPrcp: long_name = Snow precipitation on sea: ice
    SIsnPrcp: units = kg m: 2 s: 1
    SIsnPrcp: coverage_content_type = modelResult
    SIsnPrcp: direction = >0 increases snow thickness (HSNOW)
    SIsnPrcp: standard_name = snowfall_flux
    SIsnPrcp: coordinates = YC XC time
    SIsnPrcp: valid_min = : 4.334669574745931e: 05
    SIsnPrcp: valid_max = 0.0009354020585305989
```

Comments

Snow precipitation rate over sea-ice, averaged over the entire model grid cell.

../images/plots/native_plots/Ocean_and_Sea-Ice_Surface_Freshwa

Figure 62:
Dataset: OCEAN_AND_ICE_SURFACE_FW_FLUX
Variable: SIsnPrcp

15.8.11 Native Variable oceFWflx

Table 15.47: CDL description of OCEAN_AND_ICE_SURFACE_FW_FLUX's oceFWflx variable

<table>
<tr><th>Storage Type</th><th>Variable Name</th><th>Description</th><th>Unit</th></tr>
<tr><td>float32</td><td>oceFWflx</td><td>Net freshwater flux into the ocean</td><td>kg m-2 s-1</td></tr>
<tr><th colspan="4">CDL Description</th></tr>
<tr><td colspan="4">float32 oceFWflx(time, tile, j, i)
oceFWflx: _FillValue = 9.96921e+36
oceFWflx: long_name = Net freshwater flux into the ocean
oceFWflx: units = kg m: 2 s: 1
oceFWflx: coverage_content_type = modelResult
oceFWflx: direction = >0 decreases salinity (SALT)
oceFWflx: standard_name = water_flux_into_sea_water
oceFWflx: coordinates = YC XC time
oceFWflx: valid_min = : 0.003914969973266125
oceFWflx: valid_max = 0.008299433626234531</td></tr>
<tr><th colspan="4">Comments</th></tr>
<tr><td colspan="4">Net freshwater flux into the ocean including contributions from runoff, evaporation, precipitation, and mass exchange with sea-ice due to melting and freezing and snow melting. Note: oceFWflx does NOT include freshwater fluxes between the atmosphere and sea-ice and snow. The variable 'SIatmFW' accounts for freshwater fluxes out of the combined ocean+sea-ice+snow reservoir.</td></tr>
</table>

../images/plots/native_plots/Ocean_and_Sea-Ice_Surface_Freshwa

**Figure 63:
Dataset: OCEAN_AND_ICE_SURFACE_FW_FLUX
Variable: oceFWflx**

15.9 Native NetCDF OCEAN_AND_ICE_SURFACE_HEAT_FLUX

Table 15.48: Variables in the dataset OCEAN_AND_ICE_SURFACE_HEAT_FLUX

Dataset:	OCEAN_AND_ICE_SURFACE_HEAT_FLUX
Field:	EXFhl
Field:	EXFhs
Field:	EXFlwdn
Field:	EXFswdn
Field:	EXFqnet
Field:	oceQnet
Field:	SIatmQnt
Field:	TFLUX
Field:	EXFswnet
Field:	EXFlwnet
Field:	oceQsw
Field:	SIaaflux

15.9.1 Native Variable EXFhl

Table 15.49: CDL description of OCEAN_AND_ICE_SURFACE_HEAT_FLUX's EXFhl variable

Storage Type	Variable Name	Description	Unit
float32	EXFhl	Open ocean air-sea latent heat flux	W m-2
CDL Description			
float32 EXFhl(time, tile, j, i) EXFhl: _FillValue = 9.96921e+36 EXFhl: long_name = Open ocean air: sea latent heat flux EXFhl: units = W m: 2 EXFhl: coverage_content_type = modelResult EXFhl: direction = >0 increases potential temperature (THETA) EXFhl: standard_name = surface_downward_latent_heat_flux EXFhl: coordinates = XC time YC EXFhl: valid_min = : 1772.513671875 EXFhl: valid_max = 273.9528503417969			
Comments			
Air-sea latent heat flux per unit area of open water (not covered by sea-ice). Note: calculated from the bulk formula following Large and Yeager (2004) NCAR/TN-460+STR.			

../images/plots/native_plots/Ocean_and_Sea-Ice_Surface_Heat_Fl

Figure 64:
Dataset: OCEAN_AND_ICE_SURFACE_HEAT_FLUX
Variable: EXFhl

15.9.2 Native Variable EXFhs

Table 15.50: CDL description of OCEAN_AND_ICE_SURFACE_HEAT_FLUX's EXFhs variable

Storage Type	Variable Name	Description	Unit
float32	EXFhs	Open ocean air-sea sensible heat flux	W m-2
CDL Description			
float32 EXFhs(time, tile, j, i) EXFhs: _FillValue = 9.96921e+36 EXFhs: long_name = Open ocean air: sea sensible heat flux EXFhs: units = W m: 2 EXFhs: coverage_content_type = modelResult EXFhs: direction = >0 increases potential temperature (THETA) EXFhs: standard_name = surface_downward_sensible_heat_flux EXFhs: coordinates = XC time YC EXFhs: valid_min = : 2478.766357421875 EXFhs: valid_max = 362.8300476074219			
Comments			
Air-sea sensible heat flux per unit area of open water (not covered by sea-ice). Note: calculated from the bulk formula following Large and Yeager (2004) NCAR/TN-460+STR.			

../images/plots/native_plots/Ocean_and_Sea-Ice_Surface_Heat_Fl

Figure 65:
Dataset: OCEAN_AND_ICE_SURFACE_HEAT_FLUX
Variable: EXFhs

15.9.3 Native Variable EXFlwdn

Table 15.51: CDL description of OCEAN_AND_ICE_SURFACE_HEAT_FLUX's EXFlwdn variable

<table>
<tr><th>Storage Type</th><th>Variable Name</th><th>Description</th><th>Unit</th></tr>
<tr><td>float32</td><td>EXFlwdn</td><td>Downward longwave radiative flux</td><td>W m-2</td></tr>
<tr><th colspan="4">CDL Description</th></tr>
<tr><td colspan="4">float32 EXFlwdn(time, tile, j, i)
EXFlwdn: _FillValue = 9.96921e+36
EXFlwdn: long_name = Downward longwave radiative flux
EXFlwdn: units = W m: 2
EXFlwdn: coverage_content_type = modelResult
EXFlwdn: direction = >0 increases potential temperature (THETA)
EXFlwdn: standard_name = surface_downwelling_longwave_flux_in_air
EXFlwdn: coordinates = XC time YC
EXFlwdn: valid_min = 4.188045501708984
EXFlwdn: valid_max = 513.3919067382812</td></tr>
<tr><th colspan="4">Comments</th></tr>
<tr><td colspan="4">Downward longwave radiative flux. Note: sum of ERA-Interim downward longwave radiation and the control adjustment from ocean state estimation.</td></tr>
</table>

../images/plots/native_plots/Ocean_and_Sea-Ice_Surface_Heat_Fl

Figure 66:
Dataset: OCEAN_AND_ICE_SURFACE_HEAT_FLUX
Variable: EXFlwdn

15.9.4 Native Variable EXFlwnet

Table 15.52: CDL description of OCEAN_AND_ICE_SURFACE_HEAT_FLUX's EXFlwnet variable

Storage Type	Variable Name	Description	Unit
float32	EXFlwnet	Net open ocean longwave radiative flux	W m-2
CDL Description			
float32 EXFlwnet(time, tile, j, i) EXFlwnet: _FillValue = 9.96921e+36 EXFlwnet: long_name = Net open ocean longwave radiative flux EXFlwnet: units = W m: 2 EXFlwnet: coverage_content_type = modelResult EXFlwnet: direction = >0 increases potential temperature (THETA) EXFlwnet: standard_name = surface_net_downward_longwave_flux EXFlwnet: coordinates = XC time YC EXFlwnet: valid_min = : 144.3661346435547 EXFlwnet: valid_max = 293.4114990234375			
Comments			
Net longwave radiative flux per unit area of open water (not covered by sea-ice). Note: net longwave radiation over open water calculated from downward longwave radiation (EXFlwdn) and upward longwave radiation from ocean and sea-ice thermal emission (Stefan-Boltzman law).			

../images/plots/native_plots/Ocean_and_Sea-Ice_Surface_Heat_Fl

Figure 67:
Dataset: OCEAN_AND_ICE_SURFACE_HEAT_FLUX
Variable: EXFlwnet

15.9.5 Native Variable EXFqnet

Table 15.53: CDL description of OCEAN_AND_ICE_SURFACE_HEAT_FLUX's EXFqnet variable

Storage Type	Variable Name	Description	Unit
float32	EXFqnet	Open ocean net air-sea heat flux	W m-2
CDL Description			
float32 EXFqnet(time, tile, j, i) EXFqnet: _FillValue = 9.96921e+36 EXFqnet: long_name = Open ocean net air: sea heat flux EXFqnet: units = W m: 2 EXFqnet: coverage_content_type = modelResult EXFqnet: direction = >0 increases potential temperature (THETA) EXFqnet: coordinates = XC time YC EXFqnet: valid_min = : 687.8736572265625 EXFqnet: valid_max = 3408.977783203125			
Comments			
Net air-sea heat flux (turbulent and radiative) per unit area of open water (not covered by sea-ice). Note: net upward heat flux over open water, calculated as EXFlwnet+EXFswnet-EXFlh-EXFhs.			

../images/plots/native_plots/Ocean_and_Sea-Ice_Surface_Heat_Fl

Figure 68:
Dataset: OCEAN_AND_ICE_SURFACE_HEAT_FLUX
Variable: EXFqnet

15.9.6 Native Variable EXFswdn

Table 15.54: CDL description of OCEAN_AND_ICE_SURFACE_HEAT_FLUX's EXFswdn variable

Storage Type	Variable Name	Description	Unit
float32	EXFswdn	Downwelling shortwave radiative flux	W m-2
CDL Description			
float32 EXFswdn(time, tile, j, i) EXFswdn: _FillValue = 9.96921e+36 EXFswdn: long_name = Downwelling shortwave radiative flux EXFswdn: units = W m: 2 EXFswdn: coverage_content_type = modelResult EXFswdn: direction = >0 increases potential temperature (THETA) EXFswdn: standard_name = surface_downwelling_shortwave_flux_in_air EXFswdn: coordinates = XC time YC EXFswdn: valid_min = : 224.63368225097656 EXFswdn: valid_max = 707.345947265625			
Comments			
Downward shortwave radiative flux. Note: sum of ERA-Interim downward shortwave radiation and the control adjustment from ocean state estimation.			

../images/plots/native_plots/Ocean_and_Sea-Ice_Surface_Heat_Fl

Figure 69:
Dataset: OCEAN_AND_ICE_SURFACE_HEAT_FLUX
Variable: EXFswdn

15.9.7 Native Variable EXFswnet

Table 15.55: CDL description of OCEAN_AND_ICE_SURFACE_HEAT_FLUX's EXFswnet variable

Storage Type	Variable Name	Description	Unit
float32	EXFswnet	Open ocean net shortwave radiative flux	W m-2

CDL Description

```
float32 EXFswnet(time, tile, j, i)
    EXFswnet: _FillValue = 9.96921e+36
    EXFswnet: long_name = Open ocean net shortwave radiative flux
    EXFswnet: units = W m: 2
    EXFswnet: coverage_content_type = modelResult
    EXFswnet: direction = >0 increases potential temperature (THETA)
    EXFswnet: standard_name = surface_net_downward_shortwave_flux
    EXFswnet: coordinates = XC time YC
    EXFswnet: valid_min = : 655.6171264648438
    EXFswnet: valid_max = 194.18458557128906
```

Comments

Net shortwave radiative flux per unit area of open water (not covered by sea-ice). Note: net shortwave radiation over open water calculated from downward shortwave flux (EXFswdn) and ocean surface albdeo.

../images/plots/native_plots/Ocean_and_Sea-Ice_Surface_Heat_Fl

Figure 70:
Dataset: OCEAN_AND_ICE_SURFACE_HEAT_FLUX
Variable: EXFswnet

15.9.8 Native Variable SIaaflux

Table 15.56: CDL description of OCEAN_AND_ICE_SURFACE_HEAT_FLUX's SIaaflux variable

Storage Type	Variable Name	Description	Unit
float32	SIaaflux	Conservative ocean and sea-ice advective heat flux adjustment	W m-2
CDL Description			
float32 SIaaflux(time, tile, j, i) SIaaflux: _FillValue = 9.96921e+36 SIaaflux: long_name = Conservative ocean and sea: ice advective heat flux adjustment SIaaflux: units = W m: 2 SIaaflux: coverage_content_type = modelResult SIaaflux: direction = >0 decrease potential temperature (THETA) SIaaflux: coordinates = XC time YC SIaaflux: valid_min = : 16.214622497558594 SIaaflux: valid_max = 50.35451889038086			
Comments			
Heat flux associated with the temperature difference between sea surface temperature and sea-ice (assume 0 degree C in the model). Note: heat flux needed to melt/freeze sea-ice at 0 degC to sea water at the ocean surface (at sea surface temperature), excluding the latent heat of fusion.			

../images/plots/native_plots/Ocean_and_Sea-Ice_Surface_Heat_Fl

Figure 71:
Dataset: OCEAN_AND_ICE_SURFACE_HEAT_FLUX
Variable: SIaaflux

15.9.9 Native Variable SIatmQnt

Table 15.57: CDL description of OCEAN_AND_ICE_SURFACE_HEAT_FLUX's SIatmQnt variable

Storage Type	Variable Name	Description	Unit
float32	SIatmQnt	Net upward heat flux to the atmosphere	W m-2
CDL Description			
float32 SIatmQnt(time, tile, j, i) SIatmQnt: _FillValue = 9.96921e+36 SIatmQnt: long_name = Net upward heat flux to the atmosphere SIatmQnt: units = W m: 2 SIatmQnt: coverage_content_type = modelResult SIatmQnt: direction = >0 upward decreases ocean temperature SIatmQnt: standard_name = surface_upward_heat_flux_in_air SIatmQnt: coordinates = XC time YC SIatmQnt: valid_min = : 756.0607299804688 SIatmQnt: valid_max = 1704.7703857421875			
Comments			
Net upward heat flux to the atmosphere across open water and sea-ice or snow surfaces. Note: nonzero SIatmQnt may not be associated with a change in ocean potential temperature due to sea-ice growth or melting. To calculate total ocean heat content changes use the variable TFLUX which also accounts for changing ocean mass (e.g. oceFWflx).			

../images/plots/native_plots/Ocean_and_Sea-Ice_Surface_Heat_Fl

Figure 72:
Dataset: OCEAN_AND_ICE_SURFACE_HEAT_FLUX
Variable: SIatmQnt

15.9.10 Native Variable TFLUX

Table 15.58: CDL description of OCEAN_AND_ICE_SURFACE_HEAT_FLUX's TFLUX variable

Storage Type	Variable Name	Description	Unit
float32	TFLUX	Rate of change of ocean heat content per m2 accounting for mass fluxes.	W m-2
CDL Description			
float32 TFLUX(time, tile, j, i) TFLUX: _FillValue = 9.96921e+36 TFLUX: long_name = Rate of change of ocean heat content per m2 accounting for mass fluxes. TFLUX: units = W m: 2 TFLUX: coverage_content_type = modelResult TFLUX: direction = >0 increases potential temperature (THETA) TFLUX: coordinates = XC time YC TFLUX: valid_min = : 1713.51220703125 TFLUX: valid_max = 870.3130493164062			
Comments			
The rate of change of ocean heat content due to heat fluxes across the liquid surface and the addition or removal of mass. . Note: the global area integral of TFLUX and geothermal flux (geothermalFlux.bin) matches the time-derivative of ocean heat content (J/s). Unlike oceQnet, TFLUX includes the contribution to the ocean heat content from changing ocean mass (e.g. from oceFWflx).			

../images/plots/native_plots/Ocean_and_Sea-Ice_Surface_Heat_Fl

Figure 73:
Dataset: OCEAN_AND_ICE_SURFACE_HEAT_FLUX
Variable: TFLUX

15.9.11 Native Variable oceQnet

Table 15.59: CDL description of OCEAN_AND_ICE_SURFACE_HEAT_FLUX's oceQnet variable

Storage Type	Variable Name	Description	Unit
float32	oceQnet	Net heat flux into the ocean surface	W m-2

CDL Description

float32 oceQnet(time, tile, j, i)
    oceQnet: _FillValue = 9.96921e+36
    oceQnet: long_name = Net heat flux into the ocean surface
    oceQnet: units = W m: 2
    oceQnet: coverage_content_type = modelResult
    oceQnet: direction = >0 increases potential temperature (THETA)
    oceQnet: standard_name = surface_downward_heat_flux_in_sea_water
    oceQnet: coordinates = XC time YC
    oceQnet: valid_min = : 1708.8460693359375
    oceQnet: valid_max = 675.3716430664062

Comments

Net heat flux into the ocean surface from all processes: air-sea turbulent and radiative fluxes and turbulent and conductive fluxes between the ocean and sea-ice and snow. Note: oceQnet does not include the change in ocean heat content due to changing ocean ocean mass (oceFWflx). Mass fluxes from evaporation, precipitation, and runoff (EXFempmr) happen at the same temperature as the ocean surface temperature. Consequently, EmPmR does not change ocean surface temperature. Conversely, mass fluxes due to sea-ice thickening/thinning and snow melt in the model are assumed to happen at a fixed 0C. Consequently, mass fluxes due to phase changes between seawater and sea-ice and snow induce a heat flux when the ocean surface temperaure is not 0C. The variable TFLUX does include the change in ocean heat content due to changing ocean mass.

../images/plots/native_plots/Ocean_and_Sea-Ice_Surface_Heat_Fl

Figure 74:
Dataset: OCEAN_AND_ICE_SURFACE_HEAT_FLUX
Variable: oceQnet

15.9.12 Native Variable oceQsw

Table 15.60: CDL description of OCEAN_AND_ICE_SURFACE_HEAT_FLUX's oceQsw variable

Storage Type	Variable Name	Description	Unit
float32	oceQsw	Net shortwave radiative flux across the ocean surface	W m-2
CDL Description			
float32 oceQsw(time, tile, j, i) oceQsw: _FillValue = 9.96921e+36 oceQsw: long_name = Net shortwave radiative flux across the ocean surface oceQsw: units = W m: 2 oceQsw: coverage_content_type = modelResult oceQsw: direction = >0 increases potential temperature (THETA) oceQsw: coordinates = XC time YC oceQsw: valid_min = : 134.39808654785156 oceQsw: valid_max = 655.6171264648438			
Comments			
Net shortwave radiative flux across the ocean surface. Note: Shortwave radiation penetrates below the surface grid cell.			

../images/plots/native_plots/Ocean_and_Sea-Ice_Surface_Heat_Fl

Figure 75:
Dataset: OCEAN_AND_ICE_SURFACE_HEAT_FLUX
Variable: oceQsw

15.10 Native NetCDF OCEAN_AND_ICE_SURFACE_STRESS

Table 15.61: Variables in the dataset OCEAN_AND_ICE_SURFACE_STRESS

Dataset:	**OCEAN_AND_ICE_SURFACE_STRESS**
Field:	EXFtaux
Field:	EXFtauy
Field:	oceTAUX
Field:	oceTAUY

15.10.1 Native Variable EXFtaux

Table 15.62: CDL description of OCEAN_AND_ICE_SURFACE_STRESS's EXFtaux variable

Storage Type	Variable Name	Description	Unit
float32	EXFtaux	Wind stress in the model +x direction	N m-2

CDL Description

```
float32 EXFtaux(time, tile, j, i)
    EXFtaux: _FillValue = 9.96921e+36
    EXFtaux: long_name = Wind stress in the model +x direction
    EXFtaux: units = N m: 2
    EXFtaux: coverage_content_type = modelResult
    EXFtaux: direction = >0 increases horizontal velocity in the +x direction (UVEL)
    EXFtaux: standard_name = surface_downward_x_stress
    EXFtaux: coordinates = time YC XC
    EXFtaux: valid_min = : 7.474303722381592
    EXFtaux: valid_max = 3.7184090614318848
```

Comments

Wind stress in the +x direction at the tracer cell on the native model grid. Note: EXFtaux is the stress applied to the ice-free ocean surface and sea-ice covered surface. When sea-ice is present, the total stress applied to the ocean surface in the +x direction is NOT EXFtaux, but a combination of EXFtaux wind stress in the open water fraction and a stress from sea-ice in the ice-covered fraction (see oceTAUX). EXFtaux is the sum of ERA-Interim stress and the control adjustment from ocean state estimation.

../images/plots/native_plots/Ocean_and_Sea-Ice_Surface_Stress/

Figure 76:
Dataset: OCEAN_AND_ICE_SURFACE_STRESS
Variable: EXFtaux

15.10.2 Native Variable EXFtauy

Table 15.63: CDL description of OCEAN_AND_ICE_SURFACE_STRESS's EXFtauy variable

Storage Type	Variable Name	Description	Unit
float32	EXFtauy	Wind stress in the model +y direction	N m-2
CDL Description			
float32 EXFtauy(time, tile, j, i) EXFtauy: _FillValue = 9.96921e+36 EXFtauy: long_name = Wind stress in the model +y direction EXFtauy: units = N m: 2 EXFtauy: coverage_content_type = modelResult EXFtauy: direction = >0 increases horizontal velocity in the +y direction (VVEL) EXFtauy: standard_name = surface_downward_y_stress EXFtauy: coordinates = time YC XC EXFtauy: valid_min = : 3.71972918510437 EXFtauy: valid_max = 3.7044837474823			
Comments			
Wind stress in the +y direction at the tracer cell on the native model grid. Note: EXFtauy is the stress applied to the ice-free ocean surface and sea-ice covered surface. When sea-ice is present, the total stress applied to the ocean surface in the +y direction is NOT EXFtauy, but a combination of EXFtauy wind stress in the open water fraction and a stress from sea-ice in the ice-covered fraction (see oceTAUY). EXFtaux is the sum of ERA-Interim stress and the control adjustment from ocean state estimation.			

../images/plots/native_plots/Ocean_and_Sea-Ice_Surface_Stress/

Figure 77:
Dataset: OCEAN_AND_ICE_SURFACE_STRESS
Variable: EXFtauy

15.10.3 Native Variable oceTAUX

Table 15.64: CDL description of OCEAN_AND_ICE_SURFACE_STRESS's oceTAUX variable

<table>
<tr><th>Storage Type</th><th>Variable Name</th><th>Description</th><th>Unit</th></tr>
<tr><td>float32</td><td>oceTAUX</td><td>Ocean surface stress in the model +x direction</td><td>N m-2</td></tr>
<tr><th colspan="4">CDL Description</th></tr>
<tr><td colspan="4">float32 oceTAUX(time, tile, j, i_g)
oceTAUX: _FillValue = 9.96921e+36
oceTAUX: long_name = Ocean surface stress in the model +x direction
oceTAUX: units = N m: 2
oceTAUX: mate = oceTAUY
oceTAUX: coverage_content_type = modelResult
oceTAUX: direction = >0 increases horizontal velocity in the +x direction (UVEL)
oceTAUX: standard_name = downward_x_stress_at_sea_water_surface
oceTAUX: coordinates = time
oceTAUX: valid_min = : 2.2317698001861572
oceTAUX: valid_max = 1.9993581771850586</td></tr>
<tr><th colspan="4">Comments</th></tr>
<tr><td colspan="4">Ocean surface stress due to wind and sea-ice in the +x direction centered over the 'u' side of the the native model grid. Note: in the Arakawa-C grid, wind stress acts on horizontal velocities which are staggered relative to the tracer cells with indexing such that +oceTAUX(i_g,j) corresponds to +x momentum fluxes at 'u' edge of the tracer cell at (i,j,k=0). Also, the model +x direction does not necessarily correspond to the geographical east-west direction because the x and y axes of the model's curvilinear lat-lon-cap (llc) grid have arbitrary orientations which vary within and across tiles.</td></tr>
</table>

../images/plots/native_plots/Ocean_and_Sea-Ice_Surface_Stress/

Figure 78:
Dataset: OCEAN_AND_ICE_SURFACE_STRESS
Variable: oceTAUX

15.10.4 Native Variable oceTAUY

Table 15.65: CDL description of OCEAN_AND_ICE_SURFACE_STRESS's oceTAUY variable

Storage Type	Variable Name	Description	Unit
float32	oceTAUY	Ocean surface stress in the model +y direction	N m-2
CDL Description			
float32 oceTAUY(time, tile, j_g, i) oceTAUY: _FillValue = 9.96921e+36 oceTAUY: long_name = Ocean surface stress in the model +y direction oceTAUY: units = N m: 2 oceTAUY: mate = oceTAUX oceTAUY: coverage_content_type = modelResult oceTAUY: direction = >0 increases horizontal velocity in the +y direction (VVEL) oceTAUY: standard_name = downward_y_stress_at_sea_water_surface oceTAUY: coordinates = time oceTAUY: valid_min = : 2.0606131553649902 oceTAUY: valid_max = 1.9999693632125854			
Comments			
Ocean surface stress due to wind and sea-ice in the +y direction centered over the 'v' side of the the native model grid. Note: in the Arakawa-C grid, wind stress acts on horizontal velocities which are staggered relative to the tracer cells with indexing such that +oceTAUY(i_g,j) corresponds to +y momentum fluxes at 'v' edge of the tracer cell at (i,j,k=0). Also, the model +y direction does not necessarily correspond to the geographical north-south direction because the x and y axes of the model's curvilinear lat-lon-cap (llc) grid have arbitrary orientations which vary within and across tiles.			

../images/plots/native_plots/Ocean_and_Sea-Ice_Surface_Stress/

Figure 79:
Dataset: OCEAN_AND_ICE_SURFACE_STRESS
Variable: oceTAUY

15.11 Native NetCDF OCEAN_BOLUS_STREAMFUNCTION

Table 15.66: Variables in the dataset OCEAN_BOLUS_STREAMFUNCTION

Dataset:	**OCEAN_BOLUS_STREAMFUNCTION**
Field:	GM_PsiX
Field:	GM_PsiY

15.11.1 Native Variable GM_PsiX

Table 15.67: CDL description of OCEAN_BOLUS_STREAMFUNCTION's GM_PsiX variable

Storage Type	Variable Name	Description	Unit
float32	GM_PsiX	Gent-Mcwilliams bolus transport streamfunction in the model +x direction	m2 s-1
CDL Description			
float32 GM_PsiX(time, k_l, tile, j, i_g) GM_PsiX: _FillValue = 9.96921e+36 GM_PsiX: long_name = Gent: Mcwilliams bolus transport streamfunction in the model +x direction GM_PsiX: units = m2 s: 1 GM_PsiX: mate = GM_PsiY GM_PsiX: coverage_content_type = modelResult GM_PsiX: coordinates = Zl time GM_PsiX: valid_min = : 4.9964470863342285 GM_PsiX: valid_max = 4.963776111602783			
Comments			
Gent-Mcwilliams bolus transport streamfunction 'u' component. any comments welcome			

../images/plots/native_plots/Gent-McWilliams_Bolus_Transport_S

Figure 80:
Dataset: OCEAN_BOLUS_STREAMFUNCTION
Variable: GM_PsiX

15.11.2 Native Variable GM_PsiY

Table 15.68: CDL description of OCEAN_BOLUS_STREAMFUNCTION's GM_PsiY variable

Storage Type	Variable Name	Description	Unit
float32	GM_PsiY	Gent-Mcwilliams bolus transport streamfunction in the model +y direction	m2 s-1
CDL Description			
float32 GM_PsiY(time, k_l, tile, j_g, i) GM_PsiY: _FillValue = 9.96921e+36 GM_PsiY: long_name = Gent: Mcwilliams bolus transport streamfunction in the model +y direction GM_PsiY: units = m2 s: 1 GM_PsiY: mate = GM_PsiX GM_PsiY: coverage_content_type = modelResult GM_PsiY: coordinates = Zl time GM_PsiY: valid_min = : 5.0 GM_PsiY: valid_max = 4.949861526489258			
Comments			
Gent-Mcwilliams bolus transport streamfunction 'v' component. any comments welcome			

../images/plots/native_plots/Gent-McWilliams_Bolus_Transport_S

Figure 81:
Dataset: OCEAN_BOLUS_STREAMFUNCTION
Variable: GM_PsiY

15.12 Native NetCDF OCEAN_BOLUS_VELOCITY

Table 15.69: Variables in the dataset OCEAN_BOLUS_VELOCITY

Dataset:	**OCEAN_BOLUS_VELOCITY**
Field:	UVELSTAR
Field:	VVELSTAR
Field:	WVELSTAR

15.12.1 Native Variable UVELSTAR

Table 15.70: CDL description of OCEAN_BOLUS_VELOCITY's UVELSTAR variable

Storage Type	Variable Name	Description	Unit
float32	UVELSTAR	Gent-McWilliams velocity in the model +x direction scaled by time-varying grid cell thickness	m s-1
CDL Description			
float32 UVELSTAR(time, k, tile, j, i_g) UVELSTAR: _FillValue = 9.96921e+36 UVELSTAR: long_name = Gent: McWilliams velocity in the model +x direction scaled by time: varying grid cell thickness UVELSTAR: units = m s: 1 UVELSTAR: mate = VVELSTAR UVELSTAR: coverage_content_type = modelResult UVELSTAR: standard_name = sea_water_x_velocity_due_to_parameterized_mesoscale_eddies UVELSTAR: coordinates = Z time UVELSTAR: valid_min = : 0.7960150241851807 UVELSTAR: valid_max = 0.7762293219566345			
Comments			
Gent-McWilliams horizontal velocity in the +x direction at the 'u' face of the tracer cell on the native model grid. Note: UVELSTAR is not a model diagnostic but is calculated offline: UVELSTAR = -d/dz GM_PsiX. In the Arakawa-C grid, horizontal velocities are staggered relative to the tracer cells with indexing such that +UVELSTAR(i_g,j,k) corresponds to +x tracer fluxes through the 'u' face of the tracer cell at (i,j,k). Also, the model +x direction does not necessarily correspond to the geographical east-west direction because the x and y axes of the model's curvilinear lat-lon-cap (llc) grid have arbitrary orientations which vary within and across tiles. See EVELSTAR and NVELSTAR.			

../images/plots/native_plots/Gent-McWilliams_Ocean_Bolus_Veloc

Figure 82:
Dataset: OCEAN_BOLUS_VELOCITY
Variable: UVELSTAR

15.12.2 Native Variable VVELSTAR

Table 15.71: CDL description of OCEAN_BOLUS_VELOCITY's VVELSTAR variable

Storage Type	Variable Name	Description	Unit
float32	VVELSTAR	Gent-McWilliams velocity in the model +y direction scaled by time-varying grid cell thickness	m s-1
CDL Description			
float32 VVELSTAR(time, k, tile, j_g, i) VVELSTAR: _FillValue = 9.96921e+36 VVELSTAR: long_name = Gent: McWilliams velocity in the model +y direction scaled by time: varying grid cell thickness VVELSTAR: units = m s: 1 VVELSTAR: mate = UVELSTAR VVELSTAR: coverage_content_type = modelResult VVELSTAR: standard_name = sea_water_y_velocity_due_to_parameterized_mesoscale_eddies VVELSTAR: coordinates = Z time VVELSTAR: valid_min = : 0.8495296239852905 VVELSTAR: valid_max = 0.7200774550437927			
Comments			
Gent-McWilliams horizontal velocity in the +y direction at the 'v' face of the tracer cell on the native model grid. Note: VVELSTAR is not a model diagnostic but is calculated offline: VVELSTAR = -d/dz GM_PsiY. In the Arakawa-C grid, horizontal velocities are staggered relative to the tracer cells with indexing such that +VVELSTAR(i,j_g,k) corresponds to +y tracer fluxes through the 'v' face of the tracer cell at (i,j,k). Also, the model +y direction does not necessarily correspond to the geographical north-south direction because the x and y axes of the model's curvilinear lat-lon-cap (llc) grid have arbitrary orientations which vary within and across tiles. See EVELSTAR and NVELSTAR.			

../images/plots/native_plots/Gent-McWilliams_Ocean_Bolus_Veloc

Figure 83:
Dataset: OCEAN_BOLUS_VELOCITY
Variable: VVELSTAR

15.12.3 Native Variable WVELSTAR

Table 15.72: CDL description of OCEAN_BOLUS_VELOCITY's WVELSTAR variable

Storage Type	Variable Name	Description	Unit
float32	WVELSTAR	Gent-McWilliams velocity in the model +z direction	m s-1
CDL Description			
float32 WVELSTAR(time, k_l, tile, j, i) WVELSTAR: _FillValue = 9.96921e+36 WVELSTAR: long_name = Gent: McWilliams velocity in the model +z direction WVELSTAR: units = m s: 1 WVELSTAR: coverage_content_type = modelResult WVELSTAR: direction = >0 decreases volume WVELSTAR: standard_name = upward_sea_water_velocity_due_to_parameterized_mesoscale_eddies WVELSTAR: coordinates = XC YC time Zl WVELSTAR: valid_min = : 0.00037936007720418274 WVELSTAR: valid_max = 0.000465469085611403			
Comments			
Gent-McWilliams vertical bolus velocity in the +z direction at the top 'w' face of the tracer cell on the native model grid. Note: in the Arakawa-C grid, vertical velocities are staggered relative to the tracer cells with indexing such that +WVELSTAR(i,j,k_l) corresponds to upward +z motion through the top 'w' face of the tracer cell at (i,j,k).			

../images/plots/native_plots/Gent-McWilliams_Ocean_Bolus_Veloc

Figure 84:
Dataset: OCEAN_BOLUS_VELOCITY
Variable: WVELSTAR

15.13 Native NetCDF OCEAN_BOTTOM_PRESSURE

Table 15.73: Variables in the dataset OCEAN_BOTTOM_PRESSURE

Dataset:	**OCEAN_BOTTOM_PRESSURE**
Field:	OBP
Field:	OBPGMAP
Field:	PHIBOT

15.13.1 Native Variable OBP

Table 15.74: CDL description of OCEAN_BOTTOM_PRESSURE's OBP variable

Storage Type	Variable Name	Description	Unit
float32	OBP	Ocean bottom pressure given as equivalent water thickness	m
CDL Description			
float32 OBP(time, tile, j, i) OBP: _FillValue = 9.96921e+36 OBP: long_name = Ocean bottom pressure given as equivalent water thickness OBP: units = m OBP: coverage_content_type = modelResult OBP: coordinates = time XC YC OBP: valid_min = : 2.544442892074585 OBP: valid_max = 72.1243667602539			
Comments			
OBP excludes the contribution from global mean atmospheric pressure and is therefore suitable for comparisons with GRACE data products. OBP is calculated as follows. First, we calculate ocean hydrostatic bottom pressure anomaly, PHIBOT, with PHIBOT = p_b/rhoConst - gH(t), where p_b = model ocean hydrostatic bottom pressure, rhoConst = reference density (1029 kg m-3), g is acceleration due to gravity (9.81 m s-2), and H(t) is model depth at time t. Then, OBP = PHIBOT/g + corrections for i) global mean steric sea level changes related to density changes in the Boussinesq volume-conserving model (Greatbatch correction, see sterGloH) and ii) global mean atmospheric pressure variations. Use OBP for comparisons with ocean bottom pressure data products that have been corrected for global mean atmospheric pressure variations. GRACE data typically ARE corrected for global mean atmospheric pressure variations. In contrast, ocean bottom pressure gauge data typically ARE NOT corrected for global mean atmospheric pressure variations.			

../images/plots/native_plots/Ocean_Bottom_Pressure/OBP.png

Figure 85:
Dataset: OCEAN_BOTTOM_PRESSURE
Variable: OBP

15.13.2 Native Variable OBPGMAP

Table 15.75: CDL description of OCEAN_BOTTOM_PRESSURE's OBPGMAP variable

Storage Type	Variable Name	Description	Unit
float32	OBPGMAP	Ocean bottom pressure given as equivalent water thickness, includes global mean atmospheric pressure	m
CDL Description			
float32 OBPGMAP(time, tile, j, i) OBPGMAP: _FillValue = 9.96921e+36 OBPGMAP: long_name = Ocean bottom pressure given as equivalent water thickness includes global mean atmospheric pressure OBPGMAP: units = m OBPGMAP: coverage_content_type = modelResult OBPGMAP: coordinates = time XC YC OBPGMAP: valid_min = 7.395928859710693 OBPGMAP: valid_max = 82.14805603027344			
Comments			
OBPGMAP includes the contribution from global mean atmospheric pressure and is therefore suitable for comparisons with ocean bottom pressure gauge data products. OBPGMAP is calculated as follows. First, we calculate ocean hydrostatic bottom pressure anomaly, PHIBOT, with PHIBOT = p_b/rhoConst - gH(t), where p_b = model ocean hydrostatic bottom pressure, rhoConst = reference density (1029 kg m-3), g is acceleration due to gravity (9.81 m s-2), and H(t) is model depth at time t. Then, OBPGMAP= PHIBOT/g + corrections for global mean steric sea level changes related to density changes in the Boussinesq volume-conserving model (Greatbatch correction, see sterGloH). Use OBPGMAP for comparisons with ocean bottom pressure data products that have NOT been corrected for global mean atmospheric pressure variations. GRACE data typically ARE corrected for global mean atmospheric pressure variations. In contrast, ocean bottom pressure gauge data typically ARE NOT corrected for global mean atmospheric pressure variations.			

../images/plots/native_plots/Ocean_Bottom_Pressure/OBPGMAP.png

Figure 86:
Dataset: OCEAN_BOTTOM_PRESSURE
Variable: OBPGMAP

15.13.3 Native Variable PHIBOT

Table 15.76: CDL description of OCEAN_BOTTOM_PRESSURE's PHIBOT variable

Storage Type	Variable Name	Description	Unit
float32	PHIBOT	Ocean hydrostatic bottom pressure anomaly	m2 s-2
CDL Description			
float32 PHIBOT(time, tile, j, i) PHIBOT: _FillValue = 9.96921e+36 PHIBOT: long_name = Ocean hydrostatic bottom pressure anomaly PHIBOT: units = m2 s: 2 PHIBOT: coverage_content_type = modelResult PHIBOT: coordinates = time XC YC PHIBOT: valid_min = 73.01050567626953 PHIBOT: valid_max = 805.7855224609375			
Comments			
PHIBOT = p_b / rhoConst - g H(t), where p_b = hydrostatic ocean bottom pressure, rhoConst = reference density (1029 kg m-3), g is acceleration due to gravity (9.81 m s-2), and H(t) is model depth at time t. Units: p:[kg m-1 s-2], rhoConst:[kg m-3], g:[m s-2], H(t):[m]. Note: includes atmospheric pressure loading. PHIBOT accounts for the model's time-varying grid cell thickness (z* coordinate system). PHIBOT is NOT corrected for global mean steric sea level changes related to density changes in the Boussinesq volume-conserving model (Greatbatch correction, see sterGloH), and therefore should NOT be used for comparisons with ocean bottom pressure data. Instead, see OBPGMAP and OBP.			

../images/plots/native_plots/Ocean_Bottom_Pressure/PHIBOT.png

Figure 87:
Dataset: OCEAN_BOTTOM_PRESSURE
Variable: PHIBOT

15.14 Native NetCDF OCEAN_DENS_STRAT_PRESS

Table 15.77: Variables in the dataset OCEAN_DENS_STRAT_PRESS

Dataset:	OCEAN_DENS_STRAT_PRESS
Field:	RHOAnoma
Field:	DRHODR
Field:	PHIHYD
Field:	PHIHYDcR

15.14.1 Native Variable DRHODR

Table 15.78: CDL description of OCEAN_DENS_STRAT_PRESS's DRHODR variable

Storage Type	Variable Name	Description	Unit
float32	DRHODR	Density stratification	kg m-3 m-1
CDL Description			
float32 DRHODR(time, k_l, tile, j, i) DRHODR: _FillValue = 9.96921e+36 DRHODR: long_name = Density stratification DRHODR: units = kg m: 3 m: 1 DRHODR: coverage_content_type = modelResult DRHODR: coordinates = YC XC time Zl DRHODR: valid_min = : 0.8687265515327454 DRHODR: valid_max = 0.011617615818977356			
Comments			
Density stratification: d(sigma) d z-1. Note: density computations are done with in-situ density. The vertical derivatives of in-situ density and locally-referenced potential density are identical The equation of state is a modified UNESCO formula by Jackett and McDougall (1995), which uses the model variable potential temperature as input assuming a horizontally and temporally constant pressure of $p_0=-g ho_{0} z$.			

../images/plots/native_plots/Ocean_Density_Stratification_and_

Figure 88:
Dataset: OCEAN_DENS_STRAT_PRESS
Variable: DRHODR

15.14.2 Native Variable PHIHYD

Table 15.79: CDL description of OCEAN_DENS_STRAT_PRESS's PHIHYD variable

<table>
<tr><th>Storage Type</th><th>Variable Name</th><th>Description</th><th>Unit</th></tr>
<tr><td>float32</td><td>PHIHYD</td><td>Ocean hydrostatic pressure anomaly</td><td>m2 s-2</td></tr>
<tr><th colspan="4">CDL Description</th></tr>
<tr><td colspan="4">float32 PHIHYD(time, k, tile, j, i)
PHIHYD: _FillValue = 9.96921e+36
PHIHYD: long_name = Ocean hydrostatic pressure anomaly
PHIHYD: units = m2 s: 2
PHIHYD: coverage_content_type = modelResult
PHIHYD: coordinates = YC Z XC time
PHIHYD: valid_min = 74.71473693847656
PHIHYD: valid_max = 783.9188232421875</td></tr>
<tr><th colspan="4">Comments</th></tr>
<tr><td colspan="4">PHIHYD = p(k) / rhoConst - g z*(k,t), where p = hydrostatic ocean pressure at depth level k, rhoConst = reference density (1029 kg m-3), g is acceleration due to gravity (9.81 m s-2), and z*(k,t) is model depth at level k and time t. Units: p:[kg m-1 s-2], rhoConst:[kg m-3], g:[m s-2], H(t):[m]. Note: includes atmospheric pressure loading. Quantity referred to in some contexts as hydrostatic pressure anomaly. PHIBOT accounts for the model's time-varying grid cell thickness (z* coordinate system). See PHIHYDcR for hydrostatic pressure potential anomaly calculated using time-invariant grid cell thicknesses. PHIHYD is NOT corrected for global mean steric sea level changes related to density changes in the Boussinesq volume-conserving model (Greatbatch correction, see sterGloH).</td></tr>
</table>

../images/plots/native_plots/Ocean_Density_Stratification_and_

Figure 89:
Dataset: OCEAN_DENS_STRAT_PRESS
Variable: PHIHYD

15.14.3 Native Variable PHIHYDcR

Table 15.80: CDL description of OCEAN_DENS_STRAT_PRESS's PHIHYDcR variable

<table>
<tr><th>Storage Type</th><th>Variable Name</th><th>Description</th><th>Unit</th></tr>
<tr><td>float32</td><td>PHIHYDcR</td><td>Ocean hydrostatic pressure anomaly at constant depths</td><td>m2 s-2</td></tr>
<tr><th colspan="4">CDL Description</th></tr>
<tr><td colspan="4">float32 PHIHYDcR(time, k, tile, j, i)
PHIHYDcR: _FillValue = 9.96921e+36
PHIHYDcR: long_name = Ocean hydrostatic pressure anomaly at constant depths
PHIHYDcR: units = m2 s: 2
PHIHYDcR: coverage_content_type = modelResult
PHIHYDcR: coordinates = YC Z XC time
PHIHYDcR: valid_min = 73.08939361572266
PHIHYDcR: valid_max = 784.4268188476562</td></tr>
<tr><th colspan="4">Comments</th></tr>
<tr><td colspan="4">PHIHYD = p(k) / rhoConst - g z(k,t), where p = hydrostatic ocean pressure at depth level k, rhoConst = reference density (1029 kg m-3), g is acceleration due to gravity (9.81 m s-2), and z(k,t) is fixed model depth at level k. Units: p:[kg m-1 s-2], rhoConst:[kg m-3], g:[m s-2], H(t):[m]. Note: includes atmospheric pressure loading. Quantity referred to in some contexts as hydrostatic pressure potential anomaly. PHIHYDcR is calculated with respect to the model's initial, time-invariant grid cell thicknesses. See PHIHYD for hydrostatic pressure anomaly calculated using model's time-variable grid cell thicknesses (z* coordinate system). PHIHYDcR is is NOT corrected for global mean steric sea level changes related to density changes in the Boussinesq volume-conserving model (Greatbatch correction, see sterGloH).</td></tr>
</table>

../images/plots/native_plots/Ocean_Density_Stratification_and_

Figure 90:
Dataset: OCEAN_DENS_STRAT_PRESS
Variable: PHIHYDcR

15.14.4 Native Variable RHOAnoma

Table 15.81: CDL description of OCEAN_DENS_STRAT_PRESS's RHOAnoma variable

Storage Type	Variable Name	Description	Unit
float32	RHOAnoma	In-situ seawater density anomaly	kg m-3
CDL Description			
float32 RHOAnoma(time, k, tile, j, i) RHOAnoma: _FillValue = 9.96921e+36 RHOAnoma: long_name = In: situ seawater density anomaly RHOAnoma: units = kg m: 3 RHOAnoma: coverage_content_type = modelResult RHOAnoma: coordinates = YC Z XC time RHOAnoma: valid_min = : 19.919862747192383 RHOAnoma: valid_max = 25.540647506713867			
Comments			
In-situ seawater density anomaly relative to the reference density, rhoConst. rhoConst = 1029 kg m-3			

../images/plots/native_plots/Ocean_Density_Stratification_and_

Figure 91:
Dataset: OCEAN_DENS_STRAT_PRESS
Variable: RHOAnoma

15.15 Native NetCDF OCEAN_MIXED_LAYER_DEPTH

Table 15.82: Variables in the dataset OCEAN_MIXED_LAYER_DEPTH

Dataset:	**OCEAN_MIXED_LAYER_DEPTH**
Field:	MXLDEPTH

15.15.1 Native Variable MXLDEPTH

Table 15.83: CDL description of OCEAN_MIXED_LAYER_DEPTH's MXLDEPTH variable

Storage Type	Variable Name	Description	Unit
float32	MXLDEPTH	Mixed-layer depth diagnosed using the temperature difference criterion of Kara et al., 2000	m

CDL Description

```
float32 MXLDEPTH(time, tile, j, i)
    MXLDEPTH: _FillValue = 9.96921e+36
    MXLDEPTH: long_name = Mixed: layer depth diagnosed using the temperature difference criterion of Kara et al.
2000
    MXLDEPTH: units = m
    MXLDEPTH: coverage_content_type = modelResult
    MXLDEPTH: standard_name = ocean_mixed_layer_thickness
    MXLDEPTH: coordinates = time XC YC
    MXLDEPTH: valid_min = 5.000001430511475
    MXLDEPTH: valid_max = 5331.2001953125
```

Comments

Mixed-layer depth as determined by the depth where waters are first 0.8 degrees Celsius colder than the surface. See Kara et al. (JGR, 2000). . Note: the Kara et al. criterion may not be appropriate for some applications. If needed, mixed layer depth can be calculated using different criteria. See vertical density stratification (DRHODR) and density anomaly (RHOAnoma).

../images/plots/native_plots/Ocean_Mixed_Layer_Depth/MXLDEPTH.

**Figure 92:
Dataset: OCEAN_MIXED_LAYER_DEPTH
Variable: MXLDEPTH**

15.16 Native NetCDF OCEAN_TEMPERATURE_SALINITY

Table 15.84: Variables in the dataset OCEAN_TEMPERATURE_SALINITY

Dataset:	**OCEAN_TEMPERATURE_SALINITY**
Field:	THETA
Field:	SALT

15.16.1 Native Variable SALT

Table 15.85: CDL description of OCEAN_TEMPERATURE_SALINITY's SALT variable

Storage Type	Variable Name	Description	Unit
float32	SALT	Salinity	1e-3
CDL Description			
float32 SALT(time, k, tile, j, i) SALT: _FillValue = 9.96921e+36 SALT: long_name = Salinity SALT: units = 1e: 3 SALT: coverage_content_type = modelResult SALT: standard_name = sea_water_salinity SALT: coordinates = YC Z XC time SALT: valid_min = 16.73577880859375 SALT: valid_max = 41.321231842041016			
Comments			
Defined using CF convention 'Sea water salinity is the salt content of sea water, often on the Practical Salinity Scale of 1978. However, the unqualified term 'salinity' is generic and does not necessarily imply any particular method of calculation. The units of salinity are dimensionless and the units attribute should normally be given as 1e-3 or 0.001 i.e. parts per thousand.' see https://cfconventions.org/Data/cf-standard-names/73/build/cf-standard-name-table.html			

../images/plots/native_plots/Ocean_Temperature_and_Salinity/SA

Figure 93:
Dataset: OCEAN_TEMPERATURE_SALINITY
Variable: SALT

15.16.2 Native Variable THETA

Table 15.86: CDL description of OCEAN_TEMPERATURE_SALINITY's THETA variable

Storage Type	Variable Name	Description	Unit
float32	THETA	Potential temperature	degree_C
CDL Description			
float32 THETA(time, k, tile, j, i) THETA: _FillValue = 9.96921e+36 THETA: long_name = Potential temperature THETA: units = degree_C THETA: coverage_content_type = modelResult THETA: standard_name = sea_water_potential_temperature THETA: coordinates = YC Z XC time THETA: valid_min = : 2.9179372787475586 THETA: valid_max = 36.425140380859375			
Comments			
Sea water potential temperature is the temperature a parcel of sea water would have if moved adiabatically to sea level pressure. Note: the equation of state is a modified UNESCO formula by Jackett and McDougall (1995), which uses the model variable potential temperature as input assuming a horizontally and temporally constant pressure of $p_0=-g ho_{0} z$.			

../images/plots/native_plots/Ocean_Temperature_and_Salinity/TH

Figure 94:
Dataset: OCEAN_TEMPERATURE_SALINITY
Variable: THETA

15.17 Native NetCDF OCEAN_VELOCITY

Table 15.87: Variables in the dataset OCEAN_VELOCITY

Dataset:	OCEAN_VELOCITY
Field:	UVEL
Field:	VVEL
Field:	WVEL

15.17.1 Native Variable UVEL

Table 15.88: CDL description of OCEAN_VELOCITY's UVEL variable

Storage Type	Variable Name	Description	Unit
float32	UVEL	Horizontal velocity in the model +x direction	m s-1
CDL Description			
float32 UVEL(time, k, tile, j, i_g) UVEL: _FillValue = 9.96921e+36 UVEL: long_name = Horizontal velocity in the model +x direction UVEL: units = m s: 1 UVEL: mate = VVEL UVEL: coverage_content_type = modelResult UVEL: direction = >0 increases volume UVEL: standard_name = sea_water_x_velocity UVEL: coordinates = Z time UVEL: valid_min = : 2.139253616333008 UVEL: valid_max = 2.038635015487671			
Comments			
Horizontal velocity in the +x direction at the 'u' face of the tracer cell on the native model grid. Note: in the Arakawa-C grid, horizontal velocities are staggered relative to the tracer cells with indexing such that +UVEL(i_g,j,k) corresponds to +x fluxes through the 'u' face of the tracer cell at (i,j,k). Do NOT use UVEL for volume flux calculations because the model's grid cell thicknesses vary with time (z* coordinates); use UVELMASS instead. Also, the model +x direction does not necessarily correspond to the geographical east-west direction because the x and y axes of the model's curvilinear lat-lon-cap (llc) grid have arbitrary orientations which vary within and across tiles. See EVEL and NVEL for zonal and meridional velocity.			

../images/plots/native_plots/Ocean_Velocity/UVEL.png

Figure 95:
Dataset: OCEAN_VELOCITY
Variable: UVEL

15.17.2 Native Variable VVEL

Table 15.89: CDL description of OCEAN_VELOCITY's VVEL variable

Storage Type	Variable Name	Description	Unit
float32	VVEL	Horizontal velocity in the model +y direction	m s-1
CDL Description			
float32 VVEL(time, k, tile, j_g, i) VVEL: _FillValue = 9.96921e+36 VVEL: long_name = Horizontal velocity in the model +y direction VVEL: units = m s: 1 VVEL: mate = UVEL VVEL: coverage_content_type = modelResult VVEL: direction = >0 increases volume VVEL: standard_name = sea_water_y_velocity VVEL: coordinates = Z time VVEL: valid_min = : 1.7877743244171143 VVEL: valid_max = 1.9089667797088623			
Comments			
Horizontal velocity in the +y direction at the 'v' face of the tracer cell on the native model grid. Note: in the Arakawa-C grid, horizontal velocities are staggered relative to the tracer cells with indexing such that +VVEL(i,j_g,k) corresponds to +y fluxes through the 'v' face of the tracer cell at (i,j,k). Do NOT use VVEL for volume flux calculations because the model's grid cell thicknesses vary with time (z* coordinates); use VVELMASS instead. Also, the model +y direction does not necessarily correspond to the geographical north-south direction because the x and y axes of the model's curvilinear lat-lon-cap (llc) grid have arbitrary orientations which vary within and across tiles. See EVEL and NVEL for zonal and meridional velocity.			

../images/plots/native_plots/Ocean_Velocity/VVEL.png

Figure 96:
Dataset: OCEAN_VELOCITY
Variable: VVEL

15.17.3 Native Variable WVEL

Table 15.90: CDL description of OCEAN_VELOCITY's WVEL variable

Storage Type	Variable Name	Description	Unit
float32	WVEL	Vertical velocity	m s-1
CDL Description			
float32 WVEL(time, k_l, tile, j, i) WVEL: _FillValue = 9.96921e+36 WVEL: long_name = Vertical velocity WVEL: units = m s: 1 WVEL: coverage_content_type = modelResult WVEL: direction = >0 decreases volume WVEL: standard_name = upward_sea_water_velocity WVEL: coordinates = Zl YC time XC WVEL: valid_min = : 0.0023150660563260317 WVEL: valid_max = 0.0016380994347855449			
Comments			
Vertical velocity in the +z direction at the top 'w' face of the tracer cell on the native model grid. Note: in the Arakawa-C grid, vertical velocities are staggered relative to the tracer cells with indexing such that +WVEL(i,j,k_l) corresponds to upward +z motion through the top 'w' face of the tracer cell at (i,j,k). WVEL is identical to WVELMASS.			

../images/plots/native_plots/Ocean_Velocity/WVEL.png

Figure 97:
Dataset: OCEAN_VELOCITY
Variable: WVEL

15.18 Native NetCDF SEA_ICE_CONC_THICKNESS

Table 15.91: Variables in the dataset SEA_ICE_CONC_THICKNESS

Dataset:	**SEA_ICE_CONC_THICKNESS**
Field:	SIarea
Field:	SIheff
Field:	SIhsnow
Field:	sIceLoad

15.18.1 Native Variable SIarea

Table 15.92: CDL description of SEA_ICE_CONC_THICKNESS's SIarea variable

<table>
<tr><th>Storage Type</th><th>Variable Name</th><th>Description</th><th>Unit</th></tr>
<tr><td>float32</td><td>SIarea</td><td>Sea-ice concentration</td><td>1</td></tr>
<tr><th colspan="4">CDL Description</th></tr>
<tr><td colspan="4">float32 SIarea(time, tile, j, i)
SIarea: _FillValue = 9.96921e+36
SIarea: long_name = Sea: ice concentration
SIarea: units = 1
SIarea: coverage_content_type = modelResult
SIarea: standard_name = sea_ice_area_fraction
SIarea: coordinates = time YC XC
SIarea: valid_min = 0.0
SIarea: valid_max = 0.9700000286102295</td></tr>
<tr><th colspan="4">Comments</th></tr>
<tr><td colspan="4">Fraction of ocean grid cell covered with sea-ice [0 to 1]. CF Standard Name Table v73: 'Area fraction' is the fraction of a grid cell's horizontal area that has some characteristic of interest. It is evaluated as the area of interest divided by the grid cell area. It may be expressed as a fraction, a percentage, or any other dimensionless representation of a fraction. Sea ice area fraction is area of the sea surface occupied by sea ice. It is also called 'sea ice concentration'. 'Sea ice' means all ice floating in the sea which has formed from freezing sea water, rather than by other processes such as calving of land ice to form icebergs. https://cfconventions.org/Data/cf-standard-names/73/build/cf-standard-name-table.html. Defined using CF Standard Name Table v73: 'Area fraction' is the fraction of a grid cell's horizontal area that has some characteristic of interest. It is evaluated as the area of interest divided by the grid cell area. It may be expressed as a fraction, a percentage, or any other dimensionless representation of a fraction. Sea ice area fraction is area of the sea surface occupied by sea ice. It is also called 'sea ice concentration'. 'Sea ice' means all ice floating in the sea which has formed from freezing sea water and precipitation, rather than by other processes such as calving of land ice to form icebergs. https://cfconventions.org/Data/cf-standard-names/73/build/cf-standard-name-table.html</td></tr>
</table>

../images/plots/native_plots/Sea-Ice_and_Snow_Concentration_an

**Figure 98:
Dataset: SEA_ICE_CONC_THICKNESS
Variable: SIarea**

15.18.2 Native Variable SIheff

Table 15.93: CDL description of SEA_ICE_CONC_THICKNESS's SIheff variable

Storage Type	Variable Name	Description	Unit
float32	SIheff	Area-averaged sea-ice thickness	m
CDL Description			
float32 SIheff(time, tile, j, i) SIheff: _FillValue = 9.96921e+36 SIheff: long_name = Area: averaged sea: ice thickness SIheff: units = m SIheff: coverage_content_type = modelResult SIheff: standard_name = sea_ice_thickness SIheff: coordinates = time YC XC SIheff: valid_min = 0.0 SIheff: valid_max = 9.000518798828125			
Comments			
Sea-ice thickness averaged over the entire model grid cell, including open water where sea-ice thickness is zero. Note: sea-ice thickness over the ICE-COVERED fraction of the grid cell is SIheff/SIarea			

../images/plots/native_plots/Sea-Ice_and_Snow_Concentration_an

Figure 99:
Dataset: SEA_ICE_CONC_THICKNESS
Variable: SIheff

15.18.3 Native Variable SIhsnow

Table 15.94: CDL description of SEA_ICE_CONC_THICKNESS's SIhsnow variable

Storage Type	Variable Name	Description	Unit
float32	SIhsnow	Area-averaged snow thickness	m
CDL Description			
float32 SIhsnow(time, tile, j, i) SIhsnow: _FillValue = 9.96921e+36 SIhsnow: long_name = Area: averaged snow thickness SIhsnow: units = m SIhsnow: coverage_content_type = modelResult SIhsnow: standard_name = surface_snow_thickness SIhsnow: coordinates = time YC XC SIhsnow: valid_min = : 0.0004725505714304745 SIhsnow: valid_max = 2.7013046741485596			
Comments			
Snow thickness averaged over the entire model grid cell, including open water where snow thickness is zero. Note: snow thickness over the ICE-COVERED fraction of the grid cell is SIhsnow/SIarea			

../images/plots/native_plots/Sea-Ice_and_Snow_Concentration_an

Figure 100:
Dataset: SEA_ICE_CONC_THICKNESS
Variable: SIhsnow

15.18.4 Native Variable sIceLoad

Table 15.95: CDL description of SEA_ICE_CONC_THICKNESS's sIceLoad variable

<table>
<tr><th>Storage Type</th><th>Variable Name</th><th>Description</th><th>Unit</th></tr>
<tr><td>float32</td><td>sIceLoad</td><td>Average sea-ice and snow mass per unit area</td><td>kg m-2</td></tr>
<tr><th colspan="4">CDL Description</th></tr>
<tr><td colspan="4">float32 sIceLoad(time, tile, j, i)
sIceLoad: _FillValue = 9.96921e+36
sIceLoad: long_name = Average sea: ice and snow mass per unit area
sIceLoad: units = kg m: 2
sIceLoad: coverage_content_type = modelResult
sIceLoad: standard_name = sea_ice_and_surface_snow_amount
sIceLoad: coordinates = time YC XC
sIceLoad: valid_min = : 0.0015558383893221617
sIceLoad: valid_max = 8729.935546875</td></tr>
<tr><th colspan="4">Comments</th></tr>
<tr><td colspan="4">Total mass of sea-ice and snow in a model grid cell averaged over model grid cell area. Note: sIceLoad is used to correct model sea level anomaly, ETAN, to calculate dynamic sea surface height, SSH, and sea surface height without the inverted barometer (IB correction), SSHNOIBC. In the model, sea-ice is treated as floating above the sea level with ETAN tracing the location of the ocean-ice interface. Consequently, sea-ice growth in the model lowers ETAN and sea-ice melting raises ETAN. Dynamic sea surface height is obtained by correcting ETAN by the weight of ice and snow directly above following Archimedes' principle.</td></tr>
</table>

../images/plots/native_plots/Sea-Ice_and_Snow_Concentration_an

Figure 101:
Dataset: SEA_ICE_CONC_THICKNESS
Variable: sIceLoad

15.19 Native NetCDF SEA_ICE_HORIZ_VOLUME_FLUX

Table 15.96: Variables in the dataset SEA_ICE_HORIZ_VOLUME_FLUX

Dataset:	**SEA_ICE_HORIZ_VOLUME_FLUX**
Field:	ADVxHEFF
Field:	ADVyHEFF
Field:	ADVxSNOW
Field:	ADVySNOW
Field:	DFxESNOW
Field:	DFyEHEFF
Field:	DFxEHEFF
Field:	DFyESNOW

15.19.1 Native Variable ADVxHEFF

Table 15.97: CDL description of SEA_ICE_HORIZ_VOLUME_FLUX's ADVxHEFF variable

Storage Type	Variable Name	Description	Unit
float32	ADVxHEFF	Lateral advective flux of sea-ice thickness in the model +x direction	m3 s-1

CDL Description

float32 ADVxHEFF(time, tile, j, i_g)
ADVxHEFF: _FillValue = 9.96921e+36
ADVxHEFF: long_name = Lateral advective flux of sea: ice thickness in the model +x direction
ADVxHEFF: units = m3 s: 1
ADVxHEFF: mate = ADVyHEFF
ADVxHEFF: coverage_content_type = modelResult
ADVxHEFF: direction = >0 increases mean sea: ice thickness (HEFF)
ADVxHEFF: coordinates = time
ADVxHEFF: valid_min = : 151912.28125
ADVxHEFF: valid_max = 107688.7578125

Comments

Lateral advective flux of grid cell mean sea-ice thickness (HEFF) in the +x direction through the 'u' face of the tracer cell on the native model grid. Note: in the Arakawa-C grid, horizontal flux quantities are staggered relative to the tracer cells with indexing such that +ADVxHEFF(i_g,j) corresponds to +x fluxes through the 'u' face of the tracer cell at (i,j,k=0). Also, the model +x direction does not necessarily correspond to the geographical east-west direction because the x and y axes of the model's curvilinear lat-lon-cap (llc) grid have arbitrary orientations which vary within and across tiles.

../images/plots/native_plots/Sea-Ice_and_Snow_Horizontal_Volum

Figure 102:
Dataset: SEA_ICE_HORIZ_VOLUME_FLUX
Variable: ADVxHEFF

15.19.2 Native Variable ADVxSNOW

Table 15.98: CDL description of SEA_ICE_HORIZ_VOLUME_FLUX's ADVxSNOW variable

Storage Type	Variable Name	Description	Unit
float32	ADVxSNOW	Lateral advective flux of snow thickness in the model +x direction	m3 s-1
CDL Description			
float32 ADVxSNOW(time, tile, j, i_g) ADVxSNOW: _FillValue = 9.96921e+36 ADVxSNOW: long_name = Lateral advective flux of snow thickness in the model +x direction ADVxSNOW: units = m3 s: 1 ADVxSNOW: mate = ADVySNOW ADVxSNOW: coverage_content_type = modelResult ADVxSNOW: direction = >0 increases mean snow thickness (HSNOW) ADVxSNOW: coordinates = time ADVxSNOW: valid_min = : 38343.0234375 ADVxSNOW: valid_max = 20385.103515625			
Comments			
Lateral advective flux of grid cell mean snow thickness (HSNOW) in the +x direction through the 'u' face of the tracer cell on the native model grid. Note: in the Arakawa-C grid, horizontal flux quantities are staggered relative to the tracer cells with indexing such that +ADVxSNOW(i_g,j) corresponds to +x fluxes through the 'u' face of the tracer cell at (i,j,k=0). Also, the model +x direction does not necessarily correspond to the geographical east-west direction because the x and y axes of the model's curvilinear lat-lon-cap (llc) grid have arbitrary orientations which vary within and across tiles.			

../images/plots/native_plots/Sea-Ice_and_Snow_Horizontal_Volum

Figure 103:
Dataset: SEA_ICE_HORIZ_VOLUME_FLUX
Variable: ADVxSNOW

15.19.3 Native Variable ADVyHEFF

Table 15.99: CDL description of SEA_ICE_HORIZ_VOLUME_FLUX's ADVyHEFF variable

Storage Type	Variable Name	Description	Unit
float32	ADVyHEFF	Lateral advective flux of sea-ice thickness in the model +y direction	m3 s-1
CDL Description			
float32 ADVyHEFF(time, tile, j_g, i) ADVyHEFF: _FillValue = 9.96921e+36 ADVyHEFF: long_name = Lateral advective flux of sea: ice thickness in the model +y direction ADVyHEFF: units = m3 s: 1 ADVyHEFF: mate = ADVxHEFF ADVyHEFF: coverage_content_type = modelResult ADVyHEFF: direction = >0 increases mean sea: ice thickness (HEFF) ADVyHEFF: coordinates = time ADVyHEFF: valid_min = : 95350.6328125 ADVyHEFF: valid_max = 115755.4375			
Comments			
Lateral advective flux of grid cell mean sea-ice thickness (HEFF) in the +y direction through the 'v' face of the tracer cell on the native model grid. Note: in the Arakawa-C grid, horizontal flux quantities are staggered relative to the tracer cells with indexing such that +ADVyHEFF(i,j_g) corresponds to +y fluxes through the 'v' face of the tracer cell at (i,j,k=0). Also, the model +y direction does not necessarily correspond to the geographical north-south direction because the x and y axes of the model's curvilinear lat-lon-cap (llc) grid have arbitrary orientations which vary within and across tiles.			

../images/plots/native_plots/Sea-Ice_and_Snow_Horizontal_Volum

Figure 104:
Dataset: SEA_ICE_HORIZ_VOLUME_FLUX
Variable: ADVyHEFF

15.19.4 Native Variable ADVySNOW

Table 15.100: CDL description of SEA_ICE_HORIZ_VOLUME_FLUX's ADVySNOW variable

Storage Type	Variable Name	Description	Unit
float32	ADVySNOW	Lateral advective flux of snow thickness in the model +y direction	m3 s-1
CDL Description			
float32 ADVySNOW(time, tile, j_g, i) ADVySNOW: _FillValue = 9.96921e+36 ADVySNOW: long_name = Lateral advective flux of snow thickness in the model +y direction ADVySNOW: units = m3 s: 1 ADVySNOW: mate = ADVxSNOW ADVySNOW: coverage_content_type = modelResult ADVySNOW: direction = >0 increases mean snow thickness (HSNOW) ADVySNOW: coordinates = time ADVySNOW: valid_min = : 30630.552734375 ADVySNOW: valid_max = 27252.87890625			
Comments			
Lateral advective flux of grid cell mean snow thickness (HSNOW) in the +y direction through the 'v' face of the tracer cell on the native model grid. Note: in the Arakawa-C grid, horizontal flux quantities are staggered relative to the tracer cells with indexing such that +ADVySNOW(i,j_g) corresponds to +y fluxes through the 'v' face of the tracer cell at (i,j,k=0). Also, the model +y direction does not necessarily correspond to the geographical north-south direction because the x and y axes of the model's curvilinear lat-lon-cap (llc) grid have arbitrary orientations which vary within and across tiles.			

../images/plots/native_plots/Sea-Ice_and_Snow_Horizontal_Volum

Figure 105:
Dataset: SEA_ICE_HORIZ_VOLUME_FLUX
Variable: ADVySNOW

15.19.5 Native Variable DFxEHEFF

Table 15.101: CDL description of SEA_ICE_HORIZ_VOLUME_FLUX's DFxEHEFF variable

<table>
<tr><th>Storage Type</th><th>Variable Name</th><th>Description</th><th>Unit</th></tr>
<tr><td>float32</td><td>DFxEHEFF</td><td>Lateral diffusive flux of sea-ice thickness in the model +x direction.</td><td>m3 s-1</td></tr>
<tr><th colspan="4">CDL Description</th></tr>
<tr><td colspan="4">float32 DFxEHEFF(time, tile, j, i_g)
DFxEHEFF: _FillValue = 9.96921e+36
DFxEHEFF: long_name = Lateral diffusive flux of sea: ice thickness in the model +x direction.
DFxEHEFF: units = m3 s: 1
DFxEHEFF: mate = DFyEHEFF
DFxEHEFF: coverage_content_type = modelResult
DFxEHEFF: direction = >0 increases mean sea: ice thickness (HEFF)
DFxEHEFF: coordinates = time
DFxEHEFF: valid_min = : 1444.172607421875
DFxEHEFF: valid_max = 2379.271240234375</td></tr>
<tr><th colspan="4">Comments</th></tr>
<tr><td colspan="4">Lateral diffusive flux of grid cell mean sea-ice thickness (HEFF) in the +x direction through the 'u' face of the tracer cell on the native model grid. Note: in the Arakawa-C grid, horizontal flux quantities are staggered relative to the tracer cells with indexing such that +DFxEHEFF(i_g,j) corresponds to +x fluxes through the 'u' face of the tracer cell at (i,j,k=0). Also, the model +x direction does not necessarily correspond to the geographical east-west direction because the x and y axes of the model's curvilinear lat-lon-cap (llc) grid have arbitrary orientations which vary within and across tiles.</td></tr>
</table>

../images/plots/native_plots/Sea-Ice_and_Snow_Horizontal_Volum

Figure 106:
Dataset: SEA_ICE_HORIZ_VOLUME_FLUX
Variable: DFxEHEFF

15.19.6 Native Variable DFxESNOW

Table 15.102: CDL description of SEA_ICE_HORIZ_VOLUME_FLUX's DFxESNOW variable

Storage Type	Variable Name	Description	Unit
float32	DFxESNOW	Lateral diffusive flux of snow thickness in the model +x direction	m3 s-1
CDL Description			
float32 DFxESNOW(time, tile, j, i_g) DFxESNOW: _FillValue = 9.96921e+36 DFxESNOW: long_name = Lateral diffusive flux of snow thickness in the model +x direction DFxESNOW: units = m3 s: 1 DFxESNOW: mate = DFyESNOW DFxESNOW: coverage_content_type = modelResult DFxESNOW: direction = >0 increases mean snow thickness (HSNOW) DFxESNOW: coordinates = time DFxESNOW: valid_min = : 448.1134948730469 DFxESNOW: valid_max = 440.94427490234375			
Comments			
Lateral diffusive flux of grid cell mean snow thickness (HSNOW) in the +x direction through the 'u' face of the tracer cell on the native model grid. Note: in the Arakawa-C grid, horizontal flux quantities are staggered relative to the tracer cells with indexing such that +DFxESNOW(i_g,j) corresponds to +x fluxes through the 'u' face of the tracer cell at (i,j,k=0). Also, the model +x direction does not necessarily correspond to the geographical east-west direction because the x and y axes of the model's curvilinear lat-lon-cap (llc) grid have arbitrary orientations which vary within and across tiles.			

../images/plots/native_plots/Sea-Ice_and_Snow_Horizontal_Volum

Figure 107:
Dataset: SEA_ICE_HORIZ_VOLUME_FLUX
Variable: DFxESNOW

15.19.7 Native Variable DFyEHEFF

Table 15.103: CDL description of SEA_ICE_HORIZ_VOLUME_FLUX's DFyEHEFF variable

Storage Type	Variable Name	Description	Unit
float32	DFyEHEFF	Lateral diffusive flux of sea-ice thickness in the model +y direction.	m3 s-1
CDL Description			
float32 DFyEHEFF(time, tile, j_g, i) DFyEHEFF: _FillValue = 9.96921e+36 DFyEHEFF: long_name = Lateral diffusive flux of sea: ice thickness in the model +y direction. DFyEHEFF: units = m3 s: 1 DFyEHEFF: mate = DFxEHEFF DFyEHEFF: coverage_content_type = modelResult DFyEHEFF: direction = >0 increases mean sea: ice thickness (HEFF) DFyEHEFF: coordinates = time DFyEHEFF: valid_min = : 3078.810791015625 DFyEHEFF: valid_max = 1614.6512451171875			
Comments			
Lateral diffusive flux of grid cell mean sea-ice thickness (HEFF) in the +y direction through the 'v' face of the tracer cell on the native model grid. Note: in the Arakawa-C grid, horizontal flux quantities are staggered relative to the tracer cells with indexing such that +DFyEHEFF(i,j_g) corresponds to +y fluxes through the 'v' face of the tracer cell at (i,j,k=0). Also, the model +y direction does not necessarily correspond to the geographical north-south direction because the x and y axes of the model's curvilinear lat-lon-cap (llc) grid have arbitrary orientations which vary within and across tiles.			

../images/plots/native_plots/Sea-Ice_and_Snow_Horizontal_Volum

Figure 108:
Dataset: SEA_ICE_HORIZ_VOLUME_FLUX
Variable: DFyEHEFF

15.19.8 Native Variable DFyESNOW

Table 15.104: CDL description of SEA_ICE_HORIZ_VOLUME_FLUX's DFyESNOW variable

Storage Type	Variable Name	Description	Unit
float32	DFyESNOW	Lateral diffusive flux of snow thickness in the model +y direction	m3 s-1
CDL Description			
float32 DFyESNOW(time, tile, j_g, i) DFyESNOW: _FillValue = 9.96921e+36 DFyESNOW: long_name = Lateral diffusive flux of snow thickness in the model +y direction DFyESNOW: units = m3 s: 1 DFyESNOW: mate = DFxESNOW DFyESNOW: coverage_content_type = modelResult DFyESNOW: direction = >0 increases mean snow thickness (HSNOW) DFyESNOW: coordinates = time DFyESNOW: valid_min = : 662.0200805664062 DFyESNOW: valid_max = 411.7032470703125			
Comments			
Lateral diffusive flux of grid cell mean snow thickness (HSNOW) in the +y direction through the 'v' face of the tracer cell on the native model grid. Note: in the Arakawa-C grid, horizontal flux quantities are staggered relative to the tracer cells with indexing such that +DFyESNOW(i,j_g,k) corresponds to +y fluxes through the 'v' face of the tracer cell at (i,j,k=0). Also, the model +y direction does not necessarily correspond to the geographical north-south direction because the x and y axes of the model's curvilinear lat-lon-cap (llc) grid have arbitrary orientations which vary within and across tiles.			

../images/plots/native_plots/Sea-Ice_and_Snow_Horizontal_Volum

Figure 109:
Dataset: SEA_ICE_HORIZ_VOLUME_FLUX
Variable: DFyESNOW

15.20 Native NetCDF SEA_ICE_SALT_PLUME_FLUX

Table 15.105: Variables in the dataset SEA_ICE_SALT_PLUME_FLUX

Dataset:	**SEA_ICE_SALT_PLUME_FLUX**
Field:	oceSPflx
Field:	oceSPDep

15.20.1 Native Variable oceSPDep

Table 15.106: CDL description of SEA_ICE_SALT_PLUME_FLUX's oceSPDep variable

Storage Type	Variable Name	Description	Unit
float32	oceSPDep	Salt plume depth	m
CDL Description			
float32 oceSPDep(time, tile, j, i) oceSPDep: _FillValue = 9.96921e+36 oceSPDep: long_name = Salt plume depth oceSPDep: units = m oceSPDep: coverage_content_type = modelResult oceSPDep: coordinates = time YC XC oceSPDep: valid_min = 5.500708103179932 oceSPDep: valid_max = 5530.31494140625			
Comments			
Depth of parameterized salt plumes formed due to brine rejection during sea-ice formation.			

../images/plots/native_plots/Sea-Ice_Salt_Plume_Fluxes/oceSPDe

Figure 110:
Dataset: SEA_ICE_SALT_PLUME_FLUX
Variable: oceSPDep

15.20.2 Native Variable oceSPflx

Table 15.107: CDL description of SEA_ICE_SALT_PLUME_FLUX's oceSPflx variable

Storage Type	Variable Name	Description	Unit
float32	oceSPflx	Net salt flux into the ocean due to brine rejection	g m-2 s-1
CDL Description			
float32 oceSPflx(time, tile, j, i) oceSPflx: _FillValue = 9.96921e+36 oceSPflx: long_name = Net salt flux into the ocean due to brine rejection oceSPflx: units = g m: 2 s: 1 oceSPflx: coverage_content_type = modelResult oceSPflx: direction = >0 increases salinity (SALT) oceSPflx: coordinates = time YC XC oceSPflx: valid_min = 0.0 oceSPflx: valid_max = 0.058169759809970856			
Comments			
Net salt flux into the ocean due to brine rejection during sea-ice formation. Note: units are grams of salt per square meter per second, not salinity per square meter per second.			

../images/plots/native_plots/Sea-Ice_Salt_Plume_Fluxes/oceSPfl

Figure 111:
Dataset: SEA_ICE_SALT_PLUME_FLUX
Variable: oceSPflx

15.21 Native NetCDF SEA_ICE_VELOCITY

Table 15.108: Variables in the dataset SEA_ICE_VELOCITY

Dataset:	**SEA_ICE_VELOCITY**
Field:	SIuice
Field:	SIvice

15.21.1 Native Variable SIuice

Table 15.109: CDL description of SEA_ICE_VELOCITY's SIuice variable

<table>
<tr><th>Storage Type</th><th>Variable Name</th><th>Description</th><th>Unit</th></tr>
<tr><td>float32</td><td>SIuice</td><td>Sea-ice velocity in the model +x direction</td><td>m s-1</td></tr>
<tr><th colspan="4">CDL Description</th></tr>
<tr><td colspan="4">float32 SIuice(time, tile, j, i_g)
SIuice: _FillValue = 9.96921e+36
SIuice: long_name = Sea: ice velocity in the model +x direction
SIuice: units = m s: 1
SIuice: mate = SIvice
SIuice: coverage_content_type = modelResult
SIuice: standard_name = sea_ice_x_velocity
SIuice: coordinates = time
SIuice: valid_min = : 0.4000000059604645
SIuice: valid_max = 0.4000000059604645</td></tr>
<tr><th colspan="4">Comments</th></tr>
<tr><td colspan="4">Horizontal sea-ice velocity in the +x direction at the 'u' face of the tracer cell on the native model grid. Note: in the Arakawa-C grid, horizontal velocities are staggered relative to the tracer cells with indexing such that +SIuice(i_g,j) corresponds to +x fluxes through the 'u' face of the tracer cell at (i,j,k=0). Also, the model +x direction does not necessarily correspond to the geographical east-west direction because the x and y axes of the model's curvilinear lat-lon-cap (llc) grid have arbitrary orientations which vary within and across tiles.</td></tr>
</table>

../images/plots/native_plots/Sea-Ice_Velocity/SIuice.png

Figure 112:
Dataset: SEA_ICE_VELOCITY
Variable: SIuice

15.21.2 Native Variable SIvice

Table 15.110: CDL description of SEA_ICE_VELOCITY's SIvice variable

Storage Type	Variable Name	Description	Unit
float32	SIvice	Sea-ice velocity in the model +y direction	m s-1
CDL Description			
float32 SIvice(time, tile, j_g, i) SIvice: _FillValue = 9.96921e+36 SIvice: long_name = Sea: ice velocity in the model +y direction SIvice: units = m s: 1 SIvice: mate = SIuice SIvice: coverage_content_type = modelResult SIvice: standard_name = sea_ice_y_velocity SIvice: coordinates = time SIvice: valid_min = : 0.4000000059604645 SIvice: valid_max = 0.4000000059604645			
Comments			
Horizontal sea-ice velocity in the +y direction at the 'v' face of the tracer cell on the native model grid. Note: in the Arakawa-C grid, horizontal velocities are staggered relative to the tracer cells with indexing such that +SIvice(i,j_g) corresponds to +y fluxes through the 'v' face of the tracer cell at (i,j,k=0). Also, the model +y direction does not necessarily correspond to the geographical north-south direction because the x and y axes of the model's curvilinear lat-lon-cap (llc) grid have arbitrary orientations which vary within and across tiles.			

../images/plots/native_plots/Sea-Ice_Velocity/SIvice.png

Figure 113:
Dataset: SEA_ICE_VELOCITY
Variable: SIvice

15.22 Native NetCDF SEA_SURFACE_HEIGHT

Table 15.111: Variables in the dataset SEA_SURFACE_HEIGHT

Dataset:	**SEA_SURFACE_HEIGHT**
Field:	SSH
Field:	SSHIBC
Field:	SSHNOIBC
Field:	ETAN

15.22.1 Native Variable ETAN

Table 15.112: CDL description of SEA_SURFACE_HEIGHT's ETAN variable

Storage Type	Variable Name	Description	Unit
float32	ETAN	Model sea level anomaly	m
CDL Description			
float32 ETAN(time, tile, j, i) ETAN: _FillValue = 9.96921e+36 ETAN: long_name = Model sea level anomaly ETAN: units = m ETAN: coverage_content_type = modelResult ETAN: coordinates = YC time XC ETAN: valid_min = : 9.067964553833008 ETAN: valid_max = 2.1783087253570557			
Comments			
Model sea level anomaly WITHOUT corrections for global mean density (steric) changes, inverted barometer effect, or volume displacement due to submerged sea-ice and snow . Note: ETAN should NOT be used for comparisons with altimetry data products because ETAN is NOT corrected for (a) global mean steric sea level changes related to density changes in the Boussinesq volume-conserving model (Greatbatch correction, see sterGloH) nor (b) sea level displacement due to submerged sea-ice and snow (see sIceLoad). These corrections ARE made for the variables SSH and SSHNOIBC.			

../images/plots/native_plots/Sea_Surface_Height/ETAN.png

Figure 114:
Dataset: SEA_SURFACE_HEIGHT
Variable: ETAN

15.22.2 Native Variable SSH

Table 15.113: CDL description of SEA_SURFACE_HEIGHT's SSH variable

Storage Type	Variable Name	Description	Unit
float32	SSH	Dynamic sea surface height anomaly	m
CDL Description			
float32 SSH(time, tile, j, i) SSH: _FillValue = 9.96921e+36 SSH: long_name = Dynamic sea surface height anomaly SSH: units = m SSH: coverage_content_type = modelResult SSH: standard_name = sea_surface_height_above_geoid SSH: coordinates = YC time XC SSH: valid_min = : 2.4861555099487305 SSH: valid_max = 2.2875382900238037			
Comments			
Dynamic sea surface height anomaly above the geoid, suitable for comparisons with altimetry sea surface height data products that apply the inverse barometer (IB) correction. Note: SSH is calculated by correcting model sea level anomaly ETAN for three effects: a) global mean steric sea level changes related to density changes in the Boussinesq volume-conserving model (Greatbatch correction, see sterGloH), b) the inverted barometer (IB) effect (see SSHIBC) and c) sea level displacement due to sea-ice and snow pressure loading (see sIceLoad). SSH can be compared with the similarly-named SSH variable in previous ECCO products that did not include atmospheric pressure loading (e.g., Version 4 Release 3). Use SSHNOIBC for comparisons with altimetry data products that do NOT apply the IB correction.			

../images/plots/native_plots/Sea_Surface_Height/SSH.png

Figure 115:
Dataset: SEA_SURFACE_HEIGHT
Variable: SSH

15.22.3 Native Variable SSHIBC

Table 15.114: CDL description of SEA_SURFACE_HEIGHT's SSHIBC variable

<table>
<tr><th>Storage Type</th><th>Variable Name</th><th>Description</th><th>Unit</th></tr>
<tr><td>float32</td><td>SSHIBC</td><td>The inverted barometer (IB) correction to sea surface height due to atmospheric pressure loading</td><td>m</td></tr>
<tr><th colspan="4">CDL Description</th></tr>
<tr><td colspan="4">float32 SSHIBC(time, tile, j, i)
SSHIBC: _FillValue = 9.96921e+36
SSHIBC: long_name = The inverted barometer (IB) correction to sea surface height due to atmospheric pressure loading
SSHIBC: units = m
SSHIBC: coverage_content_type = modelResult
SSHIBC: coordinates = YC time XC
SSHIBC: valid_min = : 0.5228679180145264
SSHIBC: valid_max = 0.9044463634490967</td></tr>
<tr><th colspan="4">Comments</th></tr>
<tr><td colspan="4">Not an SSH itself, but a correction to model sea level anomaly (ETAN) required to account for the static part of sea surface displacement by atmosphere pressure loading: SSH = SSHNOIBC - SSHIBC. Note: Use SSH for model-data comparisons with altimetry data products that DO apply the IB correction and SSHNOIBC for comparisons with altimetry data products that do NOT apply the IB correction.</td></tr>
</table>

../images/plots/native_plots/Sea_Surface_Height/SSHIBC.png

**Figure 116:
Dataset: SEA_SURFACE_HEIGHT
Variable: SSHIBC**

15.22.4 Native Variable SSHNOIBC

Table 15.115: CDL description of SEA_SURFACE_HEIGHT's SSHNOIBC variable

Storage Type	Variable Name	Description	Unit
float32	SSHNOIBC	Sea surface height anomaly without the inverted barometer (IB) correction	m

CDL Description

float32 SSHNOIBC(time, tile, j, i)
  SSHNOIBC: _FillValue = 9.96921e+36
  SSHNOIBC: long_name = Sea surface height anomaly without the inverted barometer (IB) correction
  SSHNOIBC: units = m
  SSHNOIBC: coverage_content_type = modelResult
  SSHNOIBC: coordinates = YC time XC
  SSHNOIBC: valid_min = : 2.45104718208313
  SSHNOIBC: valid_max = 2.2390522956848145

Comments

Sea surface height anomaly above the geoid without the inverse barometer (IB) correction, suitable for comparisons with altimetry sea surface height data products that do NOT apply the inverse barometer (IB) correction. Note: SSHNOIBC is calculated by correcting model sea level anomaly ETAN for two effects: a) global mean steric sea level changes related to density changes in the Boussinesq volume-conserving model (Greatbatch correction, see sterGloH), b) sea level displacement due to sea-ice and snow pressure loading (see sIceLoad). In ECCO Version 4 Release 4 the model is forced with atmospheric pressure loading. SSHNOIBC does not correct for the static part of the effect of atmosphere pressure loading on sea surface height (the so-called inverse barometer (IB) correction). Use SSH for comparisons with altimetry data products that DO apply the IB correction.

../images/plots/native_plots/Sea_Surface_Height/SSHNOIBC.png

Figure 117:
Dataset: SEA_SURFACE_HEIGHT
Variable: SSHNOIBC

16 Latlon Dataset Coordinate Variables

16.1 Overview of the Latlon Dataset Coordinate Variables

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16.2 Latlon coordinates NetCDF GRID_GEOMETRY_ECCO

Table 16.1: Variables in the dataset GRID_GEOMETRY_ECCO

Dataset:	GRID_GEOMETRY_ECCO
Field:	hFacC
Field:	maskC

16.2.1 Latlon coordinates Variable hFacC

Table 16.2: CDL description of GRID_GEOMETRY_ECCO's hFacC variable

Storage Type	Variable Name	Description	Unit
float64	hFacC	vertical open fraction of grid cell	1
CDL Description			
float64 hFacC(Z, latitude, longitude) hFacC: _FillValue = 9.969209968386869e+36 hFacC: coverage_content_type = modelResult hFacC: long_name = vertical open fraction of grid cell hFacC: units = 1			
Comments			
Grid cells may be fractionally closed in the vertical. The open vertical fraction is hFacC. The model allows for partially-filled cells to represent topographic variations more smoothly (hFacC < 1). Completely closed (dry) tracer grid cells have hFacC = 0. Note: the lat-lon gridded hFacC is spatially-averaged from the hFacC field on the lat-lon-cap (llc90) model native grid. The total ocean volume of the ECCO V4r4 lat-lon gridded fields is within 0.05% of the total ocean volume of the native grid fields.			

../images/plots/latlon_plots_coords/Geometry_Parameters_for_th

Figure 118:
Dataset: GRID_GEOMETRY_ECCO
Variable: hFacC

16.2.2 Latlon coordinates Variable maskC

Table 16.3: CDL description of GRID_GEOMETRY_ECCO's maskC variable

<table>
<tr><th>Storage Type</th><th>Variable Name</th><th>Description</th><th>Unit</th></tr>
<tr><td>bool</td><td>maskC</td><td>wet/dry boolean mask for grid cell</td><td>N/A</td></tr>
<tr><th colspan="4">CDL Description</th></tr>
<tr><td colspan="4">bool maskC(Z, latitude, longitude)
maskC: _FillValue = 1
maskC: coverage_content_type = modelResult
maskC: long_name = wet/dry boolean mask for grid cell</td></tr>
<tr><th colspan="4">Comments</th></tr>
<tr><td colspan="4">True for grid cells with nonzero open vertical fraction (hFacC > 0), otherwise False.</td></tr>
</table>

../images/plots/latlon_plots_coords/Geometry_Parameters_for_th

**Figure 119:
Dataset: GRID_GEOMETRY_ECCO
Variable: maskC**

17 Latlon Dataset Groupings

17.1 Overview of the latlon Dataset Groupings

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17.2 Latlon NetCDF ATM_SURFACE_TEMP_HUM_WIND_PRES

Table 17.1: Variables in the dataset ATM_SURFACE_TEMP_HUM_WIND_PRES

Dataset:	**ATM_SURFACE_TEMP_HUM_WIND_PRES**
Field:	EXFatemp
Field:	EXFaqh
Field:	EXFewind
Field:	EXFnwind
Field:	EXFwspee
Field:	EXFpress

17.2.1 Latlon Variable EXFaqh

Table 17.2: CDL description of ATM_SURFACE_TEMP_HUM_WIND_PRES's EXFaqh variable

<table>
<tr><th>Storage Type</th><th>Variable Name</th><th>Description</th><th>Unit</th></tr>
<tr><td>float32</td><td>EXFaqh</td><td>Atmosphere surface (2 m) specific humidity</td><td>kg kg-1</td></tr>
<tr><th colspan="4">CDL Description</th></tr>
<tr><td colspan="4">float32 EXFaqh(time, latitude, longitude)
EXFaqh: _FillValue = 9.96921e+36
EXFaqh: coverage_content_type = modelResult
EXFaqh: long_name = Atmosphere surface (2 m) specific humidity
EXFaqh: standard_name = surface_specific_humidity
EXFaqh: units = kg kg: 1
EXFaqh: coordinates = time
EXFaqh: valid_min = : 0.0014020215021446347
EXFaqh: valid_max = 0.030145138502120097</td></tr>
<tr><th colspan="4">Comments</th></tr>
<tr><td colspan="4">Surface (2 m) specific humidity over open water. Note: sum of ERA-Interim surface specific humidity and the control adjustment from ocean state estimation.</td></tr>
</table>

../images/plots/latlon_plots/Atmosphere_Surface_Temperature_Hu

**Figure 120:
Dataset: ATM_SURFACE_TEMP_HUM_WIND_PRES
Variable: EXFaqh**

17.2.2 Latlon Variable EXFatemp

Table 17.3: CDL description of ATM_SURFACE_TEMP_HUM_WIND_PRES's EXFatemp variable

Storage Type	Variable Name	Description	Unit
float32	EXFatemp	Atmosphere surface (2 m) air temperature	degree_K
CDL Description			
float32 EXFatemp(time, latitude, longitude) EXFatemp: _FillValue = 9.96921e+36 EXFatemp: coverage_content_type = modelResult EXFatemp: long_name = Atmosphere surface (2 m) air temperature EXFatemp: standard_name = air_temperature EXFatemp: units = degree_K EXFatemp: coordinates = time EXFatemp: valid_min = 195.37054443359375 EXFatemp: valid_max = 312.8451232910156			
Comments			
Surface (2 m) air temperature over open water. Note: sum of ERA-Interim surface air temperature and the control adjustment from ocean state estimation.			

../images/plots/latlon_plots/Atmosphere_Surface_Temperature_Hu

Figure 121:
Dataset: ATM_SURFACE_TEMP_HUM_WIND_PRES
Variable: EXFatemp

17.2.3 Latlon Variable EXFewind

Table 17.4: CDL description of ATM_SURFACE_TEMP_HUM_WIND_PRES's EXFewind variable

Storage Type	Variable Name	Description	Unit
float32	EXFewind	Zonal (east-west) wind speed	m s-1
CDL Description			
float32 EXFewind(time, latitude, longitude) EXFewind: _FillValue = 9.96921e+36 EXFewind: coverage_content_type = modelResult EXFewind: long_name = Zonal (east: west) wind speed EXFewind: standard_name = eastward_wind EXFewind: units = m s: 1 EXFewind: coordinates = time EXFewind: valid_min = : 33.524742126464844 EXFewind: valid_max = 39.48556900024414			
Comments			
Zonal (east-west) component of ocean surface wind. Note: EXFewind is calculated by interpolating the model's x and y components of wind velocity (EXFuwind and EXFvwind) to tracer cell centers and then finding the zonal component of the interpolated vectors. ECCO V4r4 is forced with wind stress (see EXFtaux, EXFtauy), not vector winds + bulk formulae. EXFewind is calculated by converting wind stress to vector wind using bulk formulae.			

../images/plots/latlon_plots/Atmosphere_Surface_Temperature_Hu

Figure 122:
Dataset: ATM_SURFACE_TEMP_HUM_WIND_PRES
Variable: EXFewind

17.2.4 Latlon Variable EXFnwind

Table 17.5: CDL description of ATM_SURFACE_TEMP_HUM_WIND_PRES's EXFnwind variable

Storage Type	Variable Name	Description	Unit
float32	EXFnwind	Meridional (north-south) wind speed	m s-1
CDL Description			
float32 EXFnwind(time, latitude, longitude) EXFnwind: _FillValue = 9.96921e+36 EXFnwind: coverage_content_type = modelResult EXFnwind: long_name = Meridional (north: south) wind speed EXFnwind: standard_name = northward_wind EXFnwind: units = m s: 1 EXFnwind: coordinates = time EXFnwind: valid_min = : 30.042686462402344 EXFnwind: valid_max = 33.95014190673828			
Comments			
Meridional (north-south) component of ocean surface wind. Note: EXFnwind is calculated by interpolating the model's x and y components of wind velocity (EXFuwind and EXFvwind) to tracer cell centers and then finding the meridional component of the interpolated vectors. ECCO V4r4 is forced with wind stress (see EXFtaux, EXFtauy), not vector winds + bulk formulae. EXFnwind is calculated by converting wind stress to vector wind using bulk formulae.			

../images/plots/latlon_plots/Atmosphere_Surface_Temperature_Hu

Figure 123:
Dataset: ATM_SURFACE_TEMP_HUM_WIND_PRES
Variable: EXFnwind

17.2.5 Latlon Variable EXFpress

Table 17.6: CDL description of ATM_SURFACE_TEMP_HUM_WIND_PRES's EXFpress variable

<table>
<tr><th>Storage Type</th><th>Variable Name</th><th>Description</th><th>Unit</th></tr>
<tr><td>float32</td><td>EXFpress</td><td>Atmosphere surface pressure</td><td>N m-2</td></tr>
<tr><th colspan="4">CDL Description</th></tr>
<tr><td colspan="4">float32 EXFpress(time, latitude, longitude)
EXFpress: _FillValue = 9.96921e+36
EXFpress: coverage_content_type = modelResult
EXFpress: long_name = Atmosphere surface pressure
EXFpress: standard_name = surface_air_pressure
EXFpress: units = N m: 2
EXFpress: coordinates = time
EXFpress: valid_min = 92090.3125
EXFpress: valid_max = 106314.7734375</td></tr>
<tr><th colspan="4">Comments</th></tr>
<tr><td colspan="4">Atmospheric pressure field at sea level. Note: ERA-Interim atmospheric pressure, with air tides removed using a variety of methods. Not adjusted by the ocean state estimation.</td></tr>
</table>

../images/plots/latlon_plots/Atmosphere_Surface_Temperature_Hu

Figure 124:
Dataset: ATM_SURFACE_TEMP_HUM_WIND_PRES
Variable: EXFpress

17.2.6 Latlon Variable EXFwspee

Table 17.7: CDL description of ATM_SURFACE_TEMP_HUM_WIND_PRES's EXFwspee variable

Storage Type	Variable Name	Description	Unit
float32	EXFwspee	Wind speed	m s-1
CDL Description			
float32 EXFwspee(time, latitude, longitude) EXFwspee: _FillValue = 9.96921e+36 EXFwspee: coverage_content_type = modelResult EXFwspee: long_name = Wind speed EXFwspee: standard_name = wind_speed EXFwspee: units = m s: 1 EXFwspee: coordinates = time EXFwspee: valid_min = 0.27271032333374023 EXFwspee: valid_max = 45.87086486816406			
Comments			
10-m wind speed magnitude (>= 0) over open water. Only used for the calculation of air-sea fluxes using bulk formulae. Note: not adjusted by the ocean state estimation and not necesarily consistent with EXFuwind and EXFvwind because EXFuwind and EXFvwind are calculated from EXFtaux and EXFtauy using bulk formulae. EXFwspee != sqrt(EXFuwind**2 + EXFvwind**2.			

../images/plots/latlon_plots/Atmosphere_Surface_Temperature_Hu

Figure 125:
Dataset: ATM_SURFACE_TEMP_HUM_WIND_PRES
Variable: EXFwspee

17.3 Latlon NetCDF OCEAN_AND_ICE_SURFACE_FW_FLUX

Table 17.8: Variables in the dataset OCEAN_AND_ICE_SURFACE_FW_FLUX

Dataset:	**OCEAN_AND_ICE_SURFACE_FW_FLUX**
Field:	EXFpreci
Field:	EXFevap
Field:	EXFroff
Field:	SIsnPrcp
Field:	EXFempmr
Field:	oceFWflx
Field:	SIatmFW
Field:	SFLUX
Field:	SIacSubl
Field:	SIrsSubl
Field:	SIfwThru

17.3.1 Latlon Variable EXFempmr

Table 17.9: CDL description of OCEAN_AND_ICE_SURFACE_FW_FLUX's EXFempmr variable

<table>
<tr><th>Storage Type</th><th>Variable Name</th><th>Description</th><th>Unit</th></tr>
<tr><td>float32</td><td>EXFempmr</td><td>Open ocean net surface freshwater flux from precipitation, evaporation, and runoff</td><td>m s-1</td></tr>
<tr><th colspan="4">CDL Description</th></tr>
<tr><td colspan="4">float32 EXFempmr(time, latitude, longitude)
EXFempmr: _FillValue = 9.96921e+36
EXFempmr: coverage_content_type = modelResult
EXFempmr: direction = >0 increases salinity (SALT)
EXFempmr: long_name = Open ocean net surface freshwater flux from precipitation
evaporation
and runoff
EXFempmr: units = m s: 1
EXFempmr: coordinates = time
EXFempmr: valid_min = : 8.299433829961345e: 06
EXFempmr: valid_max = 5.400421514423215e: 07</td></tr>
<tr><th colspan="4">Comments</th></tr>
<tr><td colspan="4">Net surface freshwater flux from precipitation, evaporation, and runoff per unit area in open water (not covered by sea-ice). Excludes freshwater fluxes involving sea-ice and snow. Note: calculated as EXFevap-EXFpreci-EXFroff.</td></tr>
</table>

../images/plots/latlon_plots/Ocean_and_Sea-Ice_Surface_Freshwa

Figure 126:
Dataset: OCEAN_AND_ICE_SURFACE_FW_FLUX
Variable: EXFempmr

17.3.2 Latlon Variable EXFevap

Table 17.10: CDL description of OCEAN_AND_ICE_SURFACE_FW_FLUX's EXFevap variable

<table>
<tr><th>Storage Type</th><th>Variable Name</th><th>Description</th><th>Unit</th></tr>
<tr><td>float32</td><td>EXFevap</td><td>Open ocean evaporation rate</td><td>m s-1</td></tr>
<tr><th colspan="4">CDL Description</th></tr>
<tr><td colspan="4">float32 EXFevap(time, latitude, longitude)
EXFevap: _FillValue = 9.96921e+36
EXFevap: coverage_content_type = modelResult
EXFevap: direction = >0 increases salinity (SALT)
EXFevap: long_name = Open ocean evaporation rate
EXFevap: standard_name = lwe_water_evaporation_rate
EXFevap: units = m s: 1
EXFevap: coordinates = time
EXFevap: valid_min = : 1.0958113705328287e: 07
EXFevap: valid_max = 7.090054623404285e: 07</td></tr>
<tr><th colspan="4">Comments</th></tr>
<tr><td colspan="4">Evaporation rate per unit area of open water (not covered by sea-ice). Note: calculated using the bulk formula following Large and Yeager (2004) NCAR/TN-460+STR.</td></tr>
</table>

../images/plots/latlon_plots/Ocean_and_Sea-Ice_Surface_Freshwa

Figure 127:
Dataset: OCEAN_AND_ICE_SURFACE_FW_FLUX
Variable: EXFevap

17.3.3 Latlon Variable EXFpreci

Table 17.11: CDL description of OCEAN_AND_ICE_SURFACE_FW_FLUX's EXFpreci variable

<table>
<tr><th>Storage Type</th><th>Variable Name</th><th>Description</th><th>Unit</th></tr>
<tr><td>float32</td><td>EXFpreci</td><td>Precipitation rate</td><td>m s-1</td></tr>
<tr><th colspan="4">CDL Description</th></tr>
<tr><td colspan="4">float32 EXFpreci(time, latitude, longitude)
EXFpreci: _FillValue = 9.96921e+36
EXFpreci: coverage_content_type = modelResult
EXFpreci: direction = >0 increases salinity (SALT)
EXFpreci: long_name = Precipitation rate
EXFpreci: standard_name = lwe_precipitation_rate
EXFpreci: units = m s: 1
EXFpreci: coordinates = time
EXFpreci: valid_min = : 1.4860395936011628e: 07
EXFpreci: valid_max = 8.317776519106701e: 06</td></tr>
<tr><th colspan="4">Comments</th></tr>
<tr><td colspan="4">Precipitation rate. Note: sum of ERA-Interim precipitation and the control adjustment from ocean state estimation.</td></tr>
</table>

../images/plots/latlon_plots/Ocean_and_Sea-Ice_Surface_Freshwa

Figure 128:
Dataset: OCEAN_AND_ICE_SURFACE_FW_FLUX
Variable: EXFpreci

17.3.4 Latlon Variable EXFroff

Table 17.12: CDL description of OCEAN_AND_ICE_SURFACE_FW_FLUX's EXFroff variable

Storage Type	Variable Name	Description	Unit
float32	EXFroff	River runoff	m s-1
CDL Description			
float32 EXFroff(time, latitude, longitude) EXFroff: _FillValue = 9.96921e+36 EXFroff: coverage_content_type = modelResult EXFroff: direction = >0 increases salinity (SALT) EXFroff: long_name = River runoff EXFroff: standard_name = surface_runoff_flux EXFroff: units = m s: 1 EXFroff: coordinates = time EXFroff: valid_min = 0.0 EXFroff: valid_max = 4.185612397122895e: 06			
Comments			
River runoff freshwater flux. Note: not adjusted by the optimization.			

../images/plots/latlon_plots/Ocean_and_Sea-Ice_Surface_Freshwa

Figure 129:
Dataset: OCEAN_AND_ICE_SURFACE_FW_FLUX
Variable: EXFroff

17.3.5 Latlon Variable SFLUX

Table 17.13: CDL description of OCEAN_AND_ICE_SURFACE_FW_FLUX's SFLUX variable

<table>
<tr><th>Storage Type</th><th>Variable Name</th><th>Description</th><th>Unit</th></tr>
<tr><td>float32</td><td>SFLUX</td><td>Rate of change of total ocean salinity per m2 accounting for mass fluxes.</td><td>g m-2 s-1</td></tr>
<tr><th colspan="4">CDL Description</th></tr>
<tr><td colspan="4">float32 SFLUX(time, latitude, longitude)
SFLUX: _FillValue = 9.96921e+36
SFLUX: coverage_content_type = modelResult
SFLUX: direction = >0 increases salinity (SALT)
SFLUX: long_name = Rate of change of total ocean salinity per m2 accounting for mass fluxes.
SFLUX: units = g m: 2 s: 1
SFLUX: coordinates = time
SFLUX: valid_min = : 0.06244903802871704
SFLUX: valid_max = 0.010570422746241093</td></tr>
<tr><th colspan="4">Comments</th></tr>
<tr><td colspan="4">The rate of change of total ocean salinity due to freshwater fluxes across the liquid surface and the addition or removal of mass. Note: the global area integral of SFLUX matches the time-derivative of total ocean salinity (psu s-1). Unlike oceFWflx, SFLUX includes the contribution to the total ocean salinity from changing ocean mass (e.g. from the addition or removal of freshwater in oceFWflx).</td></tr>
</table>

../images/plots/latlon_plots/Ocean_and_Sea-Ice_Surface_Freshwa

Figure 130:
Dataset: OCEAN_AND_ICE_SURFACE_FW_FLUX
Variable: SFLUX

17.3.6 Latlon Variable SIacSubl

Table 17.14: CDL description of OCEAN_AND_ICE_SURFACE_FW_FLUX's SIacSubl variable

Storage Type	Variable Name	Description	Unit
float32	SIacSubl	Freshwater flux to the atmosphere due to sublimation-deposition of snow or ice	kg m-2 s-1
CDL Description			
float32 SIacSubl(time, latitude, longitude) SIacSubl: _FillValue = 9.96921e+36 SIacSubl: coverage_content_type = modelResult SIacSubl: direction = >0 decreases snow or sea: ice thickness (HSNOW or HEFF) SIacSubl: long_name = Freshwater flux to the atmosphere due to sublimation: deposition of snow or ice SIacSubl: standard_name = water_sublimation_flux SIacSubl: units = kg m: 2 s: 1 SIacSubl: coordinates = time SIacSubl: valid_min = 0.0 SIacSubl: valid_max = 7.735946564935148e: 05			
Comments			
Freshwater flux to the atmosphere due to sublimation-deposition of snow or ice. Positive values imply sublimation from ice/snow to vapor, negative values imply deposition from atmospheric moisture			

../images/plots/latlon_plots/Ocean_and_Sea-Ice_Surface_Freshwa

Figure 131:
Dataset: OCEAN_AND_ICE_SURFACE_FW_FLUX
Variable: SIacSubl

17.3.7 Latlon Variable SIatmFW

Table 17.15: CDL description of OCEAN_AND_ICE_SURFACE_FW_FLUX's SIatmFW variable

<table>
<tr><th>Storage Type</th><th>Variable Name</th><th>Description</th><th>Unit</th></tr>
<tr><td>float32</td><td>SIatmFW</td><td>Net freshwater flux into the open ocean, sea-ice, and snow</td><td>kg m-2 s-1</td></tr>
<tr><th colspan="4">CDL Description</th></tr>
<tr><td colspan="4">float32 SIatmFW(time, latitude, longitude)
SIatmFW: _FillValue = 9.96921e+36
SIatmFW: coverage_content_type = modelResult
SIatmFW: direction = >0 decreases salinity (SALT)
SIatmFW: long_name = Net freshwater flux into the open ocean
sea: ice
and snow
SIatmFW: standard_name = surface_downward_water_flux
SIatmFW: units = kg m: 2 s: 1
SIatmFW: coordinates = time
SIatmFW: valid_min = : 0.00043017856660299003
SIatmFW: valid_max = 0.008299433626234531</td></tr>
<tr><th colspan="4">Comments</th></tr>
<tr><td colspan="4">Net freshwater flux into the combined liquid ocean, sea-ice, and snow reservoirs from the atmosphere and runoff. Note: freshwater fluxes BETWEEN the liquid ocean and sea-ice or snow reservoirs do not contribute to SIatmFW. SIatmFW counts all fluxes to/from the atmosphere that change the TOTAL freshwater stored in the combined liquid ocean, sea-ice, and snow reservoirs.</td></tr>
</table>

../images/plots/latlon_plots/Ocean_and_Sea-Ice_Surface_Freshwa

Figure 132:
Dataset: OCEAN_AND_ICE_SURFACE_FW_FLUX
Variable: SIatmFW

17.3.8 Latlon Variable SIfwThru

Table 17.16: CDL description of OCEAN_AND_ICE_SURFACE_FW_FLUX's SIfwThru variable

<table>
<tr><th>Storage Type</th><th>Variable Name</th><th>Description</th><th>Unit</th></tr>
<tr><td>float32</td><td>SIfwThru</td><td>Precipitation through sea-ice</td><td>kg m-2 s-1</td></tr>
<tr><th colspan="4">CDL Description</th></tr>
<tr><td colspan="4">float32 SIfwThru(time, latitude, longitude)
SIfwThru: _FillValue = 9.96921e+36
SIfwThru: coverage_content_type = modelResult
SIfwThru: direction = >0 increases ocean volume
SIfwThru: long_name = Precipitation through sea: ice
SIfwThru: units = kg m: 2 s: 1
SIfwThru: coordinates = time
SIfwThru: valid_min = : 1.695218452368863e: 05
SIfwThru: valid_max = 0.0010632629273459315</td></tr>
<tr><th colspan="4">Comments</th></tr>
<tr><td colspan="4">Precipitation over sea-ice covered regions reaching ocean through sea-ice. Note: Precipitation over sea-ice covered regions that directly reaches ocean through the sea-ice. It is not due to melt of sea-ice/snow.</td></tr>
</table>

../images/plots/latlon_plots/Ocean_and_Sea-Ice_Surface_Freshwa

Figure 133:
Dataset: OCEAN_AND_ICE_SURFACE_FW_FLUX
Variable: SIfwThru

17.3.9 Latlon Variable SIrsSubl

Table 17.17: CDL description of OCEAN_AND_ICE_SURFACE_FW_FLUX's SIrsSubl variable

Storage Type	Variable Name	Description	Unit
float32	SIrsSubl	Residual sublimation freshwater flux	kg m-2 s-1
CDL Description			
float32 SIrsSubl(time, latitude, longitude) SIrsSubl: _FillValue = 9.96921e+36 SIrsSubl: coverage_content_type = modelResult SIrsSubl: direction = >0 decreases ocean volume SIrsSubl: long_name = Residual sublimation freshwater flux SIrsSubl: units = kg m: 2 s: 1 SIrsSubl: coordinates = time SIrsSubl: valid_min = : 0.00010675288649950873 SIrsSubl: valid_max = 8.640533451398369e: 06			
Comments			
Residual freshwater flux by sublimation to remove water from or add water to ocean. When implied sublimation freshwater flux SIacSubl is larger than availabe sea-ice/snow, SIrsSubl is positive and water is removed from ocean. Note: freshwater flux by sublimation that is to remove water from the ocean when it is positive.			

../images/plots/latlon_plots/Ocean_and_Sea-Ice_Surface_Freshwa

Figure 134:
Dataset: OCEAN_AND_ICE_SURFACE_FW_FLUX
Variable: SIrsSubl

17.3.10 Latlon Variable SIsnPrcp

Table 17.18: CDL description of OCEAN_AND_ICE_SURFACE_FW_FLUX's SIsnPrcp variable

Storage Type	Variable Name	Description	Unit
float32	SIsnPrcp	Snow precipitation on sea-ice	kg m-2 s-1
CDL Description			
float32 SIsnPrcp(time, latitude, longitude) SIsnPrcp: _FillValue = 9.96921e+36 SIsnPrcp: coverage_content_type = modelResult SIsnPrcp: direction = >0 increases snow thickness (HSNOW) SIsnPrcp: long_name = Snow precipitation on sea: ice SIsnPrcp: standard_name = snowfall_flux SIsnPrcp: units = kg m: 2 s: 1 SIsnPrcp: coordinates = time SIsnPrcp: valid_min = : 4.334669574745931e: 05 SIsnPrcp: valid_max = 0.0009354020585305989			
Comments			
Snow precipitation rate over sea-ice, averaged over the entire model grid cell.			

../images/plots/latlon_plots/Ocean_and_Sea-Ice_Surface_Freshwa

Figure 135:
Dataset: OCEAN_AND_ICE_SURFACE_FW_FLUX
Variable: SIsnPrcp

17.3.11 Latlon Variable oceFWflx

Table 17.19: CDL description of OCEAN_AND_ICE_SURFACE_FW_FLUX's oceFWflx variable

<table>
<tr><th>Storage Type</th><th>Variable Name</th><th>Description</th><th>Unit</th></tr>
<tr><td>float32</td><td>oceFWflx</td><td>Net freshwater flux into the ocean</td><td>kg m-2 s-1</td></tr>
<tr><th colspan="4">CDL Description</th></tr>
<tr><td colspan="4">float32 oceFWflx(time, latitude, longitude)
oceFWflx: _FillValue = 9.96921e+36
oceFWflx: coverage_content_type = modelResult
oceFWflx: direction = >0 decreases salinity (SALT)
oceFWflx: long_name = Net freshwater flux into the ocean
oceFWflx: standard_name = water_flux_into_sea_water
oceFWflx: units = kg m: 2 s: 1
oceFWflx: coordinates = time
oceFWflx: valid_min = : 0.0033125500194728374
oceFWflx: valid_max = 0.008299433626234531</td></tr>
<tr><th colspan="4">Comments</th></tr>
<tr><td colspan="4">Net freshwater flux into the ocean including contributions from runoff, evaporation, precipitation, and mass exchange with sea-ice due to melting and freezing and snow melting. Note: oceFWflx does NOT include freshwater fluxes between the atmosphere and sea-ice and snow. The variable 'SIatmFW' accounts for freshwater fluxes out of the combined ocean+sea-ice+snow reservoir.</td></tr>
</table>

../images/plots/latlon_plots/Ocean_and_Sea-Ice_Surface_Freshwa

Figure 136:
Dataset: OCEAN_AND_ICE_SURFACE_FW_FLUX
Variable: oceFWflx

17.4 Latlon NetCDF OCEAN_AND_ICE_SURFACE_HEAT_FLUX

Table 17.20: Variables in the dataset OCEAN_AND_ICE_SURFACE_HEAT_FLUX

Dataset:	OCEAN_AND_ICE_SURFACE_HEAT_FLUX
Field:	EXFhl
Field:	EXFhs
Field:	EXFlwdn
Field:	EXFswdn
Field:	EXFqnet
Field:	oceQnet
Field:	SIatmQnt
Field:	TFLUX
Field:	EXFswnet
Field:	EXFlwnet
Field:	oceQsw
Field:	SIaaflux

17.4.1 Latlon Variable EXFhl

Table 17.21: CDL description of OCEAN_AND_ICE_SURFACE_HEAT_FLUX's EXFhl variable

Storage Type	Variable Name	Description	Unit
float32	EXFhl	Open ocean air-sea latent heat flux	W m-2

CDL Description

float32 EXFhl(time, latitude, longitude)
EXFhl: _FillValue = 9.96921e+36
EXFhl: coverage_content_type = modelResult
EXFhl: direction = >0 increases potential temperature (THETA)
EXFhl: long_name = Open ocean air: sea latent heat flux
EXFhl: standard_name = surface_downward_latent_heat_flux
EXFhl: units = W m: 2
EXFhl: coordinates = time
EXFhl: valid_min = : 1772.513671875
EXFhl: valid_max = 273.9528503417969

Comments

Air-sea latent heat flux per unit area of open water (not covered by sea-ice). Note: calculated from the bulk formula following Large and Yeager (2004) NCAR/TN-460+STR.

../images/plots/latlon_plots/Ocean_and_Sea-Ice_Surface_Heat_Fl

Figure 137:
Dataset: OCEAN_AND_ICE_SURFACE_HEAT_FLUX
Variable: EXFhl

17.4.2 Latlon Variable EXFhs

Table 17.22: CDL description of OCEAN_AND_ICE_SURFACE_HEAT_FLUX's EXFhs variable

Storage Type	Variable Name	Description	Unit
float32	EXFhs	Open ocean air-sea sensible heat flux	W m-2
CDL Description			
float32 EXFhs(time, latitude, longitude) EXFhs: _FillValue = 9.96921e+36 EXFhs: coverage_content_type = modelResult EXFhs: direction = >0 increases potential temperature (THETA) EXFhs: long_name = Open ocean air: sea sensible heat flux EXFhs: standard_name = surface_downward_sensible_heat_flux EXFhs: units = W m: 2 EXFhs: coordinates = time EXFhs: valid_min = : 2478.766357421875 EXFhs: valid_max = 357.0105895996094			
Comments			
Air-sea sensible heat flux per unit area of open water (not covered by sea-ice). Note: calculated from the bulk formula following Large and Yeager (2004) NCAR/TN-460+STR.			

../images/plots/latlon_plots/Ocean_and_Sea-Ice_Surface_Heat_Fl

Figure 138:
Dataset: OCEAN_AND_ICE_SURFACE_HEAT_FLUX
Variable: EXFhs

17.4.3 Latlon Variable EXFlwdn

Table 17.23: CDL description of OCEAN_AND_ICE_SURFACE_HEAT_FLUX's EXFlwdn variable

<table>
<tr><th>Storage Type</th><th>Variable Name</th><th>Description</th><th>Unit</th></tr>
<tr><td>float32</td><td>EXFlwdn</td><td>Downward longwave radiative flux</td><td>W m-2</td></tr>
<tr><th colspan="4">CDL Description</th></tr>
<tr><td colspan="4">float32 EXFlwdn(time, latitude, longitude)
EXFlwdn: _FillValue = 9.96921e+36
EXFlwdn: coverage_content_type = modelResult
EXFlwdn: direction = >0 increases potential temperature (THETA)
EXFlwdn: long_name = Downward longwave radiative flux
EXFlwdn: standard_name = surface_downwelling_longwave_flux_in_air
EXFlwdn: units = W m: 2
EXFlwdn: coordinates = time
EXFlwdn: valid_min = 4.188045501708984
EXFlwdn: valid_max = 513.3919067382812</td></tr>
<tr><th colspan="4">Comments</th></tr>
<tr><td colspan="4">Downward longwave radiative flux. Note: sum of ERA-Interim downward longwave radiation and the control adjustment from ocean state estimation.</td></tr>
</table>

../images/plots/latlon_plots/Ocean_and_Sea-Ice_Surface_Heat_Fl

Figure 139:
Dataset: OCEAN_AND_ICE_SURFACE_HEAT_FLUX
Variable: EXFlwdn

17.4.4 Latlon Variable EXFlwnet

Table 17.24: CDL description of OCEAN_AND_ICE_SURFACE_HEAT_FLUX's EXFlwnet variable

Storage Type	Variable Name	Description	Unit
float32	EXFlwnet	Net open ocean longwave radiative flux	W m-2
CDL Description			
float32 EXFlwnet(time, latitude, longitude) EXFlwnet: _FillValue = 9.96921e+36 EXFlwnet: coverage_content_type = modelResult EXFlwnet: direction = >0 increases potential temperature (THETA) EXFlwnet: long_name = Net open ocean longwave radiative flux EXFlwnet: standard_name = surface_net_downward_longwave_flux EXFlwnet: units = W m: 2 EXFlwnet: coordinates = time EXFlwnet: valid_min = : 144.3661346435547 EXFlwnet: valid_max = 293.4114990234375			
Comments			
Net longwave radiative flux per unit area of open water (not covered by sea-ice). Note: net longwave radiation over open water calculated from downward longwave radiation (EXFlwdn) and upward longwave radiation from ocean and sea-ice thermal emission (Stefan-Boltzman law).			

../images/plots/latlon_plots/Ocean_and_Sea-Ice_Surface_Heat_Fl

Figure 140:
Dataset: OCEAN_AND_ICE_SURFACE_HEAT_FLUX
Variable: EXFlwnet

17.4.5 Latlon Variable EXFqnet

Table 17.25: CDL description of OCEAN_AND_ICE_SURFACE_HEAT_FLUX's EXFqnet variable

Storage Type	Variable Name	Description	Unit
float32	EXFqnet	Open ocean net air-sea heat flux	W m-2
CDL Description			
float32 EXFqnet(time, latitude, longitude) EXFqnet: _FillValue = 9.96921e+36 EXFqnet: coverage_content_type = modelResult EXFqnet: direction = >0 increases potential temperature (THETA) EXFqnet: long_name = Open ocean net air: sea heat flux EXFqnet: units = W m: 2 EXFqnet: coordinates = time EXFqnet: valid_min = : 687.8736572265625 EXFqnet: valid_max = 3408.977783203125			
Comments			
Net air-sea heat flux (turbulent and radiative) per unit area of open water (not covered by sea-ice). Note: net upward heat flux over open water, calculated as EXFlwnet+EXFswnet-EXFlh-EXFhs.			

../images/plots/latlon_plots/Ocean_and_Sea-Ice_Surface_Heat_Fl

**Figure 141:
Dataset: OCEAN_AND_ICE_SURFACE_HEAT_FLUX
Variable: EXFqnet**

17.4.6 Latlon Variable EXFswdn

Table 17.26: CDL description of OCEAN_AND_ICE_SURFACE_HEAT_FLUX's EXFswdn variable

Storage Type	Variable Name	Description	Unit
float32	EXFswdn	Downwelling shortwave radiative flux	W m-2
CDL Description			
float32 EXFswdn(time, latitude, longitude) EXFswdn: _FillValue = 9.96921e+36 EXFswdn: coverage_content_type = modelResult EXFswdn: direction = >0 increases potential temperature (THETA) EXFswdn: long_name = Downwelling shortwave radiative flux EXFswdn: standard_name = surface_downwelling_shortwave_flux_in_air EXFswdn: units = W m: 2 EXFswdn: coordinates = time EXFswdn: valid_min = : 224.63368225097656 EXFswdn: valid_max = 707.345947265625			
Comments			
Downward shortwave radiative flux. Note: sum of ERA-Interim downward shortwave radiation and the control adjustment from ocean state estimation.			

../images/plots/latlon_plots/Ocean_and_Sea-Ice_Surface_Heat_Fl

Figure 142:
Dataset: OCEAN_AND_ICE_SURFACE_HEAT_FLUX
Variable: EXFswdn

17.4.7 Latlon Variable EXFswnet

Table 17.27: CDL description of OCEAN_AND_ICE_SURFACE_HEAT_FLUX's EXFswnet variable

Storage Type	Variable Name	Description	Unit
float32	EXFswnet	Open ocean net shortwave radiative flux	W m-2
CDL Description			
float32 EXFswnet(time, latitude, longitude) EXFswnet: _FillValue = 9.96921e+36 EXFswnet: coverage_content_type = modelResult EXFswnet: direction = >0 increases potential temperature (THETA) EXFswnet: long_name = Open ocean net shortwave radiative flux EXFswnet: standard_name = surface_net_downward_shortwave_flux EXFswnet: units = W m: 2 EXFswnet: coordinates = time EXFswnet: valid_min = : 655.6171264648438 EXFswnet: valid_max = 193.89297485351562			
Comments			
Net shortwave radiative flux per unit area of open water (not covered by sea-ice). Note: net shortwave radiation over open water calculated from downward shortwave flux (EXFswdn) and ocean surface albdeo.			

../images/plots/latlon_plots/Ocean_and_Sea-Ice_Surface_Heat_Fl

Figure 143:
Dataset: OCEAN_AND_ICE_SURFACE_HEAT_FLUX
Variable: EXFswnet

17.4.8 Latlon Variable SIaaflux

Table 17.28: CDL description of OCEAN_AND_ICE_SURFACE_HEAT_FLUX's SIaaflux variable

Storage Type	Variable Name	Description	Unit
float32	SIaaflux	Conservative ocean and sea-ice advective heat flux adjustment	W m-2
CDL Description			
float32 SIaaflux(time, latitude, longitude) SIaaflux: _FillValue = 9.96921e+36 SIaaflux: coverage_content_type = modelResult SIaaflux: direction = >0 decrease potential temperature (THETA) SIaaflux: long_name = Conservative ocean and sea: ice advective heat flux adjustment SIaaflux: units = W m: 2 SIaaflux: coordinates = time SIaaflux: valid_min = : 16.214622497558594 SIaaflux: valid_max = 50.35451889038086			
Comments			
Heat flux associated with the temperature difference between sea surface temperature and sea-ice (assume 0 degree C in the model). Note: heat flux needed to melt/freeze sea-ice at 0 degC to sea water at the ocean surface (at sea surface temperature), excluding the latent heat of fusion.			

../images/plots/latlon_plots/Ocean_and_Sea-Ice_Surface_Heat_Fl

Figure 144:
Dataset: OCEAN_AND_ICE_SURFACE_HEAT_FLUX
Variable: SIaaflux

17.4.9 Latlon Variable SIatmQnt

Table 17.29: CDL description of OCEAN_AND_ICE_SURFACE_HEAT_FLUX's SIatmQnt variable

Storage Type	Variable Name	Description	Unit
float32	SIatmQnt	Net upward heat flux to the atmosphere	W m-2

CDL Description

```
float32 SIatmQnt(time, latitude, longitude)
    SIatmQnt: _FillValue = 9.96921e+36
    SIatmQnt: coverage_content_type = modelResult
    SIatmQnt: direction = >0 upward
decreases ocean temperature
    SIatmQnt: long_name = Net upward heat flux to the atmosphere
    SIatmQnt: standard_name = surface_upward_heat_flux_in_air
    SIatmQnt: units = W m: 2
    SIatmQnt: coordinates = time
    SIatmQnt: valid_min = : 756.0607299804688
    SIatmQnt: valid_max = 1704.7703857421875
```

Comments

Net upward heat flux to the atmosphere across open water and sea-ice or snow surfaces. Note: nonzero SIatmQnt may not be associated with a change in ocean potential temperature due to sea-ice growth or melting. To calculate total ocean heat content changes use the variable TFLUX which also accounts for changing ocean mass (e.g. oceFWflx).

../images/plots/latlon_plots/Ocean_and_Sea-Ice_Surface_Heat_Fl

Figure 145:
Dataset: OCEAN_AND_ICE_SURFACE_HEAT_FLUX
Variable: SIatmQnt

17.4.10 Latlon Variable TFLUX

Table 17.30: CDL description of OCEAN_AND_ICE_SURFACE_HEAT_FLUX's TFLUX variable

Storage Type	Variable Name	Description	Unit
float32	TFLUX	Rate of change of ocean heat content per m2 accounting for mass fluxes.	W m-2
CDL Description			
float32 TFLUX(time, latitude, longitude) TFLUX: _FillValue = 9.96921e+36 TFLUX: coverage_content_type = modelResult TFLUX: direction = >0 increases potential temperature (THETA) TFLUX: long_name = Rate of change of ocean heat content per m2 accounting for mass fluxes. TFLUX: units = W m: 2 TFLUX: coordinates = time TFLUX: valid_min = : 1713.51220703125 TFLUX: valid_max = 870.3130493164062			
Comments			
The rate of change of ocean heat content due to heat fluxes across the liquid surface and the addition or removal of mass. . Note: the global area integral of TFLUX and geothermal flux (geothermalFlux.bin) matches the time-derivative of ocean heat content (J/s). Unlike oceQnet, TFLUX includes the contribution to the ocean heat content from changing ocean mass (e.g. from oceFWflx).			

../images/plots/latlon_plots/Ocean_and_Sea-Ice_Surface_Heat_Fl

Figure 146:
Dataset: OCEAN_AND_ICE_SURFACE_HEAT_FLUX
Variable: TFLUX

17.4.11 Latlon Variable oceQnet

Table 17.31: CDL description of OCEAN_AND_ICE_SURFACE_HEAT_FLUX's oceQnet variable

<table>
<tr><th>Storage Type</th><th>Variable Name</th><th>Description</th><th>Unit</th></tr>
<tr><td>float32</td><td>oceQnet</td><td>Net heat flux into the ocean surface</td><td>W m-2</td></tr>
<tr><th colspan="4">CDL Description</th></tr>
<tr><td colspan="4">float32 oceQnet(time, latitude, longitude)
oceQnet: _FillValue = 9.96921e+36
oceQnet: coverage_content_type = modelResult
oceQnet: direction = >0 increases potential temperature (THETA)
oceQnet: long_name = Net heat flux into the ocean surface
oceQnet: standard_name = surface_downward_heat_flux_in_sea_water
oceQnet: units = W m: 2
oceQnet: coordinates = time
oceQnet: valid_min = : 1708.8460693359375
oceQnet: valid_max = 675.3716430664062</td></tr>
<tr><th colspan="4">Comments</th></tr>
<tr><td colspan="4">Net heat flux into the ocean surface from all processes: air-sea turbulent and radiative fluxes and turbulent and conductive fluxes between the ocean and sea-ice and snow. Note: oceQnet does not include the change in ocean heat content due to changing ocean ocean mass (oceFWflx). Mass fluxes from evaporation, precipitation, and runoff (EXFempmr) happen at the same temperature as the ocean surface temperature. Consequently, EmPmR does not change ocean surface temperature. Conversely, mass fluxes due to sea-ice thickening/thinning and snow melt in the model are assumed to happen at a fixed 0C. Consequently, mass fluxes due to phase changes between seawater and sea-ice and snow induce a heat flux when the ocean surface temperaure is not 0C. The variable TFLUX does include the change in ocean heat content due to changing ocean mass.</td></tr>
</table>

../images/plots/latlon_plots/Ocean_and_Sea-Ice_Surface_Heat_Fl

Figure 147:
Dataset: OCEAN_AND_ICE_SURFACE_HEAT_FLUX
Variable: oceQnet

17.4.12 Latlon Variable oceQsw

Table 17.32: CDL description of OCEAN_AND_ICE_SURFACE_HEAT_FLUX's oceQsw variable

Storage Type	Variable Name	Description	Unit
float32	oceQsw	Net shortwave radiative flux across the ocean surface	W m-2
CDL Description			
float32 oceQsw(time, latitude, longitude) oceQsw: _FillValue = 9.96921e+36 oceQsw: coverage_content_type = modelResult oceQsw: direction = >0 increases potential temperature (THETA) oceQsw: long_name = Net shortwave radiative flux across the ocean surface oceQsw: units = W m: 2 oceQsw: coordinates = time oceQsw: valid_min = : 134.39808654785156 oceQsw: valid_max = 655.6171264648438			
Comments			
Net shortwave radiative flux across the ocean surface. Note: Shortwave radiation penetrates below the surface grid cell.			

../images/plots/latlon_plots/Ocean_and_Sea-Ice_Surface_Heat_Fl

Figure 148:
Dataset: OCEAN_AND_ICE_SURFACE_HEAT_FLUX
Variable: oceQsw

17.5 Latlon NetCDF OCEAN_AND_ICE_SURFACE_STRESS

Table 17.33: Variables in the dataset OCEAN_AND_ICE_SURFACE_STRESS

Dataset:	**OCEAN_AND_ICE_SURFACE_STRESS**
Field:	EXFtaue
Field:	EXFtaun
Field:	oceTAUE
Field:	oceTAUN

17.5.1 Latlon Variable EXFtaue

Table 17.34: CDL description of OCEAN_AND_ICE_SURFACE_STRESS's EXFtaue variable

Storage Type	Variable Name	Description	Unit
float32	EXFtaue	Zonal (east-west) wind stress	N m-2
CDL Description			
float32 EXFtaue(time, latitude, longitude) EXFtaue: _FillValue = 9.96921e+36 EXFtaue: coverage_content_type = modelResult EXFtaue: direction = >0 increases eastward velocity (EVEL) EXFtaue: long_name = Zonal (east: west) wind stress EXFtaue: standard_name = surface_downward_eastward_stress EXFtaue: units = N m: 2 EXFtaue: coordinates = time EXFtaue: valid_min = : 3.1686902046203613 EXFtaue: valid_max = 3.284827709197998			
Comments			
Zonal (east-west) component of wind stress. Note: EXFtaue is the zonal wind stress applied to the ocean and sea-ice. When sea-ice is present, the total zonal stress applied to the ocean surface is NOT EXFtaue, but a combination of the wind stress in the open water fraction (EXFtaue) and a stress from sea-ice in the ice-covered fraction (see oceTAUE). EXFtaue is calculated by interpolating the model's x and y components of wind stress (EXFtaux and EXFtauy) to tracer cell centers and then finding the zonal component of the interpolated vectors. It is NOT recommended to use EXFtaue and EXFtaun for momentum budget calculations because interpolating EXFtaux and EXFtauy from the model grid to the lat-lon grid introduces errors. For momentum fluxes to the ocean surface see oceTAUx and oceTAUy.			

../images/plots/latlon_plots/Ocean_and_Sea-Ice_Surface_Stress/

Figure 149:
Dataset: OCEAN_AND_ICE_SURFACE_STRESS
Variable: EXFtaue

17.5.2 Latlon Variable EXFtaun

Table 17.35: CDL description of OCEAN_AND_ICE_SURFACE_STRESS's EXFtaun variable

Storage Type	Variable Name	Description	Unit
float32	EXFtaun	Meridional (north-south) wind stress	N m-2

CDL Description

float32 EXFtaun(time, latitude, longitude)
EXFtaun: _FillValue = 9.96921e+36
EXFtaun: coverage_content_type = modelResult
EXFtaun: direction = >0 increases northward velocity (NVEL)
EXFtaun: long_name = Meridional (north: south) wind stress
EXFtaun: standard_name = surface_downward_northward_stress
EXFtaun: units = N m: 2
EXFtaun: coordinates = time
EXFtaun: valid_min = : 4.111213207244873
EXFtaun: valid_max = 6.878159523010254

Comments

Meridional (north-south) component of wind stress. Note: EXFtaun is the stress applied to the ocean and sea-ice. When sea-ice is present, the total meridional stress applied to the ocean surface is NOT EXFtaun, but a combination of the wind stress in the open water fraction (EXFtaun) and a stress from sea-ice in the ice-covered fraction (see oceTAUN). EXFtaun is calculated by interpolating the model's x and y components of wind stress (EXFtaux and EXFtauy) to tracer cell centers and then determining the meridional component of the interpolated vectors. It is NOT recommended to use EXFtaue and EXFtaun for momentum budget calculations because interpolating EXFtaux and EXFtauy from the model grid to the lat-lon grid introduces errors. For momentum fluxes to the ocean surface see oceTAUx and oceTAUy.

../images/plots/latlon_plots/Ocean_and_Sea-Ice_Surface_Stress/

Figure 150:
Dataset: OCEAN_AND_ICE_SURFACE_STRESS
Variable: EXFtaun

17.5.3 Latlon Variable oceTAUE

Table 17.36: CDL description of OCEAN_AND_ICE_SURFACE_STRESS's oceTAUE variable

<table>
<tr><th>Storage Type</th><th>Variable Name</th><th>Description</th><th>Unit</th></tr>
<tr><td>float32</td><td>oceTAUE</td><td>Zonal (east-west) ocean surface stress</td><td>N m-2</td></tr>
<tr><th colspan="4">CDL Description</th></tr>
<tr><td colspan="4">float32 oceTAUE(time, latitude, longitude)
oceTAUE: _FillValue = 9.96921e+36
oceTAUE: coverage_content_type = modelResult
oceTAUE: direction = >0 increases eastward velocity (EVEL)
oceTAUE: long_name = Zonal (east: west) ocean surface stress
oceTAUE: standard_name = surface_downward_eastward_stress
oceTAUE: units = N m: 2
oceTAUE: coordinates = time
oceTAUE: valid_min = : 2.058817148208618
oceTAUE: valid_max = 2.000103712081909</td></tr>
<tr><th colspan="4">Comments</th></tr>
<tr><td colspan="4">Zonal (east-west) component of ocean surface stress due to wind and sea-ice. Note: oceTAUE is calculated by interpolating the model's x and y components of ocean surface stress (oceTAUX and oceTAUY) to tracer cell centers and then finding the zonal component of the interpolated vectors.</td></tr>
</table>

../images/plots/latlon_plots/Ocean_and_Sea-Ice_Surface_Stress/

Figure 151:
Dataset: OCEAN_AND_ICE_SURFACE_STRESS
Variable: oceTAUE

17.5.4 Latlon Variable oceTAUN

Table 17.37: CDL description of OCEAN_AND_ICE_SURFACE_STRESS's oceTAUN variable

Storage Type	Variable Name	Description	Unit
float32	oceTAUN	Meridional (north-south) ocean surface stress	N m-2
CDL Description			
float32 oceTAUN(time, latitude, longitude) oceTAUN: _FillValue = 9.96921e+36 oceTAUN: coverage_content_type = modelResult oceTAUN: direction = >0 increases northward velocity (NVEL) oceTAUN: long_name = Meridional (north: south) ocean surface stress oceTAUN: standard_name = surface_downward_northward_stress oceTAUN: units = N m: 2 oceTAUN: coordinates = time oceTAUN: valid_min = : 2.4036266803741455 oceTAUN: valid_max = 2.019313097000122			
Comments			
Meridional (north-south) component of ocean surface stress due to wind and sea-ice. Note: oceTAUN is calculated by interpolating the model's x and y components of ocean surface stress (oceTAUX and oceTAUY) to tracer cell centers and then finding the meridional component of the interpolated vectors.			

../images/plots/latlon_plots/Ocean_and_Sea-Ice_Surface_Stress/

Figure 152:
Dataset: OCEAN_AND_ICE_SURFACE_STRESS
Variable: oceTAUN

17.6 Latlon NetCDF OCEAN_BOLUS_VELOCITY

Table 17.38: Variables in the dataset OCEAN_BOLUS_VELOCITY

Dataset:	**OCEAN_BOLUS_VELOCITY**
Field:	EVELSTAR
Field:	NVELSTAR
Field:	WVELSTAR

17.6.1 Latlon Variable EVELSTAR

Table 17.39: CDL description of OCEAN_BOLUS_VELOCITY's EVELSTAR variable

Storage Type	Variable Name	Description	Unit
float32	EVELSTAR	Gent-McWilliams zonal (east-west) bolus velocity	m s-1
CDL Description			
float32 EVELSTAR(time, Z, latitude, longitude) EVELSTAR: _FillValue = 9.96921e+36 EVELSTAR: coverage_content_type = modelResult EVELSTAR: long_name = Gent: McWilliams zonal (east: west) bolus velocity EVELSTAR: standard_name = eastward_sea_water_velocity_due_to_parameterized_mesoscale_eddies EVELSTAR: units = m s: 1 EVELSTAR: coordinates = time Z EVELSTAR: valid_min = : 0.5832233428955078 EVELSTAR: valid_max = 0.7810457944869995			
Comments			
Zonal (east-west) component of the Gent-McWilliams bolus ocean velocity. Note: EVELSTAR is calculated by interpolating the model's x and y components of GM bolus ocean velocity (UVELSTAR and VVELSTAR) to tracer cell centers and then finding the zonal components of the interpolated vectors. One should take care when interpreting bolus velocities interpolated from the ECCO native model grid because interpolating from the model grid to the lat-lon grid introduces errors. Some closed buget calculations require bolus velocity terms on the native model grid.			

../images/plots/latlon_plots/Gent-McWilliams_Ocean_Bolus_Veloc

Figure 153:
Dataset: OCEAN_BOLUS_VELOCITY
Variable: EVELSTAR

17.6.2 Latlon Variable NVELSTAR

Table 17.40: CDL description of OCEAN_BOLUS_VELOCITY's NVELSTAR variable

Storage Type	Variable Name	Description	Unit
float32	NVELSTAR	Gent-McWilliams meridional (north-south) bolus velocity	m s-1
CDL Description			
float32 NVELSTAR(time, Z, latitude, longitude) NVELSTAR: _FillValue = 9.96921e+36 NVELSTAR: coverage_content_type = modelResult NVELSTAR: long_name = Gent: McWilliams meridional (north: south) bolus velocity NVELSTAR: standard_name = northward_sea_water_velocity_due_to_parameterized_mesoscale_eddies NVELSTAR: units = m s: 1 NVELSTAR: coordinates = time Z NVELSTAR: valid_min = : 0.6472858190536499 NVELSTAR: valid_max = 0.6751338243484497			
Comments			
Meridional (north-south) component of the Gent-McWilliams bolus ocean velocity. Note: NVELSTAR is calculated by interpolating the model's x and y components of GM bolus ocean velocity (UVELSTAR and VVELSTAR) to tracer cell centers and then finding the meridional components of the interpolated vectors. One should take care when interpreting bolus velocities interpolated from the ECCO native model grid because interpolating from the model grid to the lat-lon grid introduces errors. Some closed buget calculations require bolus velocity terms on the native model grid			

../images/plots/latlon_plots/Gent-McWilliams_Ocean_Bolus_Veloc

Figure 154:
Dataset: OCEAN_BOLUS_VELOCITY
Variable: NVELSTAR

17.6.3 Latlon Variable WVELSTAR

Table 17.41: CDL description of OCEAN_BOLUS_VELOCITY's WVELSTAR variable

Storage Type	Variable Name	Description	Unit
float32	WVELSTAR	Gent-McWilliams vertical bolus velocity	m s-1
CDL Description			
float32 WVELSTAR(time, Z, latitude, longitude) WVELSTAR: _FillValue = 9.96921e+36 WVELSTAR: coverage_content_type = modelResult WVELSTAR: direction = >0 decreases volume WVELSTAR: long_name = Gent: McWilliams vertical bolus velocity WVELSTAR: standard_name = upward_sea_water_velocity_due_to_parameterized_mesoscale_eddies WVELSTAR: units = m s: 1 WVELSTAR: coordinates = time Z WVELSTAR: valid_min = : 0.00037936007720418274 WVELSTAR: valid_max = 0.00040190346771851 18			
Comments			
Vertical component of the Gent-McWilliams bolus ocean velocity. Note: in the Arakawa-C grid used in ECCO V4r4, vertical velocities are staggered relative to the tracer cell centers with values at the TOP and BOTTOM faces of each grid cell.			

../images/plots/latlon_plots/Gent-McWilliams_Ocean_Bolus_Veloc

Figure 155:
Dataset: OCEAN_BOLUS_VELOCITY
Variable: WVELSTAR

17.7 Latlon NetCDF OCEAN_BOTTOM_PRESSURE

Table 17.42: Variables in the dataset OCEAN_BOTTOM_PRESSURE

Dataset:	**OCEAN_BOTTOM_PRESSURE**
Field:	OBP
Field:	OBPGMAP

17.7.1 Latlon Variable OBP

Table 17.43: CDL description of OCEAN_BOTTOM_PRESSURE's OBP variable

Storage Type	Variable Name	Description	Unit
float32	OBP	Ocean bottom pressure given as equivalent water thickness	m
CDL Description			
float32 OBP(time, latitude, longitude) OBP: _FillValue = 9.96921e+36 OBP: coverage_content_type = modelResult OBP: long_name = Ocean bottom pressure given as equivalent water thickness OBP: units = m OBP: coordinates = time OBP: valid_min = : 2.544442892074585 OBP: valid_max = 72.1243667602539			
Comments			
OBP excludes the contribution from global mean atmospheric pressure and is therefore suitable for comparisons with GRACE data products. OBP is calculated as follows. First, we calculate ocean hydrostatic bottom pressure anomaly, PHIBOT, with PHIBOT = p_b/rhoConst - gH(t), where p_b = model ocean hydrostatic bottom pressure, rhoConst = reference density (1029 kg m-3), g is acceleration due to gravity (9.81 m s-2), and H(t) is model depth at time t. Then, OBP = PHIBOT/g + corrections for i) global mean steric sea level changes related to density changes in the Boussinesq volume-conserving model (Greatbatch correction, see sterGloH) and ii) global mean atmospheric pressure variations. Use OBP for comparisons with ocean bottom pressure data products that have been corrected for global mean atmospheric pressure variations. GRACE data typically ARE corrected for global mean atmospheric pressure variations. In contrast, ocean bottom pressure gauge data typically ARE NOT corrected for global mean atmospheric pressure variations.			

../images/plots/latlon_plots/Ocean_Bottom_Pressure/OBP.png

Figure 156:
Dataset: OCEAN_BOTTOM_PRESSURE
Variable: OBP

17.7.2 Latlon Variable OBPGMAP

Table 17.44: CDL description of OCEAN_BOTTOM_PRESSURE's OBPGMAP variable

Storage Type	Variable Name	Description	Unit
float32	OBPGMAP	Ocean bottom pressure given as equivalent water thickness, includes global mean atmospheric pressure	m
CDL Description			
float32 OBPGMAP(time, latitude, longitude) OBPGMAP: _FillValue = 9.96921e+36 OBPGMAP: coverage_content_type = modelResult OBPGMAP: long_name = Ocean bottom pressure given as equivalent water thickness includes global mean atmospheric pressure OBPGMAP: units = m OBPGMAP: coordinates = time OBPGMAP: valid_min = 7.395928859710693 OBPGMAP: valid_max = 82.14805603027344			
Comments			
OBPGMAP includes the contribution from global mean atmospheric pressure and is therefore suitable for comparisons with ocean bottom pressure gauge data products. OBPGMAP is calculated as follows. First, we calculate ocean hydrostatic bottom pressure anomaly, PHIBOT, with PHIBOT = p_b/rhoConst - gH(t), where p_b = model ocean hydrostatic bottom pressure, rhoConst = reference density (1029 kg m-3), g is acceleration due to gravity (9.81 m s-2), and H(t) is model depth at time t. Then, OBPGMAP= PHIBOT/g + corrections for global mean steric sea level changes related to density changes in the Boussinesq volume-conserving model (Greatbatch correction, see sterGloH). Use OBPGMAP for comparisons with ocean bottom pressure data products that have NOT been corrected for global mean atmospheric pressure variations. GRACE data typically ARE corrected for global mean atmospheric pressure variations. In contrast, ocean bottom pressure gauge data typically ARE NOT corrected for global mean atmospheric pressure variations.			

../images/plots/latlon_plots/Ocean_Bottom_Pressure/OBPGMAP.png

Figure 157:
Dataset: OCEAN_BOTTOM_PRESSURE
Variable: OBPGMAP

17.8 Latlon NetCDF OCEAN_DENS_STRAT_PRESS

Table 17.45: Variables in the dataset OCEAN_DENS_STRAT_PRESS

Dataset:	OCEAN_DENS_STRAT_PRESS
Field:	RHOAnoma
Field:	DRHODR
Field:	PHIHYD

17.8.1 Latlon Variable DRHODR

Table 17.46: CDL description of OCEAN_DENS_STRAT_PRESS's DRHODR variable

Storage Type	Variable Name	Description	Unit
float32	DRHODR	Density stratification	kg m-3 m-1

CDL Description

float32 DRHODR(time, Z, latitude, longitude)
 DRHODR: _FillValue = 9.96921e+36
 DRHODR: coverage_content_type = modelResult
 DRHODR: long_name = Density stratification
 DRHODR: units = kg m: 3 m: 1
 DRHODR: coordinates = time Z
 DRHODR: valid_min = : 0.8687265515327454
 DRHODR: valid_max = 0.011617615818977356

Comments

Density stratification: d(sigma) d z-1. Note: density computations are done with in-situ density. The vertical derivatives of in-situ density and locally-referenced potential density are identical The equation of state is a modified UNESCO formula by Jackett and McDougall (1995), which uses the model variable potential temperature as input assuming a horizontally and temporally constant pressure of $p_0=-g ho_{0} z$.

../images/plots/latlon_plots/Ocean_Density_Stratification_and_

Figure 158:
Dataset: OCEAN_DENS_STRAT_PRESS
Variable: DRHODR

17.8.2 Latlon Variable PHIHYD

Table 17.47: CDL description of OCEAN_DENS_STRAT_PRESS's PHIHYD variable

Storage Type	Variable Name	Description	Unit
float32	PHIHYD	Ocean hydrostatic pressure anomaly	m2 s-2
CDL Description			
float32 PHIHYD(time, Z, latitude, longitude) PHIHYD: _FillValue = 9.96921e+36 PHIHYD: coverage_content_type = modelResult PHIHYD: long_name = Ocean hydrostatic pressure anomaly PHIHYD: units = m2 s: 2 PHIHYD: coordinates = time Z PHIHYD: valid_min = 74.71473693847656 PHIHYD: valid_max = 783.9188232421875			
Comments			
PHIHYD = p(k) / rhoConst - g z*(k,t), where p = hydrostatic ocean pressure at depth level k, rhoConst = reference density (1029 kg m-3), g is acceleration due to gravity (9.81 m s-2), and z*(k,t) is model depth at level k and time t. Units: p:[kg m-1 s-2], rhoConst:[kg m-3], g:[m s-2], H(t):[m]. Note: includes atmospheric pressure loading. Quantity referred to in some contexts as hydrostatic pressure anomaly. PHIBOT accounts for the model's time-varying grid cell thickness (z* coordinate system). See PHIHYDcR for hydrostatic pressure potential anomaly calculated using time-invariant grid cell thicknesses. PHIHYD is NOT corrected for global mean steric sea level changes related to density changes in the Boussinesq volume-conserving model (Greatbatch correction, see sterGloH).			

../images/plots/latlon_plots/Ocean_Density_Stratification_and_

Figure 159:
Dataset: OCEAN_DENS_STRAT_PRESS
Variable: PHIHYD

17.8.3 Latlon Variable RHOAnoma

Table 17.48: CDL description of OCEAN_DENS_STRAT_PRESS's RHOAnoma variable

<table>
<tr><th>Storage Type</th><th>Variable Name</th><th>Description</th><th>Unit</th></tr>
<tr><td>float32</td><td>RHOAnoma</td><td>In-situ seawater density anomaly</td><td>kg m-3</td></tr>
<tr><th colspan="4">CDL Description</th></tr>
<tr><td colspan="4">float32 RHOAnoma(time, Z, latitude, longitude)
RHOAnoma: _FillValue = 9.96921e+36
RHOAnoma: coverage_content_type = modelResult
RHOAnoma: long_name = In: situ seawater density anomaly
RHOAnoma: units = kg m: 3
RHOAnoma: coordinates = time Z
RHOAnoma: valid_min = : 19.919862747192383
RHOAnoma: valid_max = 25.540647506713867</td></tr>
<tr><th colspan="4">Comments</th></tr>
<tr><td colspan="4">In-situ seawater density anomaly relative to the reference density, rhoConst. rhoConst = 1029 kg m-3</td></tr>
</table>

../images/plots/latlon_plots/Ocean_Density_Stratification_and_

Figure 160:
Dataset: OCEAN_DENS_STRAT_PRESS
Variable: RHOAnoma

17.9 Latlon NetCDF OCEAN_MIXED_LAYER_DEPTH

Table 17.49: Variables in the dataset OCEAN_MIXED_LAYER_DEPTH

Dataset:	**OCEAN_MIXED_LAYER_DEPTH**
Field:	MXLDEPTH

17.9.1 Latlon Variable MXLDEPTH

Table 17.50: CDL description of OCEAN_MIXED_LAYER_DEPTH's MXLDEPTH variable

<table>
<tr><th>Storage Type</th><th>Variable Name</th><th>Description</th><th>Unit</th></tr>
<tr><td>float32</td><td>MXLDEPTH</td><td>Mixed-layer depth diagnosed using the temperature difference criterion of Kara et al., 2000</td><td>m</td></tr>
<tr><th colspan="4">CDL Description</th></tr>
<tr><td colspan="4">float32 MXLDEPTH(time, latitude, longitude)
MXLDEPTH: _FillValue = 9.96921e+36
MXLDEPTH: coverage_content_type = modelResult
MXLDEPTH: long_name = Mixed: layer depth diagnosed using the temperature difference criterion of Kara et al. 2000
MXLDEPTH: standard_name = ocean_mixed_layer_thickness
MXLDEPTH: units = m
MXLDEPTH: coordinates = time
MXLDEPTH: valid_min = 5.000001430511475
MXLDEPTH: valid_max = 5331.2001953125</td></tr>
<tr><th colspan="4">Comments</th></tr>
<tr><td colspan="4">Mixed-layer depth as determined by the depth where waters are first 0.8 degrees Celsius colder than the surface. See Kara et al. (JGR, 2000). . Note: the Kara et al. criterion may not be appropriate for some applications. If needed, mixed layer depth can be calculated using different criteria. See vertical density stratification (DRHODR) and density anomaly (RHOAnoma).</td></tr>
</table>

../images/plots/latlon_plots/Ocean_Mixed_Layer_Depth/MXLDEPTH.

Figure 161:
Dataset: OCEAN_MIXED_LAYER_DEPTH
Variable: MXLDEPTH

17.10 Latlon NetCDF OCEAN_TEMPERATURE_SALINITY

Table 17.51: Variables in the dataset OCEAN_TEMPERATURE_SALINITY

Dataset:	**OCEAN_TEMPERATURE_SALINITY**
Field:	THETA
Field:	SALT

17.10.1 Latlon Variable SALT

Table 17.52: CDL description of OCEAN_TEMPERATURE_SALINITY's SALT variable

<table>
<tr><th>Storage Type</th><th>Variable Name</th><th>Description</th><th>Unit</th></tr>
<tr><td>float32</td><td>SALT</td><td>Salinity</td><td>1e-3</td></tr>
<tr><th colspan="4">CDL Description</th></tr>
<tr><td colspan="4">float32 SALT(time, Z, latitude, longitude)
SALT: _FillValue = 9.96921e+36
SALT: coverage_content_type = modelResult
SALT: long_name = Salinity
SALT: standard_name = sea_water_salinity
SALT: units = 1e: 3
SALT: coordinates = time Z
SALT: valid_min = 16.73577880859375
SALT: valid_max = 41.321231842041016</td></tr>
<tr><th colspan="4">Comments</th></tr>
<tr><td colspan="4">Defined using CF convention 'Sea water salinity is the salt content of sea water, often on the Practical Salinity Scale of 1978. However, the unqualified term 'salinity' is generic and does not necessarily imply any particular method of calculation. The units of salinity are dimensionless and the units attribute should normally be given as 1e-3 or 0.001 i.e. parts per thousand.' see https://cfconventions.org/Data/cf-standard-names/73/build/cf-standard-name-table.html</td></tr>
</table>

../images/plots/latlon_plots/Ocean_Temperature_and_Salinity/SA

Figure 162:
Dataset: OCEAN_TEMPERATURE_SALINITY
Variable: SALT

17.10.2 Latlon Variable THETA

Table 17.53: CDL description of OCEAN_TEMPERATURE_SALINITY's THETA variable

Storage Type	Variable Name	Description	Unit
float32	THETA	Potential temperature	degree_C
CDL Description			
float32 THETA(time, Z, latitude, longitude) THETA: _FillValue = 9.96921e+36 THETA: coverage_content_type = modelResult THETA: long_name = Potential temperature THETA: standard_name = sea_water_potential_temperature THETA: units = degree_C THETA: coordinates = time Z THETA: valid_min = : 2.9179372787475586 THETA: valid_max = 36.425140380859375			
Comments			
Sea water potential temperature is the temperature a parcel of sea water would have if moved adiabatically to sea level pressure. Note: the equation of state is a modified UNESCO formula by Jackett and McDougall (1995), which uses the model variable potential temperature as input assuming a horizontally and temporally constant pressure of $p_0=-g ho_{0} z$.			

../images/plots/latlon_plots/Ocean_Temperature_and_Salinity/TH

Figure 163:
Dataset: OCEAN_TEMPERATURE_SALINITY
Variable: THETA

17.11 Latlon NetCDF OCEAN_VELOCITY

Table 17.54: Variables in the dataset OCEAN_VELOCITY

Dataset:	OCEAN_VELOCITY
Field:	EVEL
Field:	NVEL
Field:	WVEL

17.11.1 Latlon Variable EVEL

Table 17.55: CDL description of OCEAN_VELOCITY's EVEL variable

Storage Type	Variable Name	Description	Unit
float32	EVEL	Zonal (east-west) velocity	m s-1
CDL Description			
float32 EVEL(time, Z, latitude, longitude) EVEL: _FillValue = 9.96921e+36 EVEL: coverage_content_type = modelResult EVEL: long_name = Zonal (east: west) velocity EVEL: standard_name = eastward_sea_water_velocity EVEL: units = m s: 1 EVEL: coordinates = Z time EVEL: valid_min = : 1.746832251548767 EVEL: valid_max = 1.948591947555542			
Comments			
Zonal (east-west) component of ocean velocity. Note: EVEL is calculated by interpolating the model's x and y components of ocean velocity (UVEL and VVEL)to tracer cell centers and then finding the zonal component of the interpolated vectors. It is not recommended to use EVEL and NVEL for volume budget calculations because interpolating UVEL and VVEL from the model grid to the lat-lon grid introduces errors. Perform volume budget calculations with UVELMASS and VVELMASS on the native model grid.			

../images/plots/latlon_plots/Ocean_Velocity/EVEL.png

Figure 164:
Dataset: OCEAN_VELOCITY
Variable: EVEL

17.11.2 Latlon Variable NVEL

Table 17.56: CDL description of OCEAN_VELOCITY's NVEL variable

Storage Type	Variable Name	Description	Unit
float32	NVEL	Meridional (north-south) velocity	m s-1
CDL Description			
float32 NVEL(time, Z, latitude, longitude) NVEL: _FillValue = 9.96921e+36 NVEL: coverage_content_type = modelResult NVEL: long_name = Meridional (north: south) velocity NVEL: standard_name = northward_sea_water_velocity NVEL: units = m s: 1 NVEL: coordinates = Z time NVEL: valid_min = : 1.2522369623184204 NVEL: valid_max = 2.0500051975250244			
Comments			
Meridional (north-south) component of ocean velocity. Note: NVEL is calculated by interpolating the model's x and y components of ocean velocity (UVEL and VVEL) to tracer cell centers and then finding the meridional component of the interpolated vectors. It is not recommended to use EVEL and NVEL for volume budget calculations because interpolating UVEL and VVEL from the model grid to the lat-lon grid introduces errors. Perform volume budget calculations with UVELMASS and VVELMASS on the native model grid.			

../images/plots/latlon_plots/Ocean_Velocity/NVEL.png

Figure 165:
Dataset: OCEAN_VELOCITY
Variable: NVEL

17.11.3 Latlon Variable WVEL

Table 17.57: CDL description of OCEAN_VELOCITY's WVEL variable

Storage Type	Variable Name	Description	Unit
float32	WVEL	Vertical velocity	m s-1
CDL Description			
float32 WVEL(time, Z, latitude, longitude) WVEL: _FillValue = 9.96921e+36 WVEL: coverage_content_type = modelResult WVEL: direction = >0 decreases volume WVEL: long_name = Vertical velocity WVEL: standard_name = upward_sea_water_velocity WVEL: units = m s: 1 WVEL: coordinates = Z time WVEL: valid_min = : 0.0023150660563260317 WVEL: valid_max = 0.0016380994347855449			
Comments			
Vertical velocity in the +z direction at the top face of the grid cell. Note: in the Arakawa-C grid used in ECCO V4r4, vertical velocities are staggered relative to the tracer cell centers with values at the TOP and BOTTOM faces of each grid cell.			

../images/plots/latlon_plots/Ocean_Velocity/WVEL.png

Figure 166:
Dataset: OCEAN_VELOCITY
Variable: WVEL

17.12 Latlon NetCDF SEA_ICE_CONC_THICKNESS

Table 17.58: Variables in the dataset SEA_ICE_CONC_THICKNESS

Dataset:	**SEA_ICE_CONC_THICKNESS**
Field:	SIarea
Field:	SIheff
Field:	SIhsnow
Field:	sIceLoad

17.12.1 Latlon Variable SIarea

Table 17.59: CDL description of SEA_ICE_CONC_THICKNESS's SIarea variable

Storage Type	Variable Name	Description	Unit
float32	SIarea	Sea-ice concentration	1
CDL Description			
float32 SIarea(time, latitude, longitude) SIarea: _FillValue = 9.96921e+36 SIarea: coverage_content_type = modelResult SIarea: long_name = Sea: ice concentration SIarea: standard_name = sea_ice_area_fraction SIarea: units = 1 SIarea: coordinates = time SIarea: valid_min = 0.0 SIarea: valid_max = 0.9700000286102295			
Comments			
Fraction of ocean grid cell covered with sea-ice [0 to 1]. CF Standard Name Table v73: 'Area fraction' is the fraction of a grid cell's horizontal area that has some characteristic of interest. It is evaluated as the area of interest divided by the grid cell area. It may be expressed as a fraction, a percentage, or any other dimensionless representation of a fraction. Sea ice area fraction is area of the sea surface occupied by sea ice. It is also called 'sea ice concentration'. 'Sea ice' means all ice floating in the sea which has formed from freezing sea water, rather than by other processes such as calving of land ice to form icebergs. https://cfconventions.org/Data/cf-standard-names/73/build/cf-standard-name-table.html. Defined using CF Standard Name Table v73: 'Area fraction' is the fraction of a grid cell's horizontal area that has some characteristic of interest. It is evaluated as the area of interest divided by the grid cell area. It may be expressed as a fraction, a percentage, or any other dimensionless representation of a fraction. Sea ice area fraction is area of the sea surface occupied by sea ice. It is also called 'sea ice concentration'. 'Sea ice' means all ice floating in the sea which has formed from freezing sea water and precipitation, rather than by other processes such as calving of land ice to form icebergs. https://cfconventions.org/Data/cf-standard-names/73/build/cf-standard-name-table.html			

../images/plots/latlon_plots/Sea-Ice_and_Snow_Concentration_an

Figure 167:
Dataset: SEA_ICE_CONC_THICKNESS
Variable: SIarea

17.12.2 Latlon Variable SIheff

Table 17.60: CDL description of SEA_ICE_CONC_THICKNESS's SIheff variable

<table>
<tr><th>Storage Type</th><th>Variable Name</th><th>Description</th><th>Unit</th></tr>
<tr><td>float32</td><td>SIheff</td><td>Area-averaged sea-ice thickness</td><td>m</td></tr>
<tr><th colspan="4">CDL Description</th></tr>
<tr><td colspan="4">float32 SIheff(time, latitude, longitude)
SIheff: _FillValue = 9.96921e+36
SIheff: coverage_content_type = modelResult
SIheff: long_name = Area: averaged sea: ice thickness
SIheff: standard_name = sea_ice_thickness
SIheff: units = m
SIheff: coordinates = time
SIheff: valid_min = 0.0
SIheff: valid_max = 9.000518798828125</td></tr>
<tr><th colspan="4">Comments</th></tr>
<tr><td colspan="4">Sea-ice thickness averaged over the entire model grid cell, including open water where sea-ice thickness is zero. Note: sea-ice thickness over the ICE-COVERED fraction of the grid cell is SIheff/SIarea</td></tr>
</table>

../images/plots/latlon_plots/Sea-Ice_and_Snow_Concentration_an

Figure 168:
Dataset: SEA_ICE_CONC_THICKNESS
Variable: SIheff

17.12.3 Latlon Variable SIhsnow

Table 17.61: CDL description of SEA_ICE_CONC_THICKNESS's SIhsnow variable

Storage Type	Variable Name	Description	Unit
float32	SIhsnow	Area-averaged snow thickness	m
CDL Description			
float32 SIhsnow(time, latitude, longitude) SIhsnow: _FillValue = 9.96921e+36 SIhsnow: coverage_content_type = modelResult SIhsnow: long_name = Area: averaged snow thickness SIhsnow: standard_name = surface_snow_thickness SIhsnow: units = m SIhsnow: coordinates = time SIhsnow: valid_min = : 0.0004725505714304745 SIhsnow: valid_max = 2.5671639442443848			
Comments			
Snow thickness averaged over the entire model grid cell, including open water where snow thickness is zero. Note: snow thickness over the ICE-COVERED fraction of the grid cell is SIhsnow/SIarea			

../images/plots/latlon_plots/Sea-Ice_and_Snow_Concentration_an

Figure 169:
Dataset: SEA_ICE_CONC_THICKNESS
Variable: SIhsnow

17.12.4 Latlon Variable sIceLoad

Table 17.62: CDL description of SEA_ICE_CONC_THICKNESS's sIceLoad variable

Storage Type	Variable Name	Description	Unit
float32	sIceLoad	Average sea-ice and snow mass per unit area	kg m-2
CDL Description			
float32 sIceLoad(time, latitude, longitude) sIceLoad: _FillValue = 9.96921e+36 sIceLoad: coverage_content_type = modelResult sIceLoad: long_name = Average sea: ice and snow mass per unit area sIceLoad: standard_name = sea_ice_and_surface_snow_amount sIceLoad: units = kg m: 2 sIceLoad: coordinates = time sIceLoad: valid_min = : 0.0015558383893221617 sIceLoad: valid_max = 8729.935546875			
Comments			
Total mass of sea-ice and snow in a model grid cell averaged over model grid cell area. Note: sIceLoad is used to correct model sea level anomaly, ETAN, to calculate dynamic sea surface height, SSH, and sea surface height without the inverted barometer (IB correction), SSHNOIBC. In the model, sea-ice is treated as floating above the sea level with ETAN tracing the location of the ocean-ice interface. Consequently, sea-ice growth in the model lowers ETAN and sea-ice melting raises ETAN. Dynamic sea surface height is obtained by correcting ETAN by the weight of ice and snow directly above following Archimedes' principle.			

../images/plots/latlon_plots/Sea-Ice_and_Snow_Concentration_an

Figure 170:
Dataset: SEA_ICE_CONC_THICKNESS
Variable: sIceLoad

17.13 Latlon NetCDF SEA_ICE_VELOCITY

Table 17.63: Variables in the dataset SEA_ICE_VELOCITY

Dataset:	SEA_ICE_VELOCITY
Field:	SIeice
Field:	SInice

17.13.1 Latlon Variable SIeice

Table 17.64: CDL description of SEA_ICE_VELOCITY's SIeice variable

Storage Type	Variable Name	Description	Unit
float32	SIeice	Zonal (east-west) sea-ice velocity	m s-1

CDL Description

float32 SIeice(time, latitude, longitude)
SIeice: _FillValue = 9.96921e+36
SIeice: coverage_content_type = modelResult
SIeice: long_name = Zonal (east: west) sea: ice velocity
SIeice: standard_name = eastward_sea_ice_velocity
SIeice: units = m s: 1
SIeice: coordinates = time
SIeice: valid_min = : 0.5656854510307312
SIeice: valid_max = 0.5656854510307312

Comments

Zonal (east-west) componet of sea-ice velocity. Note: mask with SIarea to remove nonzero values where ice is absent. SIeice is calculated by interpolating the model's x and y components of sea-ice velocity (SIuice and SIvice) to tracer cell centers and then finding the zonal component of the interpolated vectors. It is NOT recommended to use SIuice and SIvice for sea-ice volume budget calculations because interpolating SIuice and SIvice from the model grid to the lat-lon grid introduces errors. Perform sea-ice mass budget calculations with ADVxHEFF, ADVyHEFF, DFxHEFF, and DFyHEFF on the native model grid.

../images/plots/latlon_plots/Sea-Ice_Velocity/SIeice.png

Figure 171:
Dataset: SEA_ICE_VELOCITY
Variable: SIeice

17.13.2 Latlon Variable SInice

Table 17.65: CDL description of SEA_ICE_VELOCITY's SInice variable

Storage Type	Variable Name	Description	Unit
float32	SInice	Meridional (north-south) sea-ice velocity	m s-1
CDL Description			
float32 SInice(time, latitude, longitude) SInice: _FillValue = 9.96921e+36 SInice: coverage_content_type = modelResult SInice: long_name = Meridional (north: south) sea: ice velocity SInice: standard_name = northward_sea_ice_velocity SInice: units = m s: 1 SInice: coordinates = time SInice: valid_min = : 0.5615208148956299 SInice: valid_max = 0.5656854510307312			
Comments			
Meridional (north-south) component of sea-ice velocity. Note: mask with SIarea to remove nonzero values where ice is absent. SInice is calculated by interpolating the model's x and y components of sea-ice velocity (SIuice and SIvice) to tracer cell centers and then finding the meridional component of the interpolated vectors. It is NOT recommended to use SIuice and SIvice for sea-ice volume budget calculations because interpolating SIuice and SIvice from the model grid to the lat-lon grid introduces errors. Perform sea-ice mass budget calculations with ADVxHEFF, ADVyHEFF, DFxHEFF, and DFyHEFF on the native model grid.			

../images/plots/latlon_plots/Sea-Ice_Velocity/SInice.png

Figure 172:
Dataset: SEA_ICE_VELOCITY
Variable: SInice

17.14 Latlon NetCDF SEA_SURFACE_HEIGHT

Table 17.66: Variables in the dataset SEA_SURFACE_HEIGHT

Dataset:	**SEA_SURFACE_HEIGHT**
Field:	SSH
Field:	SSHIBC
Field:	SSHNOIBC

17.14.1 Latlon Variable SSH

Table 17.67: CDL description of SEA_SURFACE_HEIGHT's SSH variable

Storage Type	Variable Name	Description	Unit
float32	SSH	Dynamic sea surface height anomaly	m
CDL Description			
float32 SSH(time, latitude, longitude) SSH: _FillValue = 9.96921e+36 SSH: coverage_content_type = modelResult SSH: long_name = Dynamic sea surface height anomaly SSH: standard_name = sea_surface_height_above_geoid SSH: units = m SSH: coordinates = time SSH: valid_min = : 2.4861555099487305 SSH: valid_max = 2.2875382900238037			
Comments			
Dynamic sea surface height anomaly above the geoid, suitable for comparisons with altimetry sea surface height data products that apply the inverse barometer (IB) correction. Note: SSH is calculated by correcting model sea level anomaly ETAN for three effects: a) global mean steric sea level changes related to density changes in the Boussinesq volume-conserving model (Greatbatch correction, see sterGloH), b) the inverted barometer (IB) effect (see SSHIBC) and c) sea level displacement due to sea-ice and snow pressure loading (see sIceLoad). SSH can be compared with the similarly-named SSH variable in previous ECCO products that did not include atmospheric pressure loading (e.g., Version 4 Release 3). Use SSHNOIBC for comparisons with altimetry data products that do NOT apply the IB correction.			

../images/plots/latlon_plots/Sea_Surface_Height/SSH.png

Figure 173:
Dataset: SEA_SURFACE_HEIGHT
Variable: SSH

17.14.2 Latlon Variable SSHIBC

Table 17.68: CDL description of SEA_SURFACE_HEIGHT's SSHIBC variable

Storage Type	Variable Name	Description	Unit
float32	SSHIBC	The inverted barometer (IB) correction to sea surface height due to atmospheric pressure loading	m
CDL Description			
float32 SSHIBC(time, latitude, longitude) SSHIBC: _FillValue = 9.96921e+36 SSHIBC: coverage_content_type = modelResult SSHIBC: long_name = The inverted barometer (IB) correction to sea surface height due to atmospheric pressure loading SSHIBC: units = m SSHIBC: coordinates = time SSHIBC: valid_min = : 0.5228679180145264 SSHIBC: valid_max = 0.8955588340759277			
Comments			
Not an SSH itself, but a correction to model sea level anomaly (ETAN) required to account for the static part of sea surface displacement by atmosphere pressure loading: SSH = SSHNOIBC - SSHIBC. Note: Use SSH for model-data comparisons with altimetry data products that DO apply the IB correction and SSHNOIBC for comparisons with altimetry data products that do NOT apply the IB correction.			

../images/plots/latlon_plots/Sea_Surface_Height/SSHIBC.png

Figure 174:
Dataset: SEA_SURFACE_HEIGHT
Variable: SSHIBC

17.14.3 Latlon Variable SSHNOIBC

Table 17.69: CDL description of SEA_SURFACE_HEIGHT's SSHNOIBC variable

Storage Type	Variable Name	Description	Unit
float32	SSHNOIBC	Sea surface height anomaly without the inverted barometer (IB) correction	m
CDL Description			
float32 SSHNOIBC(time, latitude, longitude) SSHNOIBC: _FillValue = 9.96921e+36 SSHNOIBC: coverage_content_type = modelResult SSHNOIBC: long_name = Sea surface height anomaly without the inverted barometer (IB) correction SSHNOIBC: units = m SSHNOIBC: coordinates = time SSHNOIBC: valid_min = : 2.45104718208313 SSHNOIBC: valid_max = 2.2390522956848145			
Comments			
Sea surface height anomaly above the geoid without the inverse barometer (IB) correction, suitable for comparisons with altimetry sea surface height data products that do NOT apply the inverse barometer (IB) correction. Note: SSHNOIBC is calculated by correcting model sea level anomaly ETAN for two effects: a) global mean steric sea level changes related to density changes in the Boussinesq volume-conserving model (Greatbatch correction, see sterGloH), b) sea level displacement due to sea-ice and snow pressure loading (see sIceLoad). In ECCO Version 4 Release 4 the model is forced with atmospheric pressure loading. SSHNOIBC does not correct for the static part of the effect of atmosphere pressure loading on sea surface height (the so-called inverse barometer (IB) correction). Use SSH for comparisons with altimetry data products that DO apply the IB correction.			

../images/plots/latlon_plots/Sea_Surface_Height/SSHNOIBC.png

Figure 175:
Dataset: SEA_SURFACE_HEIGHT
Variable: SSHNOIBC

18 1-D Dataset Groupings

18.1 Overview of the 1-D Dataset Groupings

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Vivamus at enim eget nisi ultrices facilisis a et purus. Sed tincidunt scelerisque ligula, in vehicula dui venenatis at. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Curabitur consequat commodo nunc, nec lacinia quam feugiat vel. Integer bibendum lectus sit amet quam elementum, ut pretium quam malesuada. Cras fermentum venenatis augue, id commodo libero facilisis nec. Quisque euismod, odio vitae dapibus convallis, justo enim iaculis metus, vel interdum elit nisi vel lectus. Fusce tempor elit in semper condimentum. Ut quis dui eget purus cursus interdum eu ac elit.'

18.2 1D NetCDF GLOBAL_MEAN_ATM_SURFACE_PRES

Table 18.1: Variables in the dataset GLOBAL_MEAN_ATM_SURFACE_PRES

Dataset:	**GLOBAL_MEAN_ATM_SURFACE_PRES**
Field:	Pa_global

18.2.1 1D Variable Pa_global

Table 18.2: CDL description of GLOBAL_MEAN_ATM_SURFACE_PRES's Pa_global variable

Storage Type	Variable Name	Description	Unit
float64	Pa_global	Global mean atmospheric surface pressure over the ocean and sea-ice	N m-2
CDL Description			
float64 Pa_global(time) Pa_global: _FillValue = 9.969209968386869e+36 Pa_global: coverage_content_type = modelResult Pa_global: long_name = Global mean atmospheric surface pressure over the ocean and sea: ice Pa_global: standard_name = air_pressure_at_sea_level Pa_global: units = N m: 2 Pa_global: valid_min = 100873.14755283327 Pa_global: valid_max = 101257.45252296235 Pa_global: coordinates = time			
Comments			
N/A			

../images/plots/oneD_plots/Global_Mean_Atmospheric_Pressure/Pa

Figure 176:
Dataset: GLOBAL_MEAN_ATM_SURFACE_PRES
Variable: Pa_global

18.3 1D NetCDF GLOBAL_MEAN_SEA_LEVEL

Table 18.3: Variables in the dataset GLOBAL_MEAN_SEA_LEVEL

Dataset:	GLOBAL_MEAN_SEA_LEVEL
Field:	global_mean_barystatic_sea_level_anomaly
Field:	global_mean_sea_level_anomaly
Field:	global_mean_sterodynamic_sea_level_anomaly

18.3.1 1D Variable global_mean_barystatic_sea_level_anomaly

Table 18.4: CDL description of GLOBAL_MEAN_SEA_LEVEL's global_mean_barystatic_sea_level_anomaly variable

Storage Type	Variable Name	Description	Unit
float32	global_mean_barystatic_sea_level_anomaly	Global mean of barystatic sea level anomaly	m
CDL Description			
float32 global_mean_barystatic_sea_level_anomaly(time) global_mean_barystatic_sea_level_anomaly: _FillValue = 9.96921e+36 global_mean_barystatic_sea_level_anomaly: coverage_content_type = modelResult global_mean_barystatic_sea_level_anomaly: long_name = Global mean of barystatic sea level anomaly global_mean_barystatic_sea_level_anomaly: standard_name = global_mean_barystatic_sea_level_anomaly: units = m global_mean_barystatic_sea_level_anomaly: valid_min = : 0.045110904 global_mean_barystatic_sea_level_anomaly: valid_max = 0.043493364 global_mean_barystatic_sea_level_anomaly: coordinates = time			
Comments			
Global mean barystatic sea level anomaly due to changes in total ocean mass. Note: ECCOv4 uses a volume-conserving Boussinesq formulation of the MITgcm with a free-surface boundary condition with real freshwater flux forcing. Changes in ocean mass due to evaporation, precipitation, runoff, and sea-ice growth/melt are reflected in model sea level. However, as a consequence of the Boussinsq formulation, changes to seawater density due to net buoyancy fluxes (e.g., global mean surface heating/cooling) do not change model sea level anomaly (ETAN) via seawater expansion/contraction. Changes in global ocean density therefore induce a spurious change in model ocean bottom pressure (PHIBOT) via 'virtual mass fluxes'. The 'Greatbatch correction' is a time varying, globally-uniform correction to account for changes in global mean density in Boussinesq models. This correction is used to calculate dynamic sea surface height (SSH) and ocean bottom pressure (OBP). Importantly, there is no dynamical significance to the Greatbatch correction but it is required to account for steric changes in global sea level. See Greatbatch, 1994. J. of Geophys. Res. Oceans, doi.org/10.1029/94JC00847			

../images/plots/oneD_plots/Global_Mean_Sea_Level/global_mean_b

Figure 177:
Dataset: GLOBAL_MEAN_SEA_LEVEL
Variable: global_mean_barystatic_sea_level_anomaly

18.3.2 1D Variable global_mean_sea_level_anomaly

Table 18.5: CDL description of GLOBAL_MEAN_SEA_LEVEL's global_mean_sea_level_anomaly variable

Storage Type	Variable Name	Description	Unit
float32	global_mean_sea_level_anomaly	Global mean of dynamic SSH	m
CDL Description			
float32 global_mean_sea_level_anomaly(time) global_mean_sea_level_anomaly: _FillValue = 9.96921e+36 global_mean_sea_level_anomaly: coverage_content_type = modelResult global_mean_sea_level_anomaly: long_name = Global mean of dynamic SSH global_mean_sea_level_anomaly: standard_name = global_mean_sea_level_anomaly: units = m global_mean_sea_level_anomaly: valid_min = : 0.055836163 global_mean_sea_level_anomaly: valid_max = 0.05520557 global_mean_sea_level_anomaly: coordinates = time			
Comments			
Global mean of dynamic sea level anomaly, equivalent to global mean sea level change. Note: ECCOv4 uses a volume-conserving Boussinesq formulation of the MITgcm with a free-surface boundary condition with real freshwater flux forcing. Changes in ocean mass due to evaporation, precipitation, runoff, and sea-ice growth/melt are reflected in model sea level. However, as a consequence of the Boussinsq formulation, changes to seawater density due to net buoyancy fluxes (e.g., global mean surface heating/cooling) do not change model sea level anomaly (ETAN) via seawater expansion/contraction. Changes in global ocean density therefore induce a spurious change in model ocean bottom pressure (PHIBOT) via 'virtual mass fluxes'. The 'Greatbatch correction' is a time varying, globally-uniform correction to account for changes in global mean density in Boussinesq models. This correction is used to calculate dynamic sea surface height (SSH) and ocean bottom pressure (OBP). Importantly, there is no dynamical significance to the Greatbatch correction but it is required to account for steric changes in global sea level. See Greatbatch, 1994. J. of Geophys. Res. Oceans, doi.org/10.1029/94JC00847			

../images/plots/oneD_plots/Global_Mean_Sea_Level/global_mean_s

Figure 178:
Dataset: GLOBAL_MEAN_SEA_LEVEL
Variable: global_mean_sea_level_anomaly

18.3.3 1D Variable global_mean_sterodynamic_sea_level_anomaly

Table 18.6: CDL description of GLOBAL_MEAN_SEA_LEVEL's global_mean_sterodynamic_sea_level_anomaly variable

Storage Type	Variable Name	Description	Unit
float64	global_mean_sterodynamic_sea_level_anomaly	Global mean of sterodynamic sea level anomaly	m
CDL Description			
float64 global_mean_sterodynamic_sea_level_anomaly(time) global_mean_sterodynamic_sea_level_anomaly: _FillValue = 9.969209968386869e+36 global_mean_sterodynamic_sea_level_anomaly: coverage_content_type = modelResult global_mean_sterodynamic_sea_level_anomaly: long_name = Global mean of sterodynamic sea level anomaly global_mean_sterodynamic_sea_level_anomaly: standard_name = global_mean_sterodynamic_sea_level_anomaly: units = m global_mean_sterodynamic_sea_level_anomaly: valid_min = : 0.017658796143049296 global_mean_sterodynamic_sea_level_anomaly: valid_max = 0.017642477223663407 global_mean_sterodynamic_sea_level_anomaly: coordinates = time			
Comments			
Steric sea level anomaly associated with seawater expansion/contraction due to density changes. Note: ECCOv4 uses a volume-conserving Boussinesq formulation of the MITgcm with a free-surface boundary condition with real freshwater flux forcing. Changes in ocean mass due to evaporation, precipitation, runoff, and sea-ice growth/melt are reflected in model sea level. However, as a consequence of the Boussinsq formulation, changes to seawater density due to net buoyancy fluxes (e.g., global mean surface heating/cooling) do not change model sea level anomaly (ETAN) via seawater expansion/contraction. Changes in global ocean density therefore induce a spurious change in model ocean bottom pressure (PHIBOT) via 'virtual mass fluxes'. The 'Greatbatch correction' is a time varying, globally-uniform correction to account for changes in global mean density in Boussinesq models. This correction is used to calculate dynamic sea surface height (SSH) and ocean bottom pressure (OBP). Importantly, there is no dynamical significance to the Greatbatch correction but it is required to account for steric changes in global sea level. See Greatbatch, 1994. J. of Geophys. Res. Oceans, doi.org/10.1029/94JC00847			

../images/plots/oneD_plots/Global_Mean_Sea_Level/global_mean_s

Figure 179:
Dataset: GLOBAL_MEAN_SEA_LEVEL
Variable: global_mean_sterodynamic_sea_level_anomaly

18.4 1D NetCDF SBO_CORE_PRODUCTS

Table 18.7: Variables in the dataset SBO_CORE_PRODUCTS

Dataset:	SBO_CORE_PRODUCTS
Field:	xoamc
Field:	yoamc
Field:	zoamc
Field:	xoamp
Field:	yoamp
Field:	zoamp
Field:	mass
Field:	xcom
Field:	ycom
Field:	zcom
Field:	sboarea
Field:	xoamc_si
Field:	yoamc_si
Field:	zoamc_si
Field:	mass_si
Field:	xoamp_fw
Field:	yoamp_fw
Field:	zoamp_fw
Field:	mass_fw
Field:	xcom_fw
Field:	ycom_fw
Field:	zcom_fw
Field:	mass_gc
Field:	xoamp_dsl
Field:	yoamp_dsl
Field:	zoamp_dsl

18.4.1 1D Variable mass

Table 18.8: CDL description of SBO_CORE_PRODUCTS's mass variable

Storage Type	Variable Name	Description	Unit
float64	mass	ocean mass	kg
CDL Description			
float64 mass(time) mass: _FillValue = 9.969209968386869e+36 mass: coverage_content_type = modelResult mass: long_name = ocean mass mass: units = kg mass: valid_min = 1.3737507447512265e+21 mass: valid_max = 1.3737832079900274e+21 mass: coordinates = time			
Comments			
N/A			

../images/plots/oneD_plots/SBO_Core_Products/mass.png

Figure 180:
Dataset: SBO_CORE_PRODUCTS
Variable: mass

18.4.2 1D Variable mass_fw

Table 18.9: CDL description of SBO_CORE_PRODUCTS's mass_fw variable

Storage Type	Variable Name	Description	Unit
float64	mass_fw	mass due to freshwater flux	kg
CDL Description			
float64 mass_fw(time) mass_fw: _FillValue = 9.969209968386869e+36 mass_fw: coverage_content_type = modelResult mass_fw: long_name = mass due to freshwater flux mass_fw: units = kg mass_fw: valid_min = 3.7929380693921944e+16 mass_fw: valid_max = 7.0392619494226936e+16 mass_fw: coordinates = time			
Comments			
N/A			

../images/plots/oneD_plots/SBO_Core_Products/mass_fw.png

Figure 181:
Dataset: SBO_CORE_PRODUCTS
Variable: mass_fw

18.4.3 1D Variable mass_gc

Table 18.10: CDL description of SBO_CORE_PRODUCTS's mass_gc variable

<table>
<tr><th>Storage Type</th><th>Variable Name</th><th>Description</th><th>Unit</th></tr>
<tr><td>float64</td><td>mass_gc</td><td>mass due to the Greatbatch correction</td><td>kg</td></tr>
<tr><th colspan="4">CDL Description</th></tr>
<tr><td colspan="4">float64 mass_gc(time)
mass_gc: _FillValue = 9.969209968386869e+36
mass_gc: coverage_content_type = modelResult
mass_gc: long_name = mass due to the Greatbatch correction
mass_gc: units = kg
mass_gc: valid_min = : 1.140148294309558e+19
mass_gc: valid_max = : 1.1388436906537843e+19
mass_gc: coordinates = time</td></tr>
<tr><th colspan="4">Comments</th></tr>
<tr><td colspan="4">N/A</td></tr>
</table>

../images/plots/oneD_plots/SBO_Core_Products/mass_gc.png

Figure 182:
Dataset: SBO_CORE_PRODUCTS
Variable: mass_gc

18.4.4 1D Variable mass_si

Table 18.11: CDL description of SBO_CORE_PRODUCTS's mass_si variable

<table>
<tr><th>Storage Type</th><th>Variable Name</th><th>Description</th><th>Unit</th></tr>
<tr><td>float64</td><td>mass_si</td><td>sea-ice mass</td><td>kg</td></tr>
<tr><th colspan="4">CDL Description</th></tr>
<tr><td colspan="4">float64 mass_si(time)
mass_si: _FillValue = 9.969209968386869e+36
mass_si: coverage_content_type = modelResult
mass_si: long_name = sea: ice mass
mass_si: units = kg
mass_si: valid_min = 1.5801085624300974e+16
mass_si: valid_max = 3.372421224523182e+16
mass_si: coordinates = time</td></tr>
<tr><th colspan="4">Comments</th></tr>
<tr><td colspan="4">N/A</td></tr>
</table>

../images/plots/oneD_plots/SBO_Core_Products/mass_si.png

Figure 183:
Dataset: SBO_CORE_PRODUCTS
Variable: mass_si

18.4.5 1D Variable sboarea

Table 18.12: CDL description of SBO_CORE_PRODUCTS's sboarea variable

Storage Type	Variable Name	Description	Unit
float64	sboarea	surface area of oceans	m2
CDL Description			
float64 sboarea(time) sboarea: _FillValue = 9.969209968386869e+36 sboarea: coverage_content_type = modelResult sboarea: long_name = surface area of oceans sboarea: units = m2 sboarea: valid_min = 358013861149443.5 sboarea: valid_max = 358013861149443.5 sboarea: coordinates = time			
Comments			
Note: ocean surface area is constant but provided as time series for convenience			

../images/plots/oneD_plots/SBO_Core_Products/sboarea.png

**Figure 184:
Dataset: SBO_CORE_PRODUCTS
Variable: sboarea**

18.4.6 1D Variable xcom

Table 18.13: CDL description of SBO_CORE_PRODUCTS's xcom variable

Storage Type	Variable Name	Description	Unit
float64	xcom	x-comp of center-of-mass of ocean	m
CDL Description			
float64 xcom(time) xcom: _FillValue = 9.969209968386869e+36 xcom: coverage_content_type = modelResult xcom: long_name = x: comp of center: of: mass of ocean xcom: units = m xcom: valid_min = : 763730.0399730895 xcom: valid_max = : 763667.0104211655 xcom: coordinates = time			
Comments			
N/A			

../images/plots/oneD_plots/SBO_Core_Products/xcom.png

Figure 185:
Dataset: SBO_CORE_PRODUCTS
Variable: xcom

18.4.7 1D Variable xcom_fw

Table 18.14: CDL description of SBO_CORE_PRODUCTS's xcom_fw variable

Storage Type	Variable Name	Description	Unit
float64	xcom_fw	x-comp of center-of-mass of freshwater flux	m
CDL Description			
float64 xcom_fw(time) xcom_fw: _FillValue = 9.969209968386869e+36 xcom_fw: coverage_content_type = modelResult xcom_fw: long_name = x: comp of center: of: mass of freshwater flux xcom_fw: units = m xcom_fw: valid_min = : 573864.6948562702 xcom_fw: valid_max = : 573864.6948562652 xcom_fw: coordinates = time			
Comments			
N/A			

../images/plots/oneD_plots/SBO_Core_Products/xcom_fw.png

Figure 186:
Dataset: SBO_CORE_PRODUCTS
Variable: xcom_fw

18.4.8 1D Variable xoamc

Table 18.15: CDL description of SBO_CORE_PRODUCTS's xoamc variable

Storage Type	Variable Name	Description	Unit
float64	xoamc	x-comp of oceanic angular momentum due to currents	kg m2 s-1
CDL Description			
float64 xoamc(time) xoamc: _FillValue = 9.969209968386869e+36 xoamc: coverage_content_type = modelResult xoamc: long_name = x: comp of oceanic angular momentum due to currents xoamc: units = kg m2 s: 1 xoamc: valid_min = : 3.783733447704127e+24 xoamc: valid_max = 2.555331552045857e+24 xoamc: coordinates = time			
Comments			
N/A			

../images/plots/oneD_plots/SBO_Core_Products/xoamc.png

**Figure 187:
Dataset: SBO_CORE_PRODUCTS
Variable: xoamc**

18.4.9 1D Variable xoamc_si

Table 18.16: CDL description of SBO_CORE_PRODUCTS's xoamc_si variable

Storage Type	Variable Name	Description	Unit
float64	xoamc_si	x-comp of oceanic angular momentum due to sea-ice motion	kg m2 s-1

CDL Description

float64 xoamc_si(time)
xoamc_si: _FillValue = 9.969209968386869e+36
xoamc_si: coverage_content_type = modelResult
xoamc_si: long_name = x: comp of oceanic angular momentum due to sea: ice motion
xoamc_si: units = kg m2 s: 1
xoamc_si: valid_min = : 9.76342837969224e+21
xoamc_si: valid_max = 1.3721188892065168e+22
xoamc_si: coordinates = time

Comments

N/A

../images/plots/oneD_plots/SBO_Core_Products/xoamc_si.png

Figure 188:
Dataset: SBO_CORE_PRODUCTS
Variable: xoamc_si

18.4.10 1D Variable xoamp

Table 18.17: CDL description of SBO_CORE_PRODUCTS's xoamp variable

<table>
<tr><th>Storage Type</th><th>Variable Name</th><th>Description</th><th>Unit</th></tr>
<tr><td>float64</td><td>xoamp</td><td>x-comp of oceanic angular momentum due to pressure</td><td>kg m2 s-1</td></tr>
<tr><th colspan="4">CDL Description</th></tr>
<tr><td colspan="4">float64 xoamp(time)
xoamp: _FillValue = 9.969209968386869e+36
xoamp: coverage_content_type = modelResult
xoamp: long_name = x: comp of oceanic angular momentum due to pressure
xoamp: units = kg m2 s: 1
xoamp: valid_min = 1.3543642768158851e+29
xoamp: valid_max = 1.3546098666231897e+29
xoamp: coordinates = time</td></tr>
<tr><th colspan="4">Comments</th></tr>
<tr><td colspan="4">N/A</td></tr>
</table>

../images/plots/oneD_plots/SBO_Core_Products/xoamp.png

Figure 189:
Dataset: SBO_CORE_PRODUCTS
Variable: xoamp

18.4.11 1D Variable xoamp_dsl

Table 18.18: CDL description of SBO_CORE_PRODUCTS's xoamp_dsl variable

Storage Type	Variable Name	Description	Unit
float64	xoamp_dsl	x-comp of oceanic angular momentum due to pressure based on dynamic (IB-corrected) sea level	kg m2 s-1

CDL Description
float64 xoamp_dsl(time) xoamp_dsl: _FillValue = 9.969209968386869e+36 xoamp_dsl: coverage_content_type = modelResult xoamp_dsl: long_name = x: comp of oceanic angular momentum due to pressure based on dynamic (IB: corrected) sea level xoamp_dsl: units = kg m2 s: 1 xoamp_dsl: valid_min = 1.354440386439953e+29 xoamp_dsl: valid_max = 1.3545518352698056e+29 xoamp_dsl: coordinates = time
Comments
N/A

../images/plots/oneD_plots/SBO_Core_Products/xoamp_dsl.png

Figure 190:
Dataset: SBO_CORE_PRODUCTS
Variable: xoamp_dsl

18.4.12 1D Variable xoamp_fw

Table 18.19: CDL description of SBO_CORE_PRODUCTS's xoamp_fw variable

Storage Type	Variable Name	Description	Unit
float64	xoamp_fw	x-comp of oceanic angular momentum due to freshwater flux	kg m2 s-1
CDL Description			
float64 xoamp_fw(time) xoamp_fw: _FillValue = 9.969209968386869e+36 xoamp_fw: coverage_content_type = modelResult xoamp_fw: long_name = x: comp of oceanic angular momentum due to freshwater flux xoamp_fw: units = kg m2 s: 1 xoamp_fw: valid_min = 1.805799644912138e+24 xoamp_fw: valid_max = 3.351358892803656e+24 xoamp_fw: coordinates = time			
Comments			
N/A			

../images/plots/oneD_plots/SBO_Core_Products/xoamp_fw.png

Figure 191:
Dataset: SBO_CORE_PRODUCTS
Variable: xoamp_fw

18.4.13 1D Variable ycom

Table 18.20: CDL description of SBO_CORE_PRODUCTS's ycom variable

Storage Type	Variable Name	Description	Unit
float64	ycom	y-comp of center-of-mass of ocean	m
CDL Description			
float64 ycom(time) ycom: _FillValue = 9.969209968386869e+36 ycom: coverage_content_type = modelResult ycom: long_name = y: comp of center: of: mass of ocean ycom: units = m ycom: valid_min = : 466387.24450374383 ycom: valid_max = : 466327.21844756586 ycom: coordinates = time			
Comments			
N/A			

../images/plots/oneD_plots/SBO_Core_Products/ycom.png

Figure 192:
Dataset: SBO_CORE_PRODUCTS
Variable: ycom

18.4.14 1D Variable ycom_fw

Table 18.21: CDL description of SBO_CORE_PRODUCTS's ycom_fw variable

Storage Type	Variable Name	Description	Unit
float64	ycom_fw	y-comp of center-of-mass of freshwater flux	m

CDL Description

float64 ycom_fw(time)
    ycom_fw: _FillValue = 9.969209968386869e+36
    ycom_fw: coverage_content_type = modelResult
    ycom_fw: long_name = y: comp of center: of: mass of freshwater flux
    ycom_fw: units = m
    ycom_fw: valid_min = : 324750.41529212013
    ycom_fw: valid_max = : 324750.4152921157
    ycom_fw: coordinates = time

Comments

N/A

../images/plots/oneD_plots/SBO_Core_Products/ycom_fw.png

Figure 193:
Dataset: SBO_CORE_PRODUCTS
Variable: ycom_fw

18.4.15 1D Variable yoamc

Table 18.22: CDL description of SBO_CORE_PRODUCTS's yoamc variable

Storage Type	Variable Name	Description	Unit
float64	yoamc	y-comp of oceanic angular momentum due to currents	kg m2 s-1
CDL Description			
float64 yoamc(time) yoamc: _FillValue = 9.969209968386869e+36 yoamc: coverage_content_type = modelResult yoamc: long_name = y: comp of oceanic angular momentum due to currents yoamc: units = kg m2 s: 1 yoamc: valid_min = : 2.19249690136359e+24 yoamc: valid_max = 4.179441018940977e+24 yoamc: coordinates = time			
Comments			
N/A			

../images/plots/oneD_plots/SBO_Core_Products/yoamc.png

Figure 194:
Dataset: SBO_CORE_PRODUCTS
Variable: yoamc

18.4.16 1D Variable yoamc_si

Table 18.23: CDL description of SBO_CORE_PRODUCTS's yoamc_si variable

<table>
<tr><th>Storage Type</th><th>Variable Name</th><th>Description</th><th>Unit</th></tr>
<tr><td>float64</td><td>yoamc_si</td><td>y-comp of oceanic angular momentum due to sea-ice motion</td><td>kg m2 s-1</td></tr>
<tr><th colspan="4">CDL Description</th></tr>
<tr><td colspan="4">float64 yoamc_si(time)
yoamc_si: _FillValue = 9.969209968386869e+36
yoamc_si: coverage_content_type = modelResult
yoamc_si: long_name = y: comp of oceanic angular momentum due to sea: ice motion
yoamc_si: units = kg m2 s: 1
yoamc_si: valid_min = : 1.176556337395274e+22
yoamc_si: valid_max = 1.6107851446370722e+22
yoamc_si: coordinates = time</td></tr>
<tr><th colspan="4">Comments</th></tr>
<tr><td colspan="4">N/A</td></tr>
</table>

../images/plots/oneD_plots/SBO_Core_Products/yoamc_si.png

Figure 195:
Dataset: SBO_CORE_PRODUCTS
Variable: yoamc_si

18.4.17 1D Variable yoamp

Table 18.24: CDL description of SBO_CORE_PRODUCTS's yoamp variable

Storage Type	Variable Name	Description	Unit
float64	yoamp	y-comp of oceanic angular momentum due to pressure	kg m2 s-1
CDL Description			
float64 yoamp(time) yoamp: _FillValue = 9.969209968386869e+36 yoamp: coverage_content_type = modelResult yoamp: long_name = y: comp of oceanic angular momentum due to pressure yoamp: units = kg m2 s: 1 yoamp: valid_min = 1.0476388397938864e+29 yoamp: valid_max = 1.0478581623131764e+29 yoamp: coordinates = time			
Comments			
N/A			

../images/plots/oneD_plots/SBO_Core_Products/yoamp.png

Figure 196:
Dataset: SBO_CORE_PRODUCTS
Variable: yoamp

18.4.18 1D Variable yoamp_dsl

Table 18.25: CDL description of SBO_CORE_PRODUCTS's yoamp_dsl variable

Storage Type	Variable Name	Description	Unit
float64	yoamp_dsl	y-comp of oceanic angular momentum due to pressure based on dynamic (IB-corrected) sea level	kg m2 s-1

CDL Description

```
float64 yoamp_dsl(time)
    yoamp_dsl: _FillValue = 9.969209968386869e+36
    yoamp_dsl: coverage_content_type = modelResult
    yoamp_dsl: long_name = y: comp of oceanic angular momentum due to pressure based on dynamic (IB: corrected) sea level
    yoamp_dsl: units = kg m2 s: 1
    yoamp_dsl: valid_min = 1.0476994334049981e+29
    yoamp_dsl: valid_max = 1.0478187262074598e+29
    yoamp_dsl: coordinates = time
```

Comments

N/A

../images/plots/oneD_plots/SBO_Core_Products/yoamp_dsl.png

Figure 197:
Dataset: SBO_CORE_PRODUCTS
Variable: yoamp_dsl

18.4.19 1D Variable yoamp_fw

Table 18.26: CDL description of SBO_CORE_PRODUCTS's yoamp_fw variable

Storage Type	Variable Name	Description	Unit
float64	yoamp_fw	y-comp of oceanic angular momentum due to freshwater flux	kg m2 s-1
CDL Description			
float64 yoamp_fw(time) yoamp_fw: _FillValue = 9.969209968386869e+36 yoamp_fw: coverage_content_type = modelResult yoamp_fw: long_name = y: comp of oceanic angular momentum due to freshwater flux yoamp_fw: units = kg m2 s: 1 yoamp_fw: valid_min = 2.6255410225894626e+24 yoamp_fw: valid_max = 4.872705717529432e+24 yoamp_fw: coordinates = time			
Comments			
N/A			

../images/plots/oneD_plots/SBO_Core_Products/yoamp_fw.png

Figure 198:
Dataset: SBO_CORE_PRODUCTS
Variable: yoamp_fw

18.4.20 1D Variable zcom

Table 18.27: CDL description of SBO_CORE_PRODUCTS's zcom variable

<table>
<tr><th>Storage Type</th><th>Variable Name</th><th>Description</th><th>Unit</th></tr>
<tr><td>float64</td><td>zcom</td><td>z-comp of center-of-mass of ocean</td><td>m</td></tr>
<tr><th colspan="4">CDL Description</th></tr>
<tr><td colspan="4">float64 zcom(time)
zcom: _FillValue = 9.969209968386869e+36
zcom: coverage_content_type = modelResult
zcom: long_name = z: comp of center: of: mass of ocean
zcom: units = m
zcom: valid_min = : 875420.3898804963
zcom: valid_max = : 875350.3238026679
zcom: coordinates = time</td></tr>
<tr><th colspan="4">Comments</th></tr>
<tr><td colspan="4">N/A</td></tr>
</table>

../images/plots/oneD_plots/SBO_Core_Products/zcom.png

Figure 199:
Dataset: SBO_CORE_PRODUCTS
Variable: zcom

18.4.21 1D Variable zcom_fw

Table 18.28: CDL description of SBO_CORE_PRODUCTS's zcom_fw variable

Storage Type	Variable Name	Description	Unit
float64	zcom_fw	z-comp of center-of-mass of freshater flux	m

CDL Description

```
float64 zcom_fw(time)
    zcom_fw: _FillValue = 9.969209968386869e+36
    zcom_fw: coverage_content_type = modelResult
    zcom_fw: long_name = z: comp of center: of: mass of freshater flux
    zcom_fw: units = m
    zcom_fw: valid_min = : 648386.5781734617
    zcom_fw: valid_max = : 648386.5781734567
    zcom_fw: coordinates = time
```

Comments

N/A

../images/plots/oneD_plots/SBO_Core_Products/zcom_fw.png

Figure 200:
Dataset: SBO_CORE_PRODUCTS
Variable: zcom_fw

18.4.22 1D Variable zoamc

Table 18.29: CDL description of SBO_CORE_PRODUCTS's zoamc variable

Storage Type	Variable Name	Description	Unit
float64	zoamc	z-comp of oceanic angular momentum due to currents	kg m2 s-1
CDL Description			
float64 zoamc(time) zoamc: _FillValue = 9.969209968386869e+36 zoamc: coverage_content_type = modelResult zoamc: long_name = z: comp of oceanic angular momentum due to currents zoamc: units = kg m2 s: 1 zoamc: valid_min = 7.331764457927521e+24 zoamc: valid_max = 2.207264300276968e+25 zoamc: coordinates = time			
Comments			
N/A			

../images/plots/oneD_plots/SBO_Core_Products/zoamc.png

**Figure 201:
Dataset: SBO_CORE_PRODUCTS
Variable: zoamc**

18.4.23 1D Variable zoamc_si

Table 18.30: CDL description of SBO_CORE_PRODUCTS's zoamc_si variable

Storage Type	Variable Name	Description	Unit
float64	zoamc_si	z-comp of oceanic angular momentum due to sea-ice motion	kg m2 s-1

CDL Description

```
float64 zoamc_si(time)
    zoamc_si: _FillValue = 9.969209968386869e+36
    zoamc_si: coverage_content_type = modelResult
    zoamc_si: long_name = z: comp of oceanic angular momentum due to sea: ice motion
    zoamc_si: units = kg m2 s: 1
    zoamc_si: valid_min = : 5.909426721868294e+21
    zoamc_si: valid_max = 5.930388258256482e+21
    zoamc_si: coordinates = time
```

Comments

N/A

../images/plots/oneD_plots/SBO_Core_Products/zoamc_si.png

Figure 202:
Dataset: SBO_CORE_PRODUCTS
Variable: zoamc_si

18.4.24 1D Variable zoamp

Table 18.31: CDL description of SBO_CORE_PRODUCTS's zoamp variable

Storage Type	Variable Name	Description	Unit
float64	zoamp	z-comp of oceanic angular momentum due to pressure	kg m2 s-1

CDL Description

```
float64 zoamp(time)
    zoamp: _FillValue = 9.969209968386869e+36
    zoamp: coverage_content_type = modelResult
    zoamp: long_name = z: comp of oceanic angular momentum due to pressure
    zoamp: units = kg m2 s: 1
    zoamp: valid_min = 2.927645942668479e+30
    zoamp: valid_max = 2.9277200254389854e+30
    zoamp: coordinates = time
```

Comments

N/A

../images/plots/oneD_plots/SBO_Core_Products/zoamp.png

Figure 203:
Dataset: SBO_CORE_PRODUCTS
Variable: zoamp

18.4.25 1D Variable zoamp_dsl

Table 18.32: CDL description of SBO_CORE_PRODUCTS's zoamp_dsl variable

<table>
<tr><th>Storage Type</th><th>Variable Name</th><th>Description</th><th>Unit</th></tr>
<tr><td>float64</td><td>zoamp_dsl</td><td>z-comp of oceanic angular momentum due to pressure based on dynamic (IB-corrected) sea level</td><td>kg m2 s-1</td></tr>
<tr><th colspan="4">CDL Description</th></tr>
<tr><td colspan="4">float64 zoamp_dsl(time)
zoamp_dsl: _FillValue = 9.969209968386869e+36
zoamp_dsl: coverage_content_type = modelResult
zoamp_dsl: long_name = z: comp of oceanic angular momentum due to pressure based on dynamic (IB: corrected) sea level
zoamp_dsl: units = kg m2 s: 1
zoamp_dsl: valid_min = 2.9276609546728614e+30
zoamp_dsl: valid_max = 2.9277328440911863e+30
zoamp_dsl: coordinates = time</td></tr>
<tr><th colspan="4">Comments</th></tr>
<tr><td colspan="4">N/A</td></tr>
</table>

../images/plots/oneD_plots/SBO_Core_Products/zoamp_dsl.png

Figure 204:
Dataset: SBO_CORE_PRODUCTS
Variable: zoamp_dsl

18.4.26 1D Variable zoamp_fw

Table 18.33: CDL description of SBO_CORE_PRODUCTS's zoamp_fw variable

<table>
<tr><th>Storage Type</th><th>Variable Name</th><th>Description</th><th>Unit</th></tr>
<tr><td>float64</td><td>zoamp_fw</td><td>z-comp of oceanic angular momentum due to freshwater flux</td><td>kg m2 s-1</td></tr>
<tr><th colspan="4">CDL Description</th></tr>
<tr><td colspan="4">float64 zoamp_fw(time)
zoamp_fw: _FillValue = 9.969209968386869e+36
zoamp_fw: coverage_content_type = modelResult
zoamp_fw: long_name = z: comp of oceanic angular momentum due to freshwater flux
zoamp_fw: units = kg m2 s: 1
zoamp_fw: valid_min = 7.774584605728723e+25
zoamp_fw: valid_max = 1.442874536478883e+26
zoamp_fw: coordinates = time</td></tr>
<tr><th colspan="4">Comments</th></tr>
<tr><td colspan="4">N/A</td></tr>
</table>

../images/plots/oneD_plots/SBO_Core_Products/zoamp_fw.png

Figure 205:
Dataset: SBO_CORE_PRODUCTS
Variable: zoamp_fw

19 ECCO Metadata Specification

19.1 Overview Description of the ECCO Metadata Model

The GHRSST data are global collections compiled by scientists and data production systems in many countries, so the ISO 19115-2 International Geographic Metadata Standard (extensions for imagery and gridded data) has been adopted as the standard for GDS 2.0 metadata. This standard provides a structured way to manage not just the data usage and granule-level discovery metadata provided by the CF metadata in the GHRSST netCDF files, but also collection-level discovery, data quality, lineage, and other information needed for long-term stewardship and necessary metadata management. The GHRSST GDAC and LTSRF work with individual RDACs to create and maintain the collection-level ISO record for each of their datasets (one collection level record for each product line). The collection level record will be combined by the GDAC with metadata embedded in the netCDF-4 files preferred by the GDS 2.0. In the event that an RDAC chooses to produce netCDF-3 files instead of netCDF-4, they must also create a separate XML metadata record for each granule (following the GDS 1.6 specification detail in [RD-1]). RDACs will assist with maintaining the collection portion of the ISO metadata record and will update it on an as-needed basis. This approach ensures that for every L2P, L3, L4, or GMPE granule that is generated, appropriate ISO metadata can be registered at the GHRSST Master Metadata Repository (MMR) system. Details of this approach are provided in Section 13.3 after a brief description of the heritage GDS 1.0 metadata approach.

19.2 Evolution from the GHRSST GDS 1.0 Metadata Model

The GDS 1.6 specification metadata model ([RD-1]) contained three distinct metadata records. The Data Set Descriptions (DSD) included metadata that provided an overall description of a GHRSST product, including discovery and distribution. These metadata changed infrequently and were termed collection level metadata. The File Records (FR) contained metadata that describe a single data file or granule (traditionally called granule metadata). Finally there was also granule metadata captured in the CF attributes of a netCDF3 file. Under the new GDS 2.0 initial GHRSST 2.0 Metadata Model, all three types of metadata are leveraged into a single ISO-compliant metadata file as shown in Figure 13-2. Future revisions of the GDS 2.0 will incorporate more of the ISO metadata capabilities.

19.3 The ISO 19115-2 Metadata Model

The ISO metadata model is made up of a set of containers (also referred to as classes or objects) that contain metadata elements or other objects that, in turn, contain other elements or objects (see Figure 13-1 and Table 13-1). The root element is MI_Metadata1 [1] . It contains twelve major classes that document various aspects of the resource (series or dataset) being described. The MD_DataIdentification object contains other major classes that also describe various aspects of the dataset.

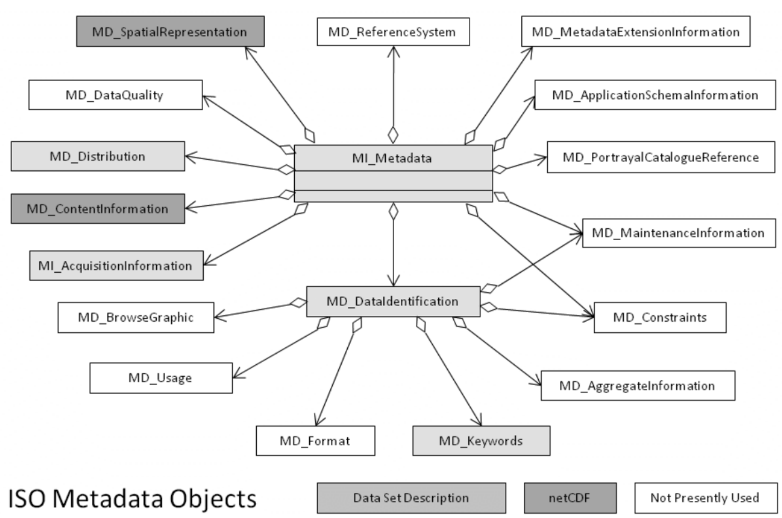

Figure 206: ISO Metadata Objects and their sources

[1]The ISO Standard for Geographic Data has two parts. ISO 19115 is the base standard. ISO 19115-2 includes 19115 and adds extensions for images and gridded data. We will use both parts in this model and refer to the standard used as 19115-2.

Table 19.1: Major ISO Objects. Objects in use in the GHRSST metadata model are shaded in gray.

ISO Object	Explanation
MI_Metadata	Root element that contains information about the metadata itself.
MI_AcquisitionInformation	Information about instruments, platforms, operations and other element of data acquisition.
MD_ContentInformation	Information about the physical parameters and other attributes contained in a resource.
MD_Distribution	Information about who makes a resource available and how to get it.
MD_DataQuality	Information about the quality and lineage of a resource.
MD_SpatialRepresentation	Information about the geospatial representation of a resource.
MD_ReferenceSystem	Information about the spatial and temporal reference systems used in the resource.
MD_MetadataExtensionInformation	Information about user specified extensions to the metadata standard used to describe the resource.
MD_ApplicationSchemaInformation	Information about the application schema used to build a dataset (not presently used for GHRSST metadata).
MD_PortrayalCatalogueReference	Information identifying portrayal catalogues used for the resource (not presently used for GHRSST metadata).
MD_MaintenanceInformation	Information about maintenance of the metadata and the resource it describes.
MD_Constraints	Information about constraints on the use of the metadata and the resource it describes.
MD_DataIdentification	Information about constraints on the use of the metadata and the resource it describes.
MD_AggregateInformation	Information about groups that the resource belongs to.
MD_Keywords	Information about discipline, themes, locations, and times included in the resource.
MD_Format	Information about formats that the resource is available in.
MD_Usage	Information about how the resource has been used and identified limitations.
MD_BrowseGraphic	Information about graphical representations of the resource.

MI_Metadata objects can be aggregated into several kinds of series that include metadata describing particular elements of the series, termed dataset metadata, as well as metadata describing the entire series (i.e. series or collection metadata). Unlike the GDS 1.0 Metadata Model, the ISO-based GDS 2.0 model combines both collection level and granule level metadata into a single XML file. The initial approach will be to extract and translate granule metadata from netCDF-4 CF attributes in conjunction with collection level metadata from existing GDS 1.0 compliant DSD records. In the case of a data producer providing a netCDF-3 granule, an additional FR metadata record **must** still be provided (see GDS 1.6 for details on the format of the FR metadata records). The flow of metadata production is described below in two scenarios:

Existing GDS 1.0 GHRSST products

1. Generate ISO collection level metadata from existing GDS 1.0 DSD records
2. Generate ISO granule level metadata from CF attributes embedded in a GDS 2.0 specification netCDF4 granule
3. Combine 1 and 2 into a complete GDS 2.0 ISO 19115-2 record
4. If the granule is GDS 1.0 netCDF3 format the RDAC must provide a File Record

GDS 2.0 GHRSST products

1. Use existing ISO collection level metadata. RDACs will provide the initial metadata record from a template.
2. Generate ISO granule level metadata from CF attributes embedded in a GDS 2.0 specification netCDF4 granule
3. Combine 1 and 2 into a complete GDS 2.0 ISO 19115-2 record

In both cases, the GDAC has the primary role to create the ISO metadata records in steps 1-3. A RDAC can also choose to do steps 1-3, or maintain only the collection level portion.

A diagram of the production approach is shown in Figure 13-2. The root element for the combined file is DS_Series which includes dataset and series metadata. Dataset metadata will be constructed using metadata extracted from the netCDF-4 CF attributes (or a FR record if the file is in netCDF3 format). Series Metadata will be constructed with information from (initially) the DSD or the collection level portion of an existing GDS 2.0 specification ISO record.

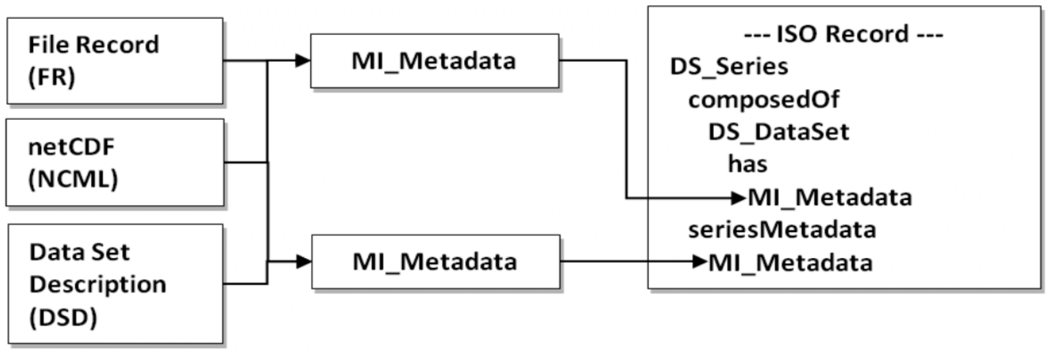

Figure 207: Initial GHRSST Metadata Translation Approach to ISO record

To see the comprehensive details of the GHRSST GDS 2.0 metadata model refer to the GDS 2.0 Metadata Specification documents and example at the GDAC (`http://ghrsst.jpl.nasa.gov`).

20 GDS 2.0 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.

20.1 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.

20.2 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

20.3 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

20.4 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.

20.5 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

20.6 GDS Document Publication

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

20.7 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.

20.8 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 BookCaptain before publication.

20.9 Document retrieval

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

20.10 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.

20.11 Retention and long term archive

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

20.12 Document workflow

1. Each GDS document shall be owned and administered by a document Book Captain.
2. A GDS BookCaptain 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.

20.13 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.

How to 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)	`http://ghrsst.jpl.nasa.gov`
GHRSST LTSRF (Archive)	`http://ghrsst.nodc.noaa.gov`
GHRSST HRDDS (diagnostics)	`http://www.hrdds.net`
GHRSST MDB (validation)	`http://www.ifremer.fr/matchupdb`
GHRSST GMPE (L4 ensembles)	`http://ghrsst-pp.metoffice.com/pages/latest\_analysis/sst\_monitor/daily/ens/index.html`
GHRSST data discovery	`http://ghrsst.jpl.nasa.gov/data\_search.html`
GHRSST data visualisation (EU)	`http://www.naiad.fr`
GHRSST data visualisation (USA)	`http://podaac-tools.jpl.nasa.gov/dataminer/`

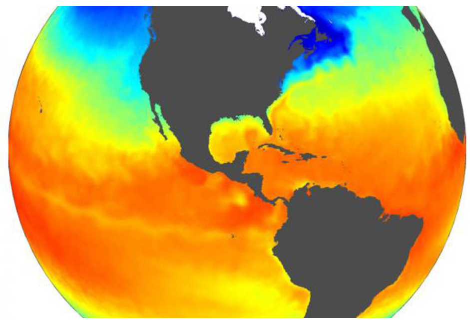

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Table 12.3: GHRSST Processing Level Conventions and Codes

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	Preprocessed 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		