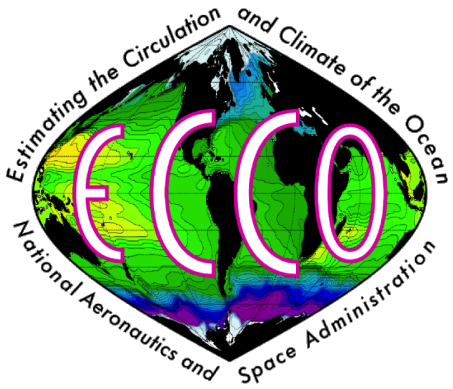

The ECCO V4r4 Dataset Catalog and Variable Compendium

The ECCO Team (2025)

May 2025

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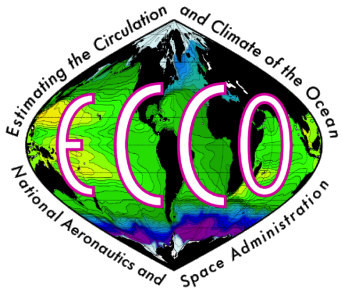
Estimating the Circulation and Climate of the Ocean
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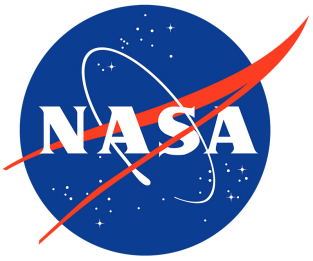
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2 Executive Summary

The ECCO Version 4 Release 4 (V4r4) products are comprehensive global ocean and sea-ice state estimates spanning from 1992 to 2018. These datasets are dynamically and kinematically consistent reconstructions of the three-dimensional, time-evolving ocean, sea-ice, and surface atmospheric states. They include a wide range of variables such as temperature, salinity, velocity, sea level anomalies, and fluxes (e.g., heat, freshwater, and salt). The data are available at daily, monthly, and instantaneous intervals on both the high-resolution LLC90 grid and a 0.5-degree interpolated grid. The datasets adhere to modern metadata standards and are formatted in netCDF-4 (and may be available in other data format such as Zarr data format) for accessibility via NASA's Earthdata Cloud infrastructure (PO.DAAC-NASA).

The key features of ECCO V4r4 include its ability to assimilate diverse observational datasets from satellites and in situ measurements using the MIT general circulation model (MITgcm). This allows for accurate representation of global ocean dynamics and climate processes. The release also introduces advanced cloud-native services for efficient data access and processing. These products are essential for studying ocean circulation, climate variability, sea-level changes, and freshwater fluxes on a global scale.

This user guide document first provides the scope and the key overall content of the present document, then an overview of ECCO data products (Level 4) followed by detailed technical specifications of dataset filename, file structure and supporting configuration. Finaly, a full description of grid geometry, the coordinates and the data variables for both native lat-lon-cap 90 (llc90), latlon 0.5-degree and 1D datasets are provided with example of each of them.

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6 Scope and Content of this Document

This document has been developed to provide guidance to ECCO V4r4 data users for easily navigating the list of available datasets. It offers an overview of the ECCO V4r4 datasets, including the data storage format, filename conventions, supporting metadata conventions, and the structure of data product files.
Descriptions are provided for NetCDF data files, including global attributes, dimensions, coordinates, and variable metadata. Additionally, detailed descriptions are included for each ECCO V4r4 dataset: the native Lat-Lon-Cap 90 (LLC90) grid, the regular 0.5-degree latitude-longitude grid, and the one-dimensional dataset. Grid geometry details are also provided for both the native LLC90 grid and the 0.5-degree latitude-longitude grid configurations. Illustrative figures accompany each section to enhance understanding.

7 Overview of ECCO Data

ECCO (Estimating the Circulation and Climate of the Ocean) is a NASA-led initiative creating detailed, physically consistent reconstructions of Earth's ocean and sea-ice systems since 1992. Its version 4 release 4 (V4r4) represents the most advanced synthesis of satellite data, in-situ measurements (like Argo floats), and MIT's ocean/sea-ice model to produce a "digital replica" of marine environments. Unlike conventional ocean models, ECCO strictly adheres to conservation laws of physics while assimilating billions of observations. Indeed, the ECCO V4r4 data products provide a dynamically and kinematically consistent global reconstruction of the ocean, sea-ice, and surface atmospheric states from 1992 to 2018. These datasets include daily, monthly, and instantaneous time intervals and are available on two primary grids: the native Lat-Lon-Cap 90 (LLC90) grid and a 0.5°latitude-longitude interpolated grid.

The LLC90 grid is a curvilinear Cartesian grid with five faces, including a latitude-longitude grid between 70°S and 57°N and an Arctic cap. It features varying resolutions (22–110 km horizontally) and 50 vertical levels, with finer resolution at higher latitudes. The LLC90 grid configurations offer a unique cubed-sphere design in the northern hemisphere and a dipolar arrangement in the southern hemisphere, with an Arctic "cap" north of 57°N. Its geometry includes 13 tiles of 90x90 cells each, with detailed geometric parameters like cell areas, side lengths, rotation angles, bathymetry, and land/ocean masks. This design enables accurate modeling of global ocean dynamics while accommodating complex geometries like the Arctic cap. The interpolated grid (0.5°latitude-longitude grid) offers user-friendly access for daily or monthly averages, but is less suitable for budget closure analyses. The datasets cover a wide range of parameters, such as temperature, salinity, velocity, fluxes, sea level anomalies, and sea-ice properties.

The V4r4 data are formatted in netCDF-4 and adhere to CF 1.8 and ACDD 1.3 metadata standards. Accessible through NASA's Earthdata Cloud infrastructure, these datasets are optimized for cloud-native workflows via APIs like Harmony for conversion to formats like Zarr. This comprehensive framework supports diverse applications in oceanography, climate studies, and Earth system modeling. Note that NASA's Earthdata enables efficient access of the ECCO V4r4 via HTTPS or AWS S3 services.

7.1 Why trust ECCO?

The ECCO ocean and sea-ice state estimation system is a mathematically rigorous, mature, state-of-the-art data tool for synthesizing NASA's diverse Earth system observations – especially remote sensing data – into a complete and physically-consistent description of the three-dimensional time-varying global ocean and sea-ice state. So,

ECCO:

- Eliminates Unrealistic "Jumps" in Data
- Can Be Run Forward & Backwards
- Is Constrained by Billions of Data Points
- Fills in the Gaps of Sparse Ocean Database
- Provides a "Climate Change Assessment" Toolkit
- Helps Understand Impacts on Ocean Ecosystems
- Reveals Coastal Transformation in Our Warming Climate

7.2 Why Choose ECCO Over Alternatives?

ECCO's cloud-native architecture allows direct access to 3TB+ data via NASA Earthdata Cloud, with tools for format conversion and subsetting. This makes it uniquely suited for researchers needing physically rigorous, observationally grounded reconstructions of ocean-climate interactions.

Feature	ECCO Advantage
Physical Consistency	Perfectly satisfies thermodynamics laws vs. statistical approximations in traditional reanalyses
Time Flexibility	Can analyze causes/effects backward/forward in time (e.g., tracing sea level rise origins)
Data Integration	Synthesizes 300M+ satellite observations and 1B+ in-situ measurements into unified framework
Application Range	Used for climate studies, marine biology (habitat modeling), coastal flood prediction, and sensor placement optimization

8 ECCO Data Filenames and Supporting Conventions

ECCO Version 4 Release 4 (V4r4) follows a structured filename convention to organize its extensive datasets. The filenames encode essential information about the dataset's content, grid type, temporal resolution, and version. Below is an overview of the naming convention.

8.1 General filename Structure

For ECCO dataset product files:

```
[ShortName]_[TemporalResolution]_[Indicative Time]_ECCO_[Version]_[GridType].<File Type>
```

For ECCO data geometry and grid files:

```
[ShortName]_ECCO_[Version]_[GridType].<File Type>
```

Keypoins	Description
ShortName:	Describes the dataset variable (e.g., SSH for sea surface height, TEMP_SALINITY for temperature and salinity).
TemporalResolution:	Indicates the time averaging or snapshot type (e.g., DAILY, MONTHLY, SNAP).
GridType :	Specifies the grid used (e.g., **native_llc90** for the native ECCO grid or **laton_0p50deg** for interpolated 0.5 °lat-lon grid). It can also be a specific information such as **1D** to indication the one-dimentional dataset files over the full period of ECCO data availability.
Version:	Identifies the ECCO release version (e.g., V4r4).
Indicative Time:	Encodes the time period covered by the file (e.g., monthly files use YYYY-MM, daily files use YYYY-MM-DD)
File Type	netCDF or Zarr data format.

8.2 Examples

Daily atmosphere surface temperature, humidity, winds, and pressure on the lat-lon-cap 90 (llc90) native model grid (first) and on the interpolated regular 0.5-degree lat-lon grid (second) from ECCO V4r4 on 2017-12-29.

- ATM_SURFACE_TEMP_HUM_WIND_PRES_day_mean_2017-12-29_ECCO_V4r4_native_llc0090.nc
- ATM_SURFACE_TEMP_HUM_WIND_PRES_day_mean_2017-12-29_ECCO_V4r4_latlon_0p50deg.nc

Dynamic sea surface height interpolated on the latlon regular 0.5-degree model grid from ECCO V4r4 on 2017-12-29.

- SEA_SURFACE_HEIGHT_day_mean_2017-12-29_ECCO_V4r4_native_llc0090.nc

One-dimentional field of global mean atmospheric surface pressure over the ocean and sea-ice fromthe ECCO V4r4.

- GLOBAL_MEAN_ATM_SURFACE_PRES_snap_ECCO_V4r4_1D.nc

Geometric parameters for the regular 0.5-degree lat-lon grid from ECCO V4r4.

- GRID_GEOMETRY_ECCO_V4r4_latlon_0p50deg.nc

9 ECCO Data Product File Structure

9.1 Overview of the ECCO Data netCDF File Format

ECCO data files preferentially use the **netCDF-4** format. These ECCO formatted data comply with the Climate and Forecast (CF) Conventions, 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) 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, ECCO formatted files follow some of the recommendations of the Unidata Attribute Convention for Dataset Discovery.

In the context of netCDF, a variable refers to data stored in the file as a vector or as a multidimensional array. 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 has its own attributes, referred to as variable attributes. These variable attributes define, for example, an axis, long_name, standard_name, units, a descriptive version of the variable name, and a fill value (if apply), which is used to indicate array elements that do not contain valid data.

Overall, the ECCO netCDF files are structured in five (5) blocks:

- Dimensions
- Coordinates (non-dimension coordinate)
- Data variables
- Global Attributes

9.2 ECCO netCFD Global Attributes

The globale attributes used in the ECCO V4r4 data netCDF files are listed in the table below.

Table 9.1: Global Attributes used in ECCO V4r4 data netCDF files

Attribute Name	Format	Description	Source
Conventions	string	A text string identifying the netCDF conventions followed. This attribute should be set to the version of CF used and should also include the ACDD. For example: 'CF-1.4, Unidata Observation Dataset v1.0'.	CF
acknowledgement	string	Information about funding source and how to cite the use of these data.	ACDD
author	TBD	TBD	TBD
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. For ECCO, it is 'grid'.	ACDD
comment	string	Miscellaneous information about the data or methods used to produce it.	CF, ACDD

Table 9.1: Global Attributes used in ECCO V4r4 data netCDF files

coordinates_comment	TBD	TBD	TBD
creator_email	string	Provide an email address for the most relevant point of contact at the producing RDAC relevant to this data set.	ACDD
creator_institution	TBD	TBD	TBD
creator_name	string	Provide a name for the most relevant point of contact at the producing RDAC relevant to this data set.	ACDD
creator_type	TBD	TBD	TBD
creator_url	string	Provide a URL address relevant to this data set.	ACDD
date_created	string	The date and time the data file was created in the form "YYYY-MM-DDThh:mm:ssZ". This time format is ISO 8601 compliant.	ACDD
date_issued	TBD	TBD	TBD
date_metadata_modified	TBD	TBD	TBD
date_modified	TBD	TBD	TBD
geospatial_bounds_crs	TBD	TBD	TBD
geospatial_lat_max	TBD	TBD	TBD
geospatial_lat_min	TBD	TBD	TBD
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_max	TBD	TBD	TBD
geospatial_lon_min	TBD	TBD	TBD
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
geospatial_vertical_max	TBD	TBD	TBD
geospatial_vertical_min	TBD	TBD	TBD
geospatial_vertical_positive	TBD	TBD	TBD
geospatial_vertical_resolution	TBD	TBD	TBD
geospatial_vertical_units	TBD	TBD	TBD
history	string	History of all applications that have modified the original data to create this file.	CF, ACDD
id	string	The unique ECCO character string for this product.	ACDD
institution	string	ECCO code or institution where the data were produced.	CF, ACDD
instrument_vocabulary	TBD	TBD	TBD
keywords	string	A comma-separated list of key words and/or phrases	ACDD
keywords_vocabulary	string	Unique name or identifier of the vocabulary from which keywords are taken. f more than one keyword vocabulary is used, each may be presented with a prefix and a following comma, so that keywords may optionally be prefixed with the controlled vocabulary key.	ACDD
license	string	Provide the URL to a standard or specific license, enter 'Public Domain', 'Freely Distributed' or 'None', or describe any restrictions to data access and distribution in free text	ACDD
metadata_link	string	Link to collection metadata record at archive	ACDD
naming_authority	string	The organization that provides the initial 'id' for the dataset. The naming authority is uniquely specified by this attribute	ACDD

Table 9.1: Global Attributes used in ECCO V4r4 data netCDF files

platform	string	Satellite(s) used to create this data file. Select from the entries found in the Satellite Platform and provide as a comma separated list if there is more than one.	GDS
platform_vocabulary	TBD	TBD	TBD
processing_level	string	A textual description of the processing (or quality control) level of the data. For ECCO, it is level 4 (L4)	ACDD, GDS
product_name	TBD	TBD	TBD
product_time_coverage_end	TBD	TBD	TBD
product_time_coverage_start	TBD	TBD	TBD
product_version	string	The product version of this data file, which may be different than the file version used in the file naming convention	GDS
program	TBD	TBD	TBD
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. For ECCO, it is: podaac@podaac.jpl.nasa.gov	ACDD
publisher_institution	TBD	TBD	TBD
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_type	TBD	TBD	TBD
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. For ECCO, it is : https://podaac.jpl.nasa.gov	ACDD
references	string	Published or web-based references that describe the data or methods used to produce it.	CF
source	string	Comma separated list of all source data present in this file. Provides the method of production of the original data in detail with the model and its version, as specifically as could be useful.	CF
standard_name_vocabulary	string	The name and version of the controlled vocabulary from which variable standard names are taken. Values for any standard_name attribute must come from the CF Standard Names vocabulary for the data file or product to comply with CF.	ACDD
summary	string	A paragraph describing the dataset.	ACDD
time_coverage_duration	TBD	TBD	TBD
time_coverage_end	string	Identical to 'stop_time'. Included for increased ACDD compliance.	ACDD
time_coverage_resolution	TBD	TBD	TBD
time_coverage_start	string	Identical to 'start_time'. Included for increased ACDD compliance.	ACDD
title	string	A descriptive title for the ECCO data set	CF, ACDD

Table 9.1: Global Attributes used in ECCO V4r4 data netCDF 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_I dentifier for more information and tools.	ACDD

9.3 ECCO Data netCFD Coordinates, Dimensions and Variabiles Attributes

The attributes of the ECCO V4r4 data Coordinates, Dimensions and Variabiles used in the netCDF files are listed in the table below.

Table 9.2: Coordinates, Dimensions and Variables Attributes used in ECCO V4r4 data netCDF files

Attribute Name	Format	Description	Source
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.	CF
bounds	TBD	TBD	TBD
c_grid_axis_shift	TBD	TBD	TBD
comment	string	Miscellaneous information about the variable or the methods used to produce it.	CF
coordinate	TBD	TBD	TBD
coverage_content_type	TBD	TBD	TBD
direction	TBD	TBD	TBD
long_name	string	A free-text descriptive variable name.	CF, ACDD
mate	TBD	TBD	TBD
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'.	CF
standard_name	string	Provides a standard and unique description of a physical quantity. The standard name table can be found at http://cfpcmdi.llnl.gov/documents/cf-standard-names/standard-name-table/11/standard-name-table.	CF, ACDD
swap_dim	TBD	TBD	TBD
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
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 9.2: Coordinates, Dimensions and Variables Attributes used in ECCO V4r4 data netCDF files

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

9.4 ECCO Data netCDF Dimensions definition

From the Climate and Forecast (CF) metadata conventions, the dimensions of the variable define the axes of the quantity it contains. Dimensions other than those of space and time may be included. Across all ot the ECCO V4r4 data netCDF files, at least 12 dimensions can be identified (see table below). Note that **nv** is not a spatial or temporal dimension per se. It is a kind of dummy dimension of length 2 for the coordiante **time_bnds** which has both a starting and ending time for each one averaging period. The same is true of **nb** which has length 4 and is used by **XC_bnds** and **YC_bnds** to store coordinates for the 4 corners of each tracer grid cell (more details in the followings sections).

Table 9.3: Dimensions used in used in ECCO V4r4 data netCDF files

Name	Length	Description
i	90	grid index in x for variables at tracer and 'v' locations
i_g	90	grid index in x for variables at 'u' and 'g' locations
j	90	grid index in y for variables at tracer and 'u' locations
j_g	90	grid index in y for variables at 'v' and 'g' locations
k	50	grid index in z for tracer variables
k_u	50	grid index in z corresponding to the bottom face of tracer grid cells ('w' locations)
k_l	50	grid index in z corresponding to the top face of tracer grid cells ('w' locations)
k_p1	51	grid index in z for variables at 'w' locations
tile	13	lat-lon-cap tile index
nb	4	It is a kind of dummy dimension of length 4 and is used by XC_bnds and YC_bnds to store coordinates for the 4 corners of each tracer grid cell.
nv	2	It is a kind of dummy dimension of length 2 for the coordiante time_bnds which has both a starting and ending time for each one averaging period.
time	Depend on the data frequence: SANP, AVG_DAY or AVG_MON	indicates the center time of the averaging period
latitude	360	latitude at grid cell center
longitude	720	longitude at grid cell center
Z	50	depth of grid cell center

Nate that (i, j, k, tile, time) are centered dimension coordinates while i_g, j_g, k_l and k_u are not centered.

9.5 ECCO Data netCDF Coordinates variabile definition

The so-called non-dimension coordinates: i- are variables that (may) contain coordinate data, but are not a dimension coordinate; ii- they can be multidimensional and there is no relationship between the name of a non-

dimension coordinate and the name(s) of its dimension(s); iii- can be useful for indexing or plotting ... Table below provides a list of unique coordinates used in ECCO V4r4 data.

Table 9.4: Coordinates used in used in ECCO V4r4 data netCDF files

Name	Dims	Description	Units
XC	('tile', 'j', 'i')	longitude of tracer grid cell center	degrees_east
YC	('tile', 'j', 'i')	latitude of tracer grid cell center	degrees_north
XG	('tile', 'j_g', 'i_g')	longitude of 'southwest' corner of tracer grid cell	degrees_east
YG	('tile', 'j_g', 'i_g')	latitude of 'southwest' corner of tracer grid cell	degrees_north
Zp1	('k_p1',)	depth of tracer grid cell interface	m
Zu	('k_u',)	depth of the bottom face of tracer grid cells	m
Zl	('k_l',)	depth of the top face of tracer grid cells	m
XC_bnds	('tile', 'j', 'i', 'nb')	longitudes of tracer grid cell corners	–none–
YC_bnds	('tile', 'j', 'i', 'nb')	latitudes of tracer grid cell corners	–none–
Z_bnds	('Z', 'nv')	depths of grid cell upper and lower interfaces	–none–
time_bnds	('time', 'nv')	time bounds of averaging period	–none–
latitude_bnds	('latitude', 'nv')	latitudes of grid cell edges	–none–
longitude_bnds	('longitude', 'nv')	longitudes of grid cell edges	–none–

Regular latitude/logitude grids

This is for the regular interpolated latlon grid of the ECCO V4r4 dataset geographic localization of each variabile. On such a projection, only two coordinate variables are requested and they are stored as vector arrays. Longitudes range from -180 to +180, corresponding to 180 degrees West to 180 degrees East. Latitudes range from -90 to +90, corresponding to 90 degrees South to 90 degrees North. See example of CDL display in the table below.

Non-regular latitude/longitude grids

The ECCO V4r4 uses the Lat-Lon-Cap 90 (LLC90) grid, a native specialized global grid designed for ocean and sea-ice modeling. The LLC90 grid divides the globe into five faces, with dimensions: 1- [90x270], 2- [90x270], 3- [90x90], 4- [270x90], and 5- [270x90]. Each face consists of 90x90 tiles, hence the name LLC90. LLC90 grid combines a latitude-longitude grid between 70°S and 57°N with an Arctic "cap" in the northern hemisphere to handle polar regions effectively. The horizontal resolution varies spatially from about 22 km in high latitudes to 110 km in mid-latitudes. Redarding the vertical and horizontal resolutions, the grid has 50 vertical levels, with spacing increasing from 10 m near the surface to 457 m near the ocean bottom, which is set at a maximum depth of 6145 m. The Cartesian coordinates (x, y) are locally oriented within each tile, which may differ from traditional longitude-latitude directions. Diagnostic outputs include both native (UVEL, VVEL) and conventional (EVEL, NVEL) velocity components for ease of analysis. The datasets include geometric details such as cell areas, side lengths, rotation angles, bathymetry, and land/ocean masks. LLC90 grid geometric parameters are essential for accurate modeling and budget calculations. The LLC90 grid is particularly suited for global ocean circulation studies due to its efficient handling of polar regions and its variable resolution that balances computational efficiency with detail where needed.

9.6 Example of ECCO V4r4 netCDF latlon grid datasets

Table 9.5: 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" 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 MXLDEPTH (time, latitude, longitude) MXLDEPTH:_FillValue = "9.969209968386869e+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"

Table 9.5: Example CDL description of latlon dataset

MXLDEPTH:comment = "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)."
MXLDEPTH:coordinates = "time"
MXLDEPTH:valid_min = "5.000001430511475"
MXLDEPTH:valid_max = "5331.2001953125"

9.7 Example of ECCO V4r4 netCDF native llc90 grid datasets

Table 9.6: 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 nb = 4 nv = 2
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" 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"

Table 9.6: Example CDL description of native dataset

```
    int32 k_u (k_u)
        k_u:axis = "Z"
        k_u:long_name = "grid index in z corresponding to the bottom face of tracer grid cells ('w' locations)"
        k_u:c_grid_axis_shift = "0.5"
        k_u:swap_dim = "Zu"
        k_u:comment = "First index corresponds to the bottom face of the uppermost tracer grid cell. The use of 'u'
in the variable name follows the MITgcm convention for naming the bottom face of ocean tracer grid cells."
        k_u:coverage_content_type = "coordinate"
    int32 k_l (k_l)
        k_l:axis = "Z"
        k_l:long_name = "grid index in z corresponding to the top face of tracer grid cells ('w' locations)"
        k_l:c_grid_axis_shift = "-0.5"
        k_l:swap_dim = "Zl"
        k_l:comment = "First index corresponds to the top face of the uppermost tracer grid cell.  The use of 'l' in
the variable name follows the MITgcm convention for naming the top face of ocean tracer grid cells."
        k_l:coverage_content_type = "coordinate"
    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"
    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"
```

Table 9.6: Example CDL description of native dataset

```
    float32 YG (tile, j_g, i_g)
        YG:long_name = "latitude of 'southwest' corner of tracer grid cell"
        YG:units = "degrees_north"
        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"
        YG:coordinates = "YG XG"
    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 top/bottom face of tracer grid cell"
        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 top face of the uppermost grid cell. Last element is the depth of the bottom face of the deepest grid
cell."
        Zp1:coverage_content_type = "coordinate"
        Zp1:standard_name = "depth"
    float32 Zu (k_u)
        Zu:long_name = "depth of bottom face of tracer grid cell"
        Zu:units = "m"
        Zu:positive = "up"
        Zu:comment = "First element is -10m, the depth of the bottom face of the uppermost 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 naming the bottom face of ocean tracer grid cells."
        Zu:coverage_content_type = "coordinate"
        Zu:standard_name = "depth"
    float32 Zl (k_l)
        Zl:long_name = "depth of top face of tracer grid cell"
        Zl:units = "m"
        Zl:positive = "up"
        Zl:comment = "First element is 0m, the depth of the top face of the uppermost tracer grid cell (i.e., the
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 naming the top face of ocean tracer grid cells."
        Zl:coverage_content_type = "coordinate"
        Zl:standard_name = "depth"
    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 orienta-
tion 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)
```

Table 9.6: Example CDL description of native dataset

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 top and bottom faces of tracer grid cell"

data variables

float32 DIFFKR (k, tile, j, i)
DIFFKR:_FillValue = "9.969209968386869e+36"
DIFFKR:coverage_content_type = "modelResult"
DIFFKR:long_name = "Vertical diffusivity"
DIFFKR:units = "m2 s-1"
DIFFKR:comment = "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."
DIFFKR:valid_min = "9.999999974752427e-07"
DIFFKR:valid_max = "0.00018549950618762523"
DIFFKR:coordinates = "Z XC YC"
float32 KAPGM (k, tile, j, i)
KAPGM:_FillValue = "9.969209968386869e+36"
KAPGM:coverage_content_type = "modelResult"
KAPGM:long_name = "Gent-McWilliams diffusivity"
KAPGM:units = "m2 s-1"
KAPGM:comment = "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."
KAPGM:valid_min = "100.0"
KAPGM:valid_max = "10000.0"
KAPGM:coordinates = "Z XC YC"
float32 KAPREDI (k, tile, j, i)
KAPREDI:_FillValue = "9.969209968386869e+36"
KAPREDI:coverage_content_type = "modelResult"
KAPREDI:long_name = "Along-isopycnal diffusivity"
KAPREDI:units = "m2 s-1"
KAPREDI:comment = "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."
KAPREDI:valid_min = "100.0"
KAPREDI:valid_max = "10000.0"
KAPREDI:coordinates = "Z XC YC"

9.8 Example of ECCO V4r4 netCDF for 1D data

Table 9.7: 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
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"

10 Native lat-lon-cap 90 (llc90) Coordinates and Grid Geometry

10.1 Native coordinates GRID_GEOMETRY_ECCO

10.1.1 Overview

This dataset provides geometric parameters for the lat-lon-cap 90 (llc90) native model grid from the ECCO Version 4 Release 4 (V4r4) ocean and sea-ice state estimate. Parameters include areas and lengths of grid cell sides, horizontal and vertical coordinates of grid cell centers and corners, grid rotation angles, and global domain geometry including bathymetry and land/ocean masks.

Table 10.1: Coordinates and Variables in the dataset GRID_GEOMETRY_ECCO

Coordinates	Description of data coordinates	Unit
i	Grid index in x for variables at tracer and 'v' locations	–none–
i_g	Grid index in x for variables at 'u' and 'g' locations	–none–
j	Grid index in y for variables at tracer and 'u' locations	–none–
j_g	Grid index in y for variables at 'v' and 'g' locations	–none–
k	Grid index in z for tracer variables	–none–
k_u	Grid index in z corresponding to the bottom face of tracer grid cells ('w' locations)	–none–
k_l	Grid index in z corresponding to the top face of tracer grid cells ('w' locations)	–none–
k_p1	Grid index in z for variables at 'w' locations	–none–
tile	Lat-lon-cap tile index	–none–
XC	Longitude of tracer grid cell center	degrees_east
YC	Latitude of tracer grid cell center	degrees_north
XG	Longitude of 'southwest' corner of tracer grid cell	degrees_east
YG	Latitude of 'southwest' corner of tracer grid cell	degrees_north
Z	Depth of tracer grid cell center	m
Zp1	Depth of top/bottom face of tracer grid cell	m
Zu	Depth of bottom face of tracer grid cell	m
Zl	Depth of top face of tracer grid cell	m
XC_bnds	Longitudes of tracer grid cell corners	–none–
YC_bnds	Latitudes of tracer grid cell corners	–none–
Z_bnds	Depths of top and bottom faces of tracer grid cell	–none–
Variables	**Description of data variables**	**Unit**
CS	Cosine of tracer grid cell orientation vs geographical north	1
SN	Sine of tracer grid cell orientation vs geographical north	1
rA	Area of tracer grid cell	m2
dxG	Distance between 'southwest' and 'southeast' corners of the tracer grid cell	m
dyG	Distance between 'southwest' and 'northwest' corners of the tracer grid cell	m
Depth	Model seafloor depth below ocean surface at rest	m
rAz	Area of vorticity 'g' grid cell	m2
dxC	Distance between centers of adjacent tracer grid cells in the 'x' direction	m
dyC	Distance between centers of adjacent tracer grid cells in the 'y' direction	m
rAw	Area of 'v' grid cell	m2
rAs	Area of 'u' grid cell	m2
drC	Distance between the centers of adjacent tracer grid cells in the 'z' direction	m
drF	Distance between the upper and lower interfaces of the model grid cell	m

Table 10.1: Coordinates and Variables in the dataset GRID_GEOMETRY_ECCO

PHrefC	Reference ocean hydrostatic pressure at tracer grid cell center	m2 s-2
PHrefF	Reference ocean hydrostatic pressure at tracer grid cell top/bottom interface	m2 s-2
hFacC	Vertical open fraction of tracer grid cell	1
hFacW	Vertical open fraction of tracer grid cell 'west' face	1
hFacS	Vertical open fraction of tracer grid cell 'south' face	1
maskC	Wet/dry boolean mask for tracer grid cell	–none–
maskW	Wet/dry boolean mask for 'west' face of tracer grid cell	–none–
maskS	Wet/dry boolean mask for 'south' face of tracer grid cell	–none–

10.1.2 Native coordinates Variable: XC

Table 10.2: Attributes description of the variable 'XC' from GRID_GEOMETRY_ECCO's dataset.

Storage Type	Variable Name	Description	Unit
float32	XC	Longitude of tracer grid cell center	degrees_east

Description of the variable in Common Data language (CDL)

```
float32 XC(tile, j, i)
    XC: bounds =     XC bnds
    XC: coordinate = YC     XC
    XC: coverage_content_type = coordinate
    XC: long_name = longitude of tracer grid cell center
    XC: standard_name = longitude
    XC: units = degrees east
```

Comments

Nonuniform grid spacing

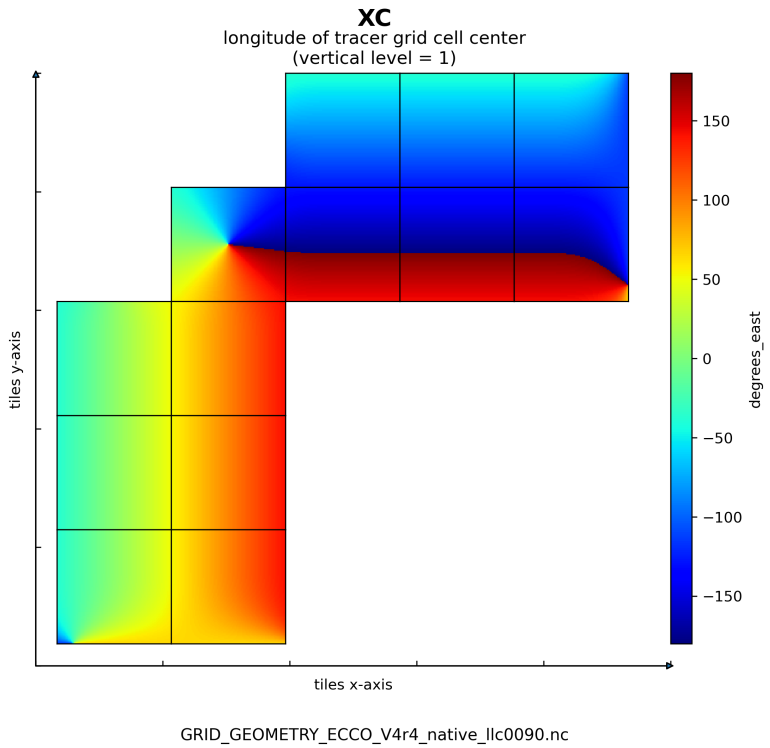


Figure 1: Dataset: GRID_GEOMETRY_ECCO, Variable: XC

10.1.3 Native coordinates Variable: YC

Table 10.3: Attributes description of the variable 'YC' from GRID_GEOMETRY_ECCO's dataset.

Storage Type	Variable Name	Description	Unit
float32	YC	Latitude of tracer grid cell center	degrees_north

Description of the variable in Common Data language (CDL)

```
float32 YC(tile, j, i)
    YC: bounds =     YC bnds
    YC: coordinate =     YC XC
    YC: coverage_content_type = coordinate
    YC: long_name = latitude of tracer grid cell center
    YC: standard_name = latitude
    YC: units = degrees north
```

Comments

Nonuniform grid spacing

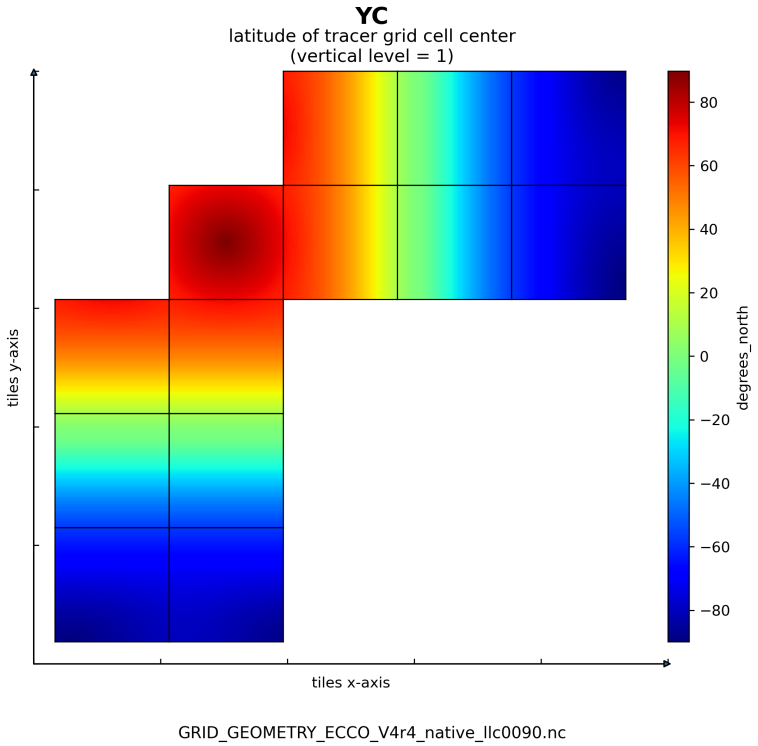


Figure 2: Dataset: GRID_GEOMETRY_ECCO, Variable: YC

10.1.4 Native coordinates Variable: XG

Table 10.4: Attributes description of the variable 'XG' from GRID_GEOMETRY_ECCO's dataset.

Storage Type	Variable Name	Description	Unit
float32	XG	Longitude of 'southwest' corner of tracer grid cell	degrees_east

Description of the variable in Common Data language (CDL)

```
float32 XG(tile, j_g, i_g)
   XG: coordinate = YG    XG
   XG: coverage_content_type = coordinate
   XG: long_name = longitude of southwest corner of tracer grid cell
   XG: standard_name = longitude
   XG: units = degrees east
```

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.

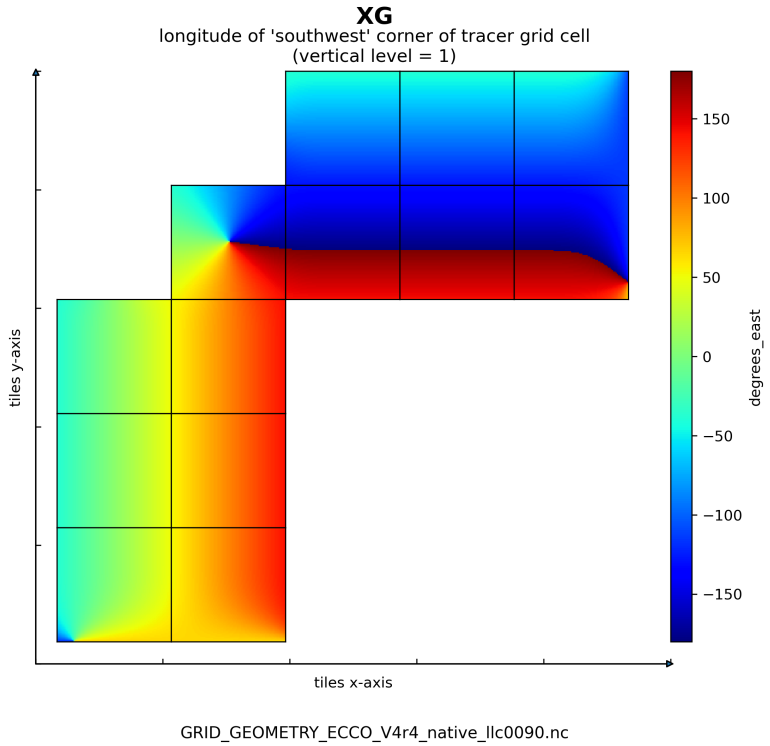


Figure 3: Dataset: GRID_GEOMETRY_ECCO, Variable: XG

10.1.5 Native coordinates Variable: YG

Table 10.5: Attributes description of the variable 'YG' from GRID_GEOMETRY_ECCO's dataset.

Storage Type	Variable Name	Description	Unit
float32	YG	Latitude of 'southwest' corner of tracer grid cell	degrees_north

Description of the variable in Common Data language (CDL)

```
float32 YG(tile, j_g, i_g)
    YG: coordinates =    YG XG
    YG: coverage_content_type = coordinate
    YG: long_name = latitude of southwest corner of tracer grid cell
    YG: standard_name = latitude
    YG: units = degrees north
```

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.

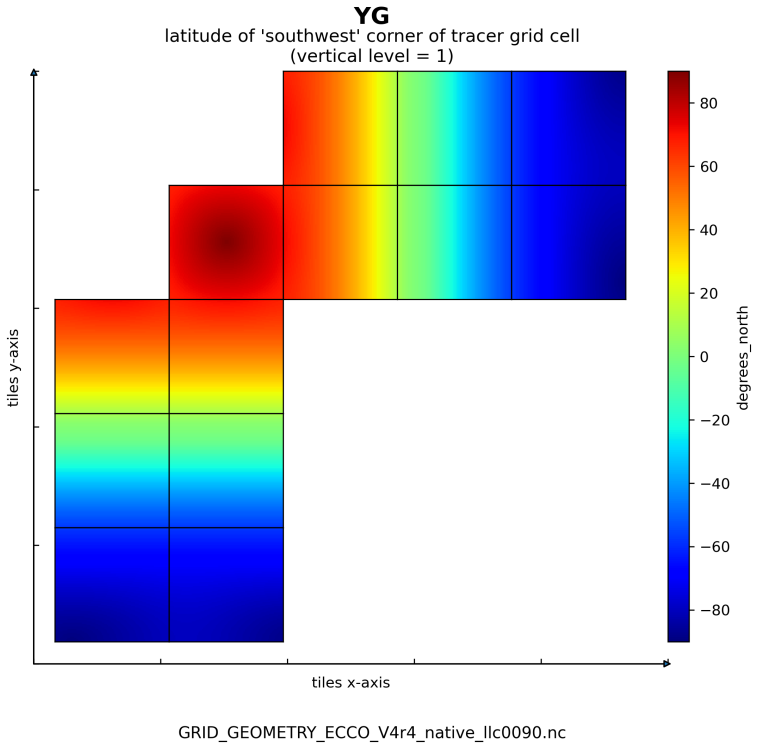


Figure 4: Dataset: GRID_GEOMETRY_ECCO, Variable: YG

10.1.6 Native coordinates Variable: CS

Table 10.6: Attributes description of the variable 'CS' from GRID_GEOMETRY_ECCO's dataset.

Storage Type	Variable Name	Description	Unit
float32	CS	Cosine of tracer grid cell orientation vs geographical north	1

Description of the variable in Common Data language (CDL)

```
float32 CS(tile, j, i)
    CS: _FillValue = 9.96921e+36
    CS: coordinate = YC XC
    CS: coordinates = YC XC
    CS: coverage_content_type = modelResult
    CS: long_name = cosine of tracer grid cell orientation vs geographical north
    CS: units = 1
```

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: r_{east} = cs r_x - sn r_y. r_{north} = sn r_x + cs r_y

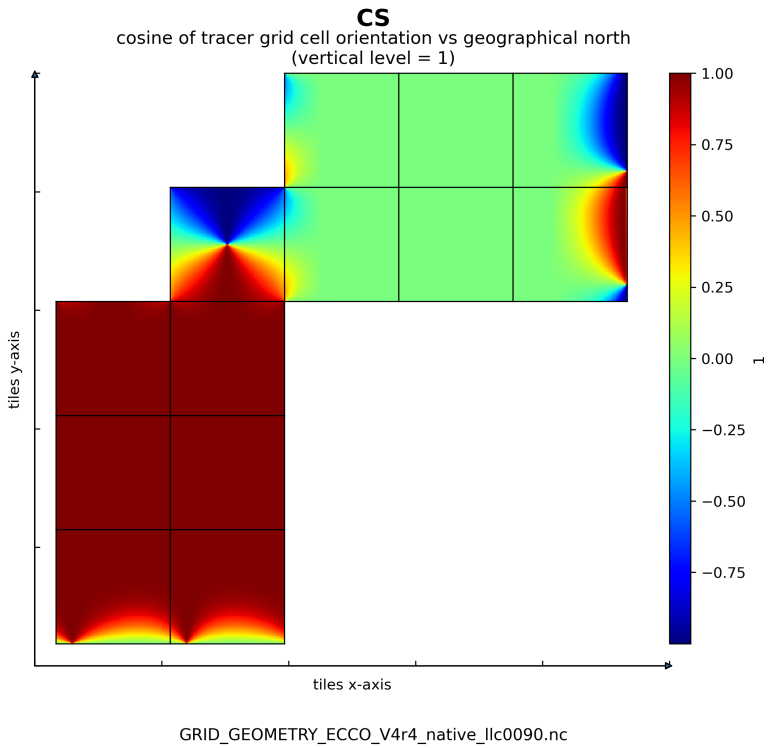


Figure 5: Dataset: GRID_GEOMETRY_ECCO, Variable: CS

10.1.7 Native coordinates Variable: SN

Table 10.7: Attributes description of the variable 'SN' from GRID_GEOMETRY_ECCO's dataset.

Storage Type	Variable Name	Description	Unit
float32	SN	Sine of tracer grid cell orientation vs geographical north	1

Description of the variable in Common Data language (CDL)

```
float32 SN(tile, j, i)
    SN: _FillValue = 9.96921e+36
    SN: coordinate = YC XC
    SN: coordinates = YC XC
    SN: coverage_content_type = modelResult
    SN: long_name = sine of tracer grid cell orientation vs geographical north
    SN: units = 1
```

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.

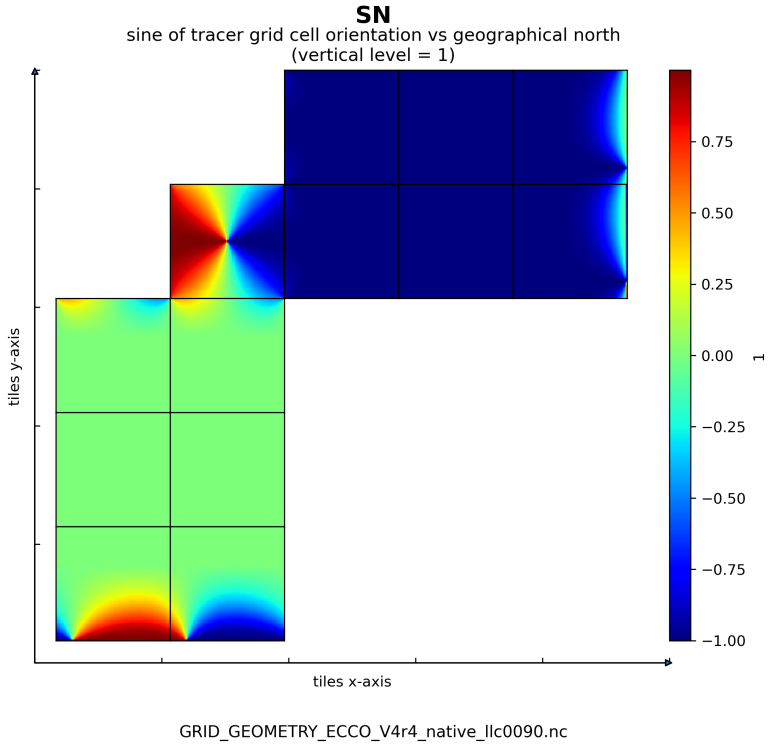


Figure 6: Dataset: GRID_GEOMETRY_ECCO, Variable: SN

10.1.8 Native coordinates Variable: rA

Table 10.8: Attributes description of the variable 'rA' from GRID_GEOMETRY_ECCO's dataset.

Storage Type	Variable Name	Description	Unit
float32	rA	Area of tracer grid cell	m2

Description of the variable in Common Data language (CDL)

```
float32 rA(tile, j, i)
    rA: _FillValue = 9.96921e+36
    rA: coordinate = YC XC
    rA: coordinates = YC XC
    rA: coverage_content_type = modelResult
    rA: long_name = area of tracer grid cell
    rA: standard_name = cell area
    rA: units = m2
```

Comments

N/a

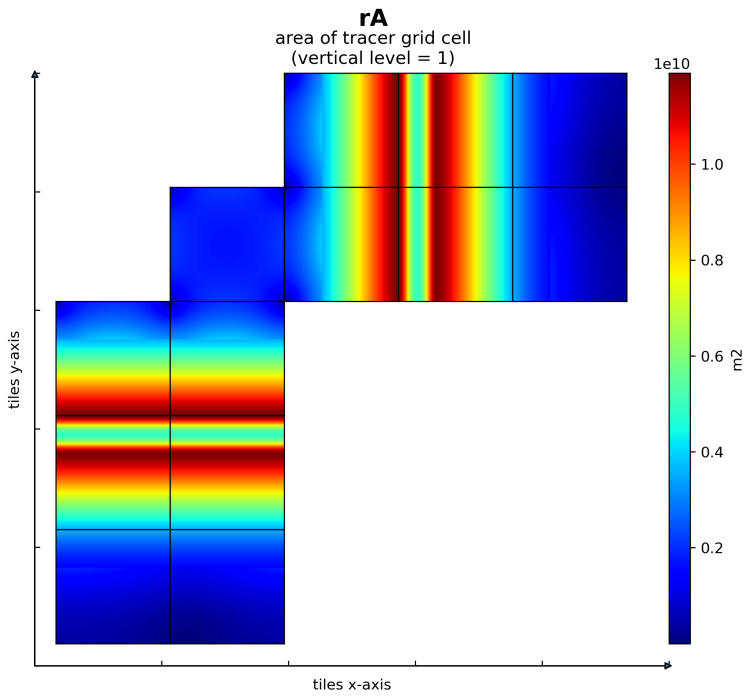


Figure 7: Dataset: GRID_GEOMETRY_ECCO, Variable: rA

10.1.9 Native coordinates Variable: dxG

Table 10.9: Attributes description of the variable 'dxG' from GRID_GEOMETRY_ECCO's dataset.

Storage Type	Variable Name	Description	Unit
float32	dxG	Distance between 'southwest' and 'southeast' corners of the tracer grid cell	m

Description of the variable in Common Data language (CDL)

```
float32 dxG(tile, j_g, i)
    dxG: _FillValue = 9.96921e+36
    dxG: coordinate = YG XC
    dxG: coverage_content_type = modelResult
    dxG: long_name = distance between southwest and southeast corners of the tracer grid cell
    dxG: units = m
```

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.

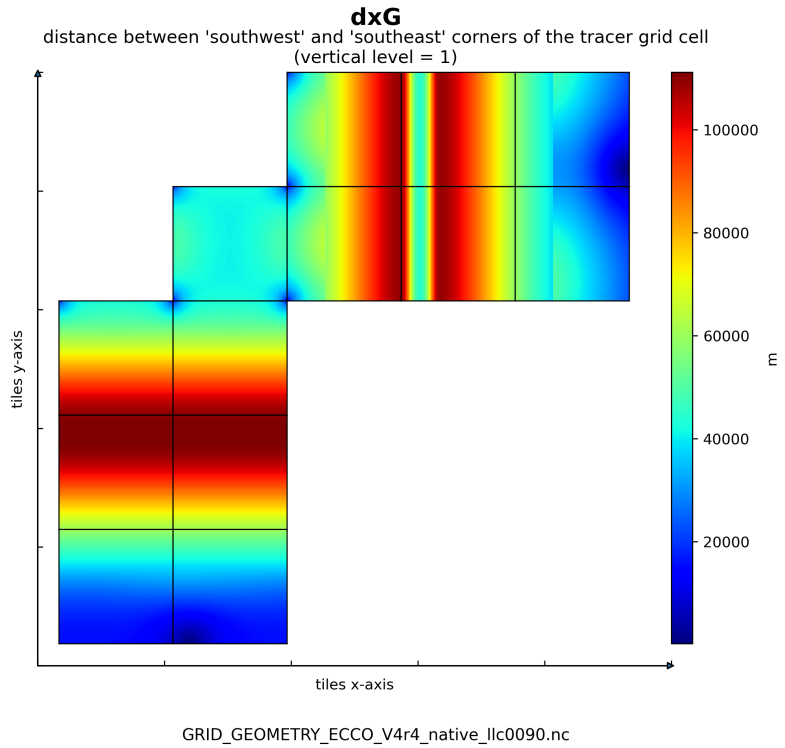


Figure 8: Dataset: GRID_GEOMETRY_ECCO, Variable: dxG

10.1.10 Native coordinates Variable: dyG

Table 10.10: Attributes description of the variable 'dyG' from GRID_GEOMETRY_ECCO's dataset.

Storage Type	Variable Name	Description	Unit
float32	dyG	Distance between 'southwest' and 'northwest' corners of the tracer grid cell	m

Description of the variable in Common Data language (CDL)

```
float32 dyG(tile, j, i_g)
    dyG: _FillValue = 9.96921e+36
    dyG: coordinate = YC XG
    dyG: coverage_content_type = modelResult
    dyG: long_name = distance between southwest and northwest corners of the tracer grid cell
    dyG: units = m
```

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.

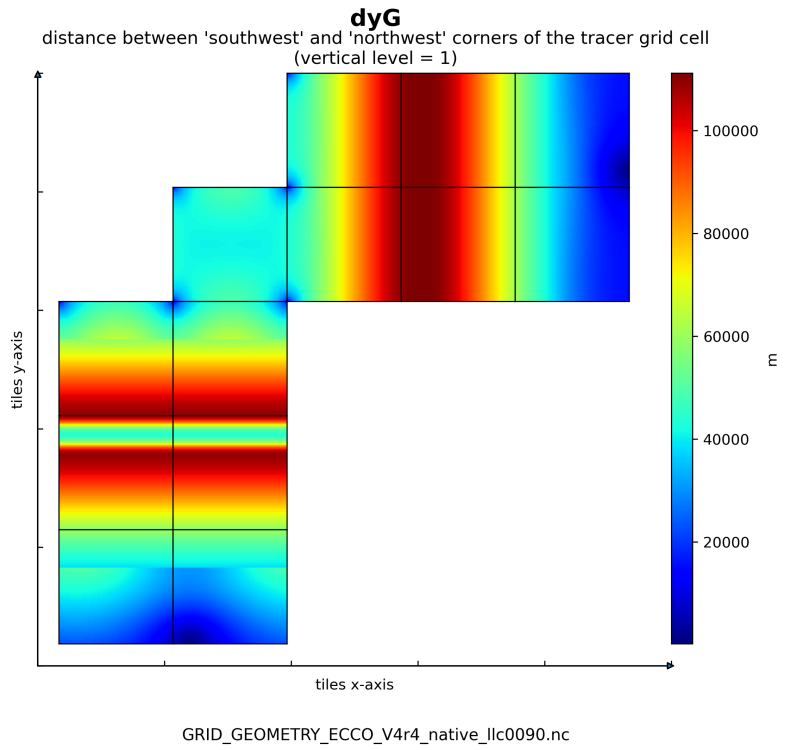


Figure 9: Dataset: GRID_GEOMETRY_ECCO, Variable: dyG

10.1.11 Native coordinates Variable: Depth

Table 10.11: Attributes description of the variable 'Depth' from GRID_GEOMETRY_ECCO's dataset.

Storage Type	Variable Name	Description	Unit
float32	Depth	Model seafloor depth below ocean surface at rest	m

Description of the variable in Common Data language (CDL)

```
float32 Depth(tile, j, i)
    Depth:  _FillValue = 9.96921e+36
    Depth:  coordinate = XC YC
    Depth:  coordinates = YC XC
    Depth:  coverage_content_type = modelResult
    Depth:  long_name = model seafloor depth below ocean surface at rest
    Depth:  standard_name = sea floor depth below geoid
    Depth:  units = m
```

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.

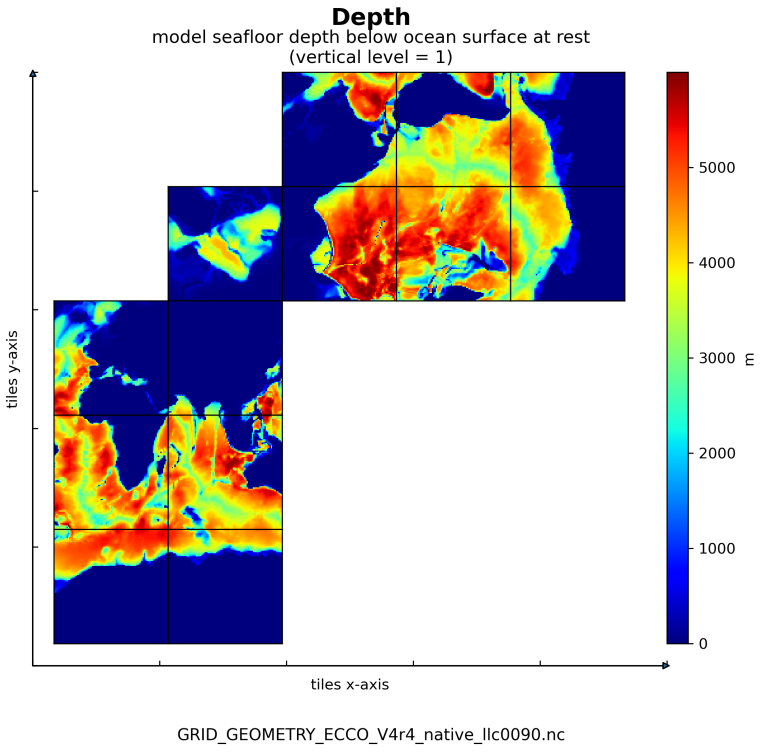


Figure 10: Dataset: GRID_GEOMETRY_ECCO, Variable: Depth

10.1.12 Native coordinates Variable: rAz

Table 10.12: Attributes description of the variable 'rAz' from GRID_GEOMETRY_ECCO's dataset.

Storage Type	Variable Name	Description	Unit
float32	rAz	Area of vorticity 'g' grid cell	m2

Description of the variable in Common Data language (CDL)

```
float32 rAz(tile, j_g, i_g)
   rAz:  _FillValue = 9.96921e+36
   rAz:  coordinate = YG XG
   rAz:  coordinates = YG XG
   rAz:  coverage_content_type = modelResult
   rAz:  long_name = area of vorticity g grid cell
   rAz:  standard_name = cell area
   rAz:  units = m2
```

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.

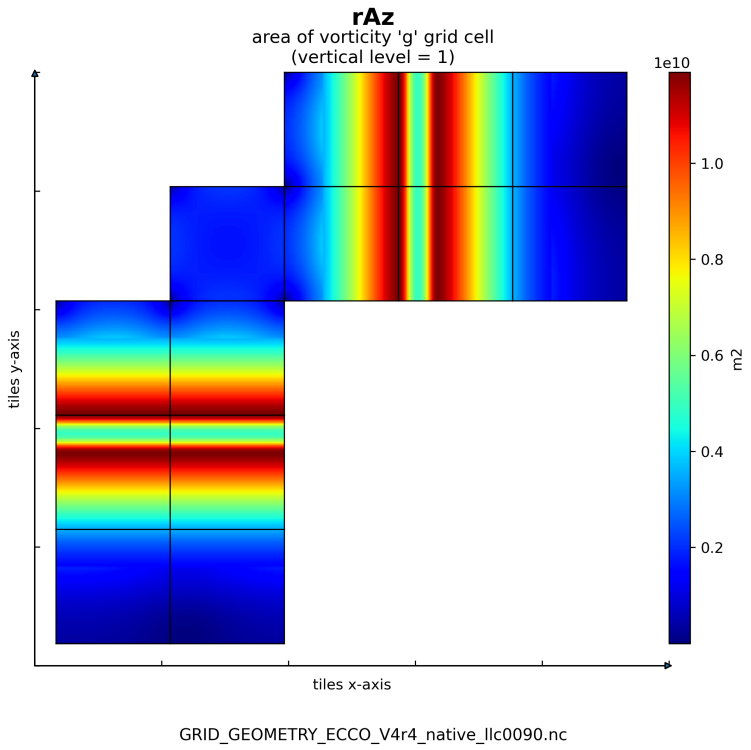


Figure 11: Dataset: GRID_GEOMETRY_ECCO, Variable: rAz

10.1.13 Native coordinates Variable: dxC

Table 10.13: Attributes description of the variable 'dxC' from GRID_GEOMETRY_ECCO's dataset.

Storage Type	Variable Name	Description	Unit
float32	dxC	Distance between centers of adjacent tracer grid cells in the 'x' direction	m

Description of the variable in Common Data language (CDL)

```
float32 dxC(tile, j, i_g)
    dxC: _FillValue = 9.96921e+36
    dxC: coordinate = YC XG
    dxC: coverage_content_type = modelResult
    dxC: long_name = distance between centers of adjacent tracer grid cells in the x direction
    dxC: units = m
```

Comments

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.

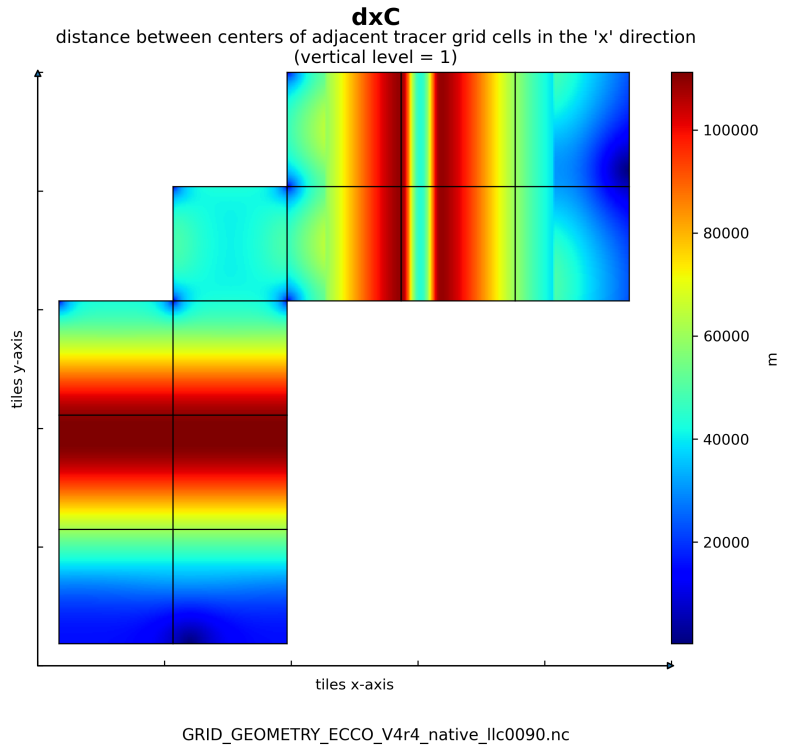


Figure 12: Dataset: GRID_GEOMETRY_ECCO, Variable: dxC

10.1.14 Native coordinates Variable: dyC

Table 10.14: Attributes description of the variable 'dyC' from GRID_GEOMETRY_ECCO's dataset.

Storage Type	Variable Name	Description	Unit
float32	dyC	Distance between centers of adjacent tracer grid cells in the 'y' direction	m

Description of the variable in Common Data language (CDL)

```
float32 dyC(tile, j_g, i)
   dyC: _FillValue = 9.96921e+36
   dyC: coordinate = YG XC
   dyC: coverage_content_type = modelResult
   dyC: long_name = distance between centers of adjacent tracer grid cells in the y direction
   dyC: units = m
```

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.

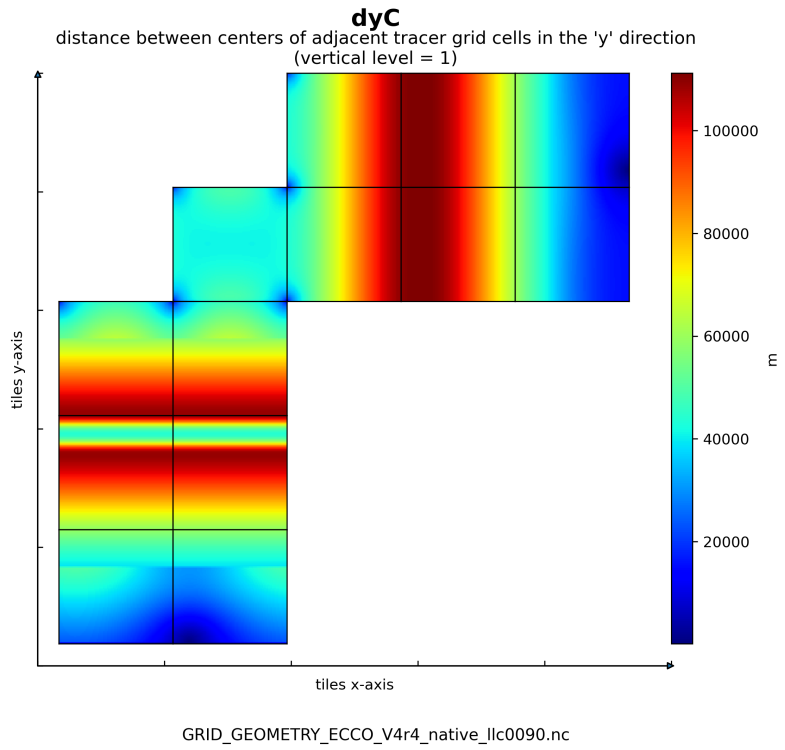


Figure 13: Dataset: GRID_GEOMETRY_ECCO, Variable: dyC

10.1.15 Native coordinates Variable: rAw

Table 10.15: Attributes description of the variable 'rAw' from GRID_GEOMETRY_ECCO's dataset.

Storage Type	Variable Name	Description	Unit
float32	rAw	Area of 'v' grid cell	m2

Description of the variable in Common Data language (CDL)

```
float32 rAw(tile, j, i_g)
   rAw:  _FillValue = 9.96921e+36
   rAw:  coordinate = YG XC
   rAw:  coverage_content_type = modelResult
   rAw:  long_name = area of v grid cell
   rAw:  standard_name = cell area
   rAw:  units = m2
```

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.

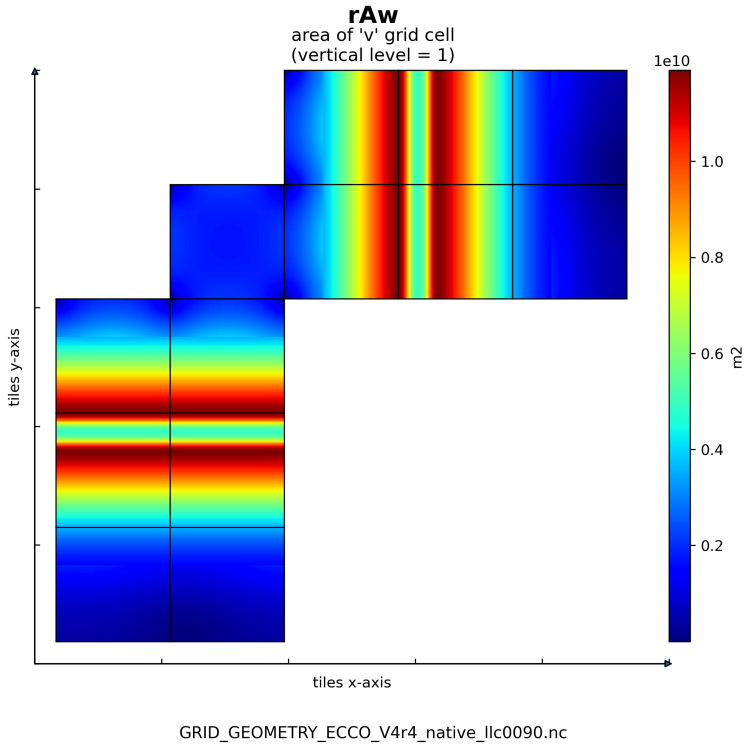


Figure 14: Dataset: GRID_GEOMETRY_ECCO, Variable: rAw

10.1.16 Native coordinates Variable: rAs

Table 10.16: Attributes description of the variable 'rAs' from GRID_GEOMETRY_ECCO's dataset.

Storage Type	Variable Name	Description	Unit
float32	rAs	Area of 'u' grid cell	m2

Description of the variable in Common Data language (CDL)

```
float32 rAs(tile, j_g, i)
   rAs:  _FillValue = 9.96921e+36
   rAs:  coordinates = YG XC
   rAs:  coverage_content_type = modelResult
   rAs:  long_name = area of u grid cell
   rAs:  standard_name = cell area
   rAs:  units = m2
```

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.

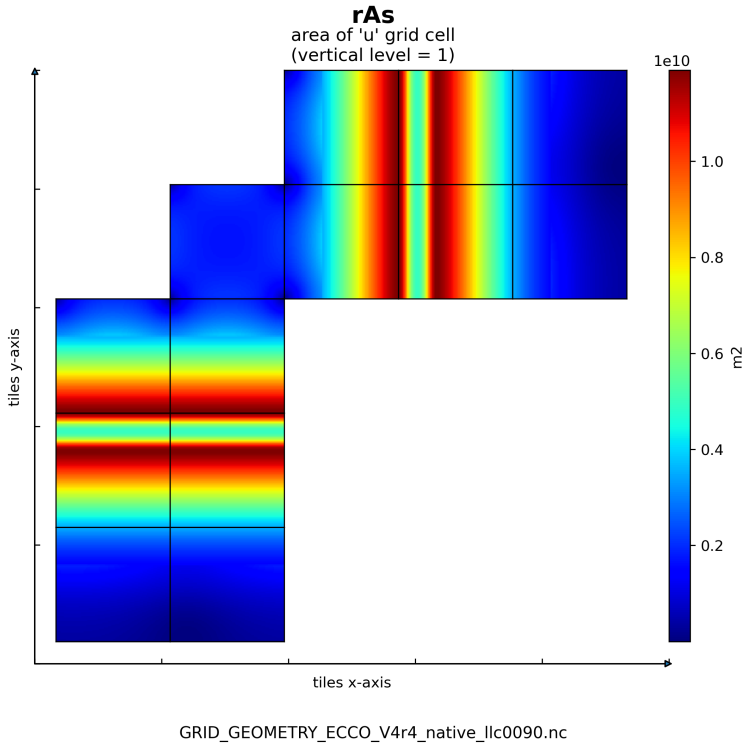


Figure 15: Dataset: GRID_GEOMETRY_ECCO, Variable: rAs

10.1.17 Native coordinates Variable: hFacC

Table 10.17: Attributes description of the variable 'hFacC' from GRID_GEOMETRY_ECCO's dataset.

Storage Type	Variable Name	Description	Unit
float32	hFacC	Vertical open fraction of tracer grid cell	1

Description of the variable in Common Data language (CDL)

```
float32 hFacC(k, tile, j, i)
   hFacC: _FillValue = 9.96921e+36
   hFacC: coordinates = Z YC XC
   hFacC: coverage_content_type = modelResult
   hFacC: long_name = vertical open fraction of tracer grid cell
   hFacC: units = 1
```

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.

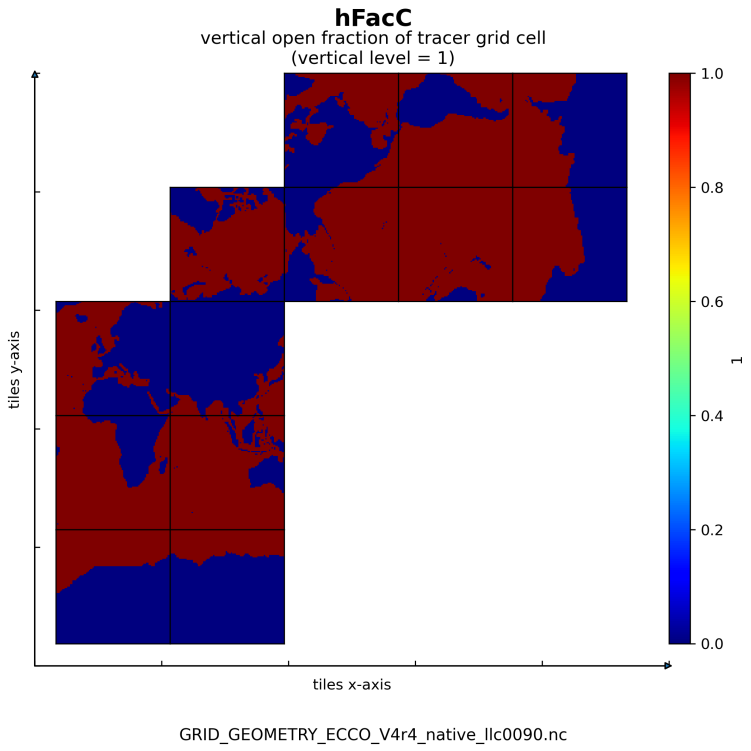


Figure 16: Dataset: GRID_GEOMETRY_ECCO, Variable: hFacC

10.1.18 Native coordinates Variable: hFacW

Table 10.18: Attributes description of the variable 'hFacW' from GRID_GEOMETRY_ECCO's dataset.

Storage Type	Variable Name	Description	Unit
float32	hFacW	Vertical open fraction of tracer grid cell 'west' face	1

Description of the variable in Common Data language (CDL)

```
float32 hFacW(k, tile, j, i_g)
   hFacW: _FillValue = 9.96921e+36
   hFacW: coordinates = Z
   hFacW: coverage_content_type = modelResult
   hFacW: long_name = vertical open fraction of tracer grid cell west face
   hFacW: units = 1
```

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.

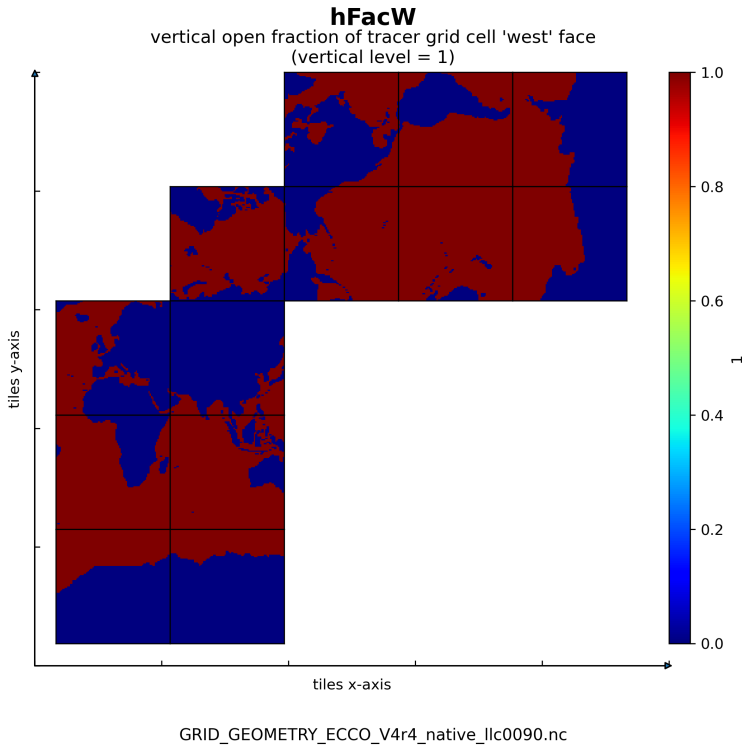


Figure 17: Dataset: GRID_GEOMETRY_ECCO, Variable: hFacW

10.1.19 Native coordinates Variable: hFacS

Table 10.19: Attributes description of the variable 'hFacS' from GRID_GEOMETRY_ECCO's dataset.

Storage Type	Variable Name	Description	Unit
float32	hFacS	Vertical open fraction of tracer grid cell 'south' face	1

Description of the variable in Common Data language (CDL)

```
float32 hFacS(k, tile, j_g, i)
   hFacS: _FillValue = 9.96921e+36
   hFacS: coordinates = Z
   hFacS: coverage_content_type = modelResult
   hFacS: long_name = vertical open fraction of tracer grid cell south face
   hFacS: units = 1
```

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.

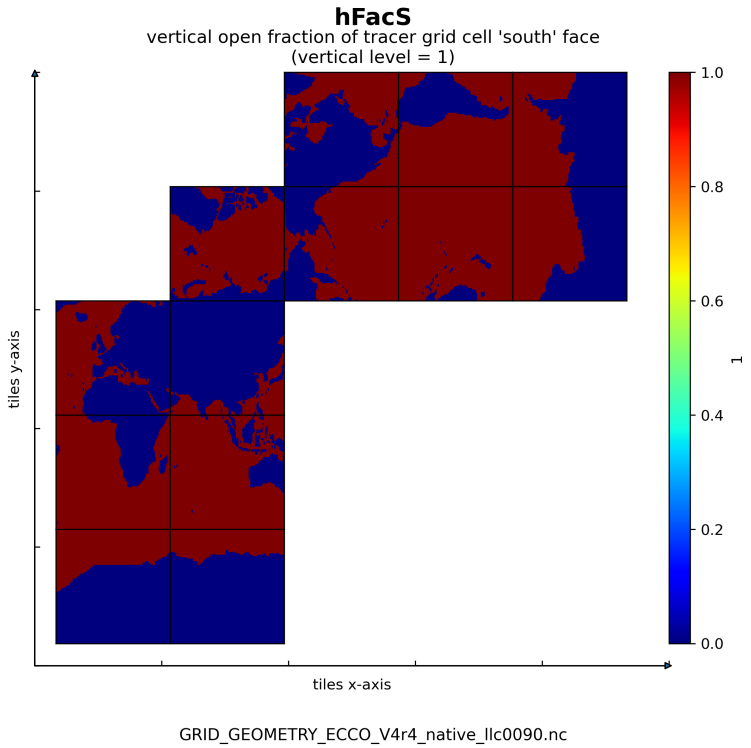


Figure 18: Dataset: GRID_GEOMETRY_ECCO, Variable: hFacS

10.1.20 Native coordinates Variable: maskC

Table 10.20: Attributes description of the variable 'maskC' from GRID_GEOMETRY_ECCO's dataset.

Storage Type	Variable Name	Description	Unit
bool	maskC	Wet/dry boolean mask for tracer grid cell	N/A

Description of the variable in Common Data language (CDL)

```
bool maskC(k, tile, j, i)
   maskC: _FillValue = 1
   maskC: coordinates = Z YC XC
   maskC: coverage_content_type = modelResult
   maskC: long_name = wet/dry boolean mask for tracer grid cell
```

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.

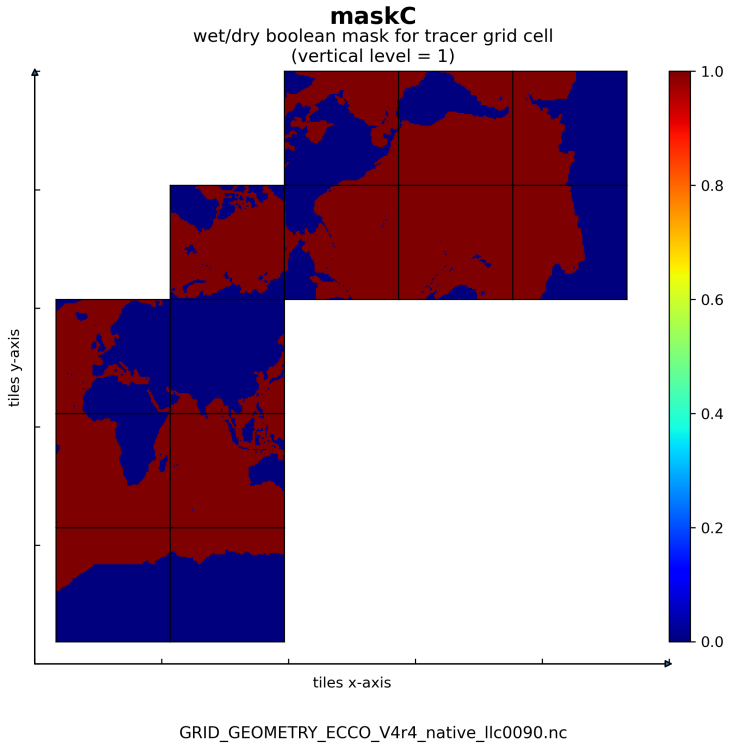


Figure 19: Dataset: GRID_GEOMETRY_ECCO, Variable: maskC

10.1.21 Native coordinates Variable: maskW

Table 10.21: Attributes description of the variable 'maskW' from GRID_GEOMETRY_ECCO's dataset.

Storage Type	Variable Name	Description	Unit
bool	maskW	Wet/dry boolean mask for 'west' face of tracer grid cell	N/A

Description of the variable in Common Data language (CDL)

```
bool maskW(k, tile, j, i_g)
   maskW: _FillValue = 1
   maskW: coordinates = Z
   maskW: coverage_content_type = modelResult
   maskW: long_name = wet/dry boolean mask for west face of tracer grid cell
```

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:

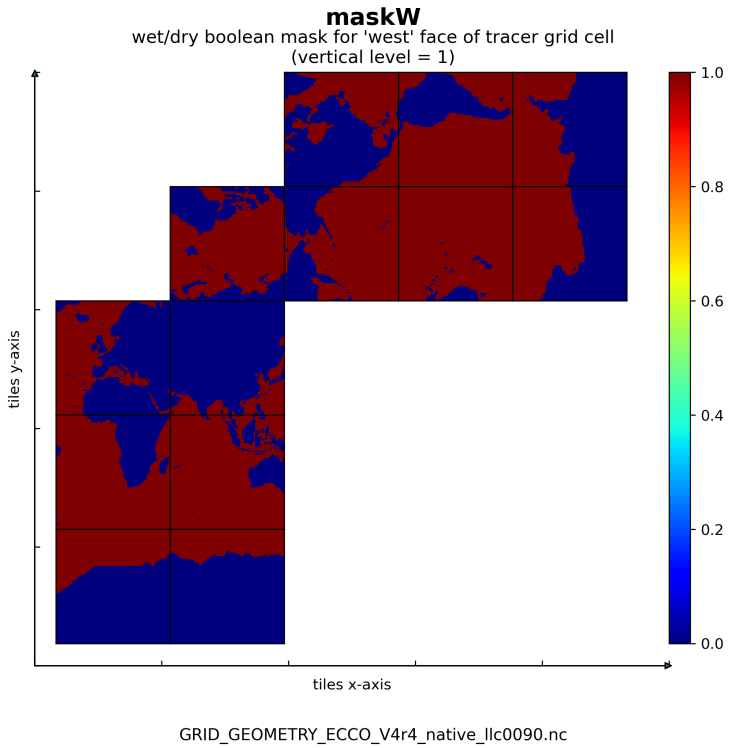


Figure 20: Dataset: GRID_GEOMETRY_ECCO, Variable: maskW

10.1.22 Native coordinates Variable: maskS

Table 10.22: Attributes description of the variable 'maskS' from GRID_GEOMETRY_ECCO's dataset.

Storage Type	Variable Name	Description	Unit
bool	maskS	Wet/dry boolean mask for 'south' face of tracer grid cell	N/A

Description of the variable in Common Data language (CDL)

```
bool maskS(k, tile, j_g, i)
   maskS: _FillValue = 1
   maskS: coordinates = Z
   maskS: coverage_content_type = modelResult
   maskS: long_name = wet/dry boolean mask for south face of tracer grid cell
```

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:

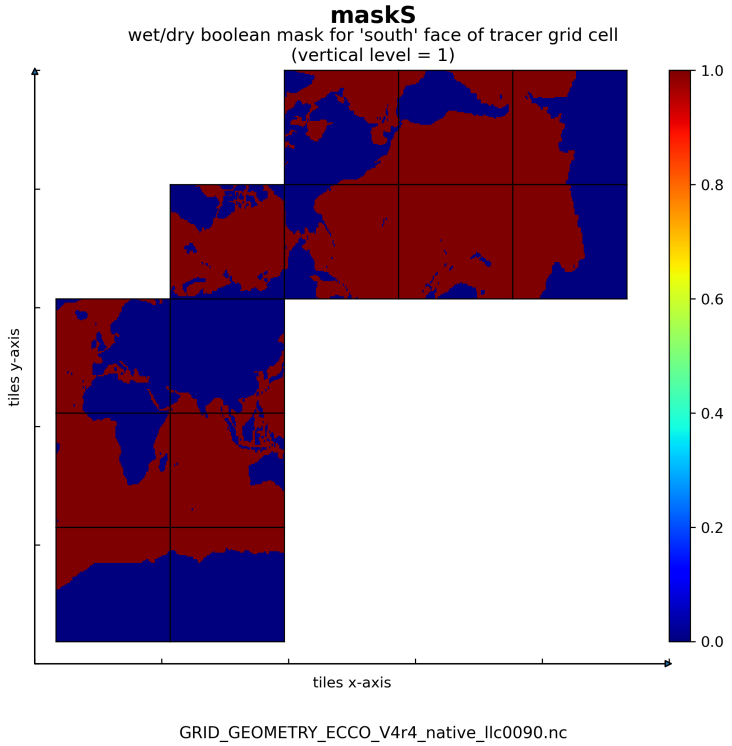


Figure 21: Dataset: GRID_GEOMETRY_ECCO, Variable: maskS

11 Native Dataset Groupings

11.1 Native dataset of ATM_SURFACE_TEMP_HUM_WIND_PRES

11.1.1 Overview

This dataset provides 2D fields of atmosphere surface temperature, humidity, winds, and pressure on the lat-lon-cap 90 (llc90) native model grid from the ECCO Version 4 Release 4 (V4r4) ocean and sea-ice state estimate. The dataset is provided on daily-average and monthly-average time resolution.

Table 11.1: Coordinates and Variables in the dataset ATM_SURFACE_TEMP_HUM_WIND_PRES

Coordinates	Description of data coordinates	Unit
i	Grid index in x for variables at tracer and 'v' locations	–none–
i_g	Grid index in x for variables at 'u' and 'g' locations	–none–
j	Grid index in y for variables at tracer and 'u' locations	–none–
j_g	Grid index in y for variables at 'v' and 'g' locations	–none–
tile	Lat-lon-cap tile index	–none–
time	Center time of averaging period	–none–
XC	Longitude of tracer grid cell center	degrees_east
YC	Latitude of tracer grid cell center	degrees_north
XG	Longitude of 'southwest' corner of tracer grid cell	degrees_east
YG	Latitude of 'southwest' corner of tracer grid cell	degrees_north
time_bnds	Time bounds of averaging period	–none–
XC_bnds	Longitudes of tracer grid cell corners	–none–
YC_bnds	Latitudes of tracer grid cell corners	–none–
Variables	**Description of data variables**	**Unit**
EXFatemp	Atmosphere surface (2 m) air temperature	degree_K
EXFaqh	Atmosphere surface (2 m) specific humidity	kg kg-1
EXFuwind	Wind speed at 10m in the model +x direction	m s-1
EXFvwind	Wind speed at 10m in the model +y direction	m s-1
EXFwspee	Wind speed	m s-1
EXFpress	Atmosphere surface pressure	N m-2

11.1.2 Native Variable: EXFaqh

Table 11.2: Attributes description of the variable 'EXFaqh' from ATM_SURFACE_TEMP_HUM_WIND_PRES's dataset.

Storage Type	Variable Name	Description	Unit
float32	EXFaqh	Atmosphere surface (2 m) specific humidity	kg kg-1

Description of the variable in Common Data language (CDL)

```
float32 EXFaqh(time, tile, j, i)
    EXFaqh:  _FillValue = 9.96921e+36
    EXFaqh:  coordinates = time XC YC
    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:  valid_max = 0.03014513850212097
    EXFaqh:  valid_min = -0.0014020215021446347
```

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.

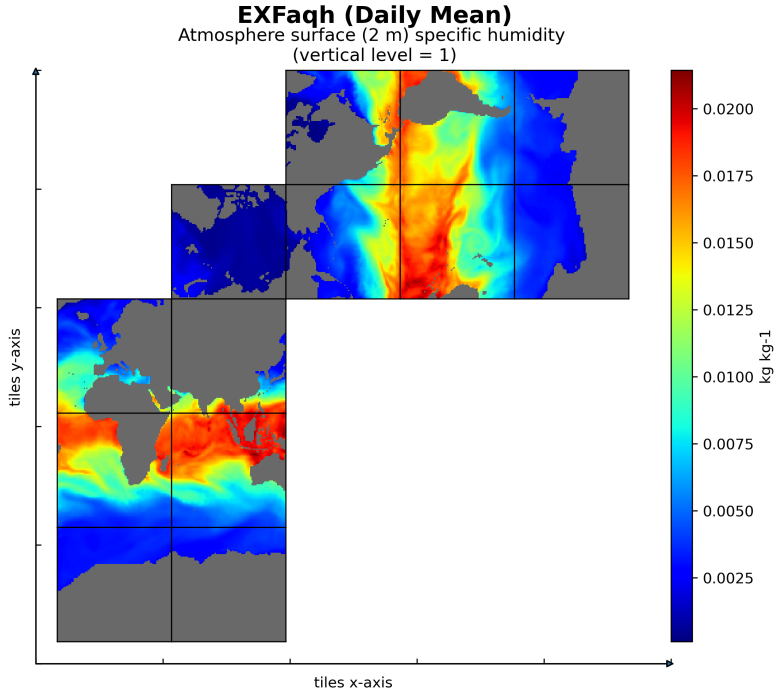


Figure 22: Dataset: ATM_SURFACE_TEMP_HUM_WIND_PRES, Variable: EXFaqh

11.1.3 Native Variable: EXFatemp

Table 11.3: Attributes description of the variable 'EXFatemp' from ATM_SURFACE_TEMP_HUM_WIND_PRES's dataset.

Storage Type	Variable Name	Description	Unit
float32	EXFatemp	Atmosphere surface (2 m) air temperature	degree_K

Description of the variable in Common Data language (CDL)

```
float32 EXFatemp(time, tile, j, i)
    EXFatemp:  _FillValue = 9.96921e+36
    EXFatemp:  coordinates = time XC YC
    EXFatemp:  coverage_content_type = modelResult
    EXFatemp:  long_name = Atmosphere surface (2 m) air temperature
    EXFatemp:  standard_name = air temperature
    EXFatemp:  units = degree K
    EXFatemp:  valid_max = 312.8451232910156
    EXFatemp:  valid_min = 195.37054443359375
```

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.

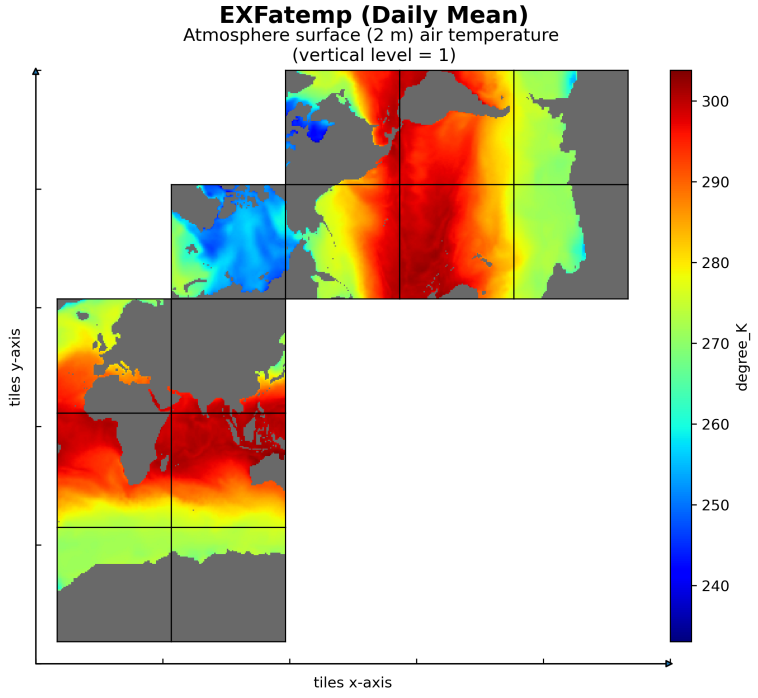


Figure 23: Dataset: ATM_SURFACE_TEMP_HUM_WIND_PRES, Variable: EXFatemp

11.1.4 Native Variable: EXFpress

Table 11.4: Attributes description of the variable 'EXFpress' from ATM_SURFACE_TEMP_HUM_WIND_PRES's dataset.

Storage Type	Variable Name	Description	Unit
float32	EXFpress	Atmosphere surface pressure	N m-2

Description of the variable in Common Data language (CDL)

```
float32 EXFpress(time, tile, j, i)
    EXFpress:  _FillValue = 9.96921e+36
    EXFpress:  coordinates = time XC YC
    EXFpress:  coverage_content_type = modelResult
    EXFpress:  long_name = Atmosphere surface pressure
    EXFpress:  standard_name = surface air pressure
    EXFpress:  units = N m-2
    EXFpress:  valid_max = 106314.7734375
    EXFpress:  valid_min = 92044.171875
```

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.

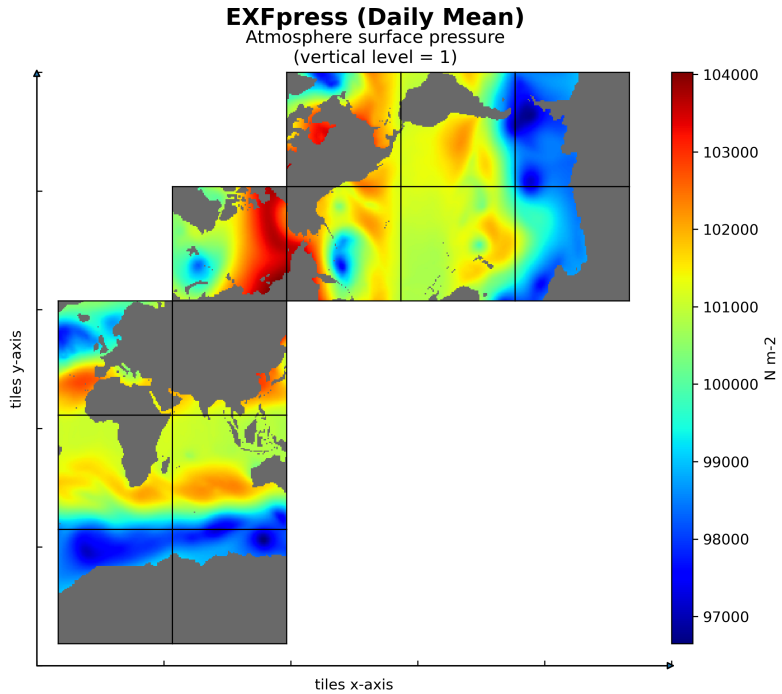


Figure 24: Dataset: ATM_SURFACE_TEMP_HUM_WIND_PRES, Variable: EXFpress

11.1.5 Native Variable: EXFuwind

Table 11.5: Attributes description of the variable 'EXFuwind' from ATM_SURFACE_TEMP_HUM_WIND_PRES's dataset.

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

Description of the variable in Common Data language (CDL)

```
float32 EXFuwind(time, tile, j, i)
    EXFuwind:  _FillValue = 9.96921e+36
    EXFuwind:  coordinates = time XC YC
    EXFuwind:  coverage_content_type = modelResult
    EXFuwind:  long_name = Wind speed at 10m in the model +x direction
    EXFuwind:  standard_name = x wind
    EXFuwind:  units = m s-1
    EXFuwind:  valid_max = 29.92486572265625
    EXFuwind:  valid_min = -34.528900146484375
```

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.

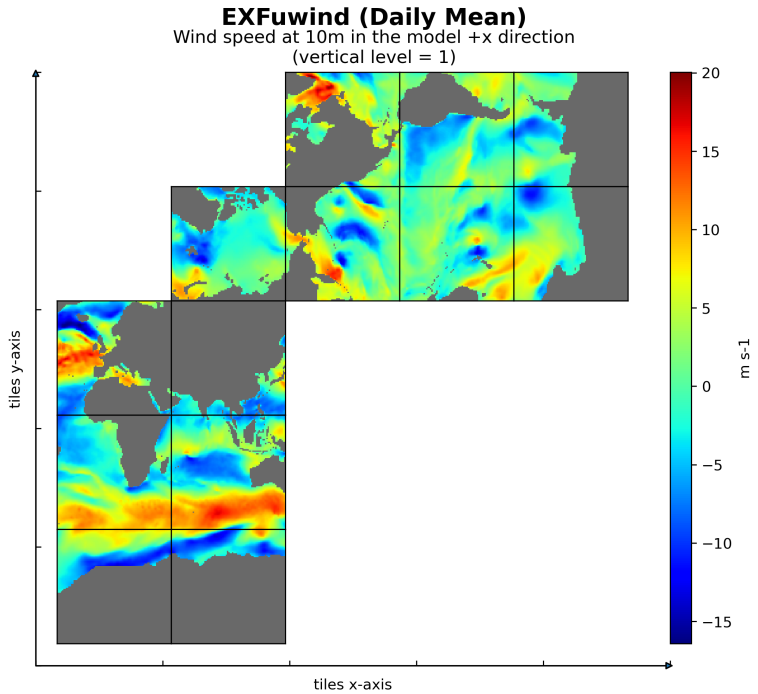


Figure 25: Dataset: ATM_SURFACE_TEMP_HUM_WIND_PRES, Variable: EXFuwind

11.1.6 Native Variable: EXFvwind

Table 11.6: Attributes description of the variable 'EXFvwind' from ATM_SURFACE_TEMP_HUM_WIND_PRES's dataset.

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

Description of the variable in Common Data language (CDL)

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

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.

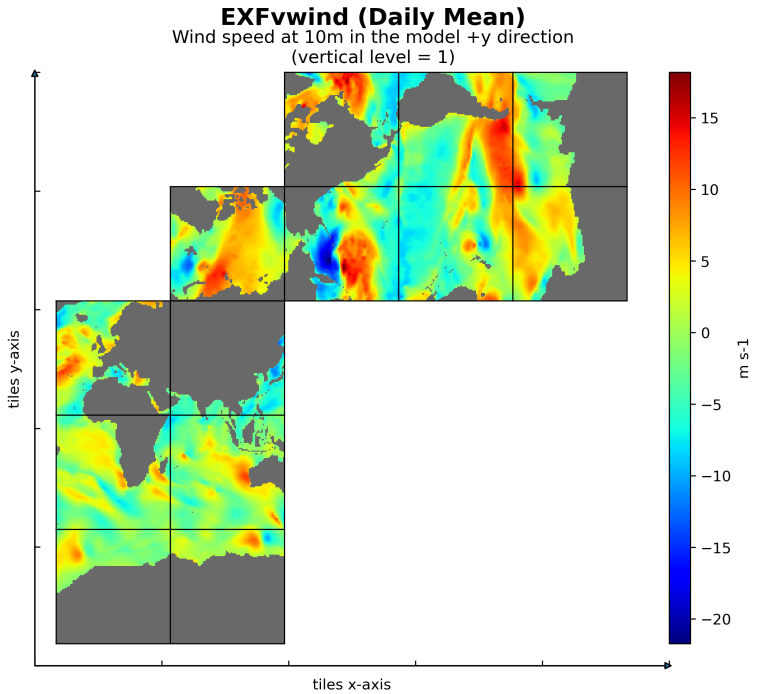


Figure 26: Dataset: ATM_SURFACE_TEMP_HUM_WIND_PRES, Variable: EXFvwind

11.1.7 Native Variable: EXFwspee

Table 11.7: Attributes description of the variable 'EXFwspee' from ATM_SURFACE_TEMP_HUM_WIND_PRES's dataset.

Storage Type	Variable Name	Description	Unit
float32	EXFwspee	Wind speed	m s-1

Description of the variable in Common Data language (CDL)

```
float32 EXFwspee(time, tile, j, i)
    EXFwspee:  _FillValue = 9.96921e+36
    EXFwspee:  coordinates = time XC YC
    EXFwspee:  coverage_content_type = modelResult
    EXFwspee:  long_name = Wind speed
    EXFwspee:  standard_name = wind speed
    EXFwspee:  units = m s-1
    EXFwspee:  valid_max = 45.87086486816406
    EXFwspee:  valid_min = 0.27271032333374023
```

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.

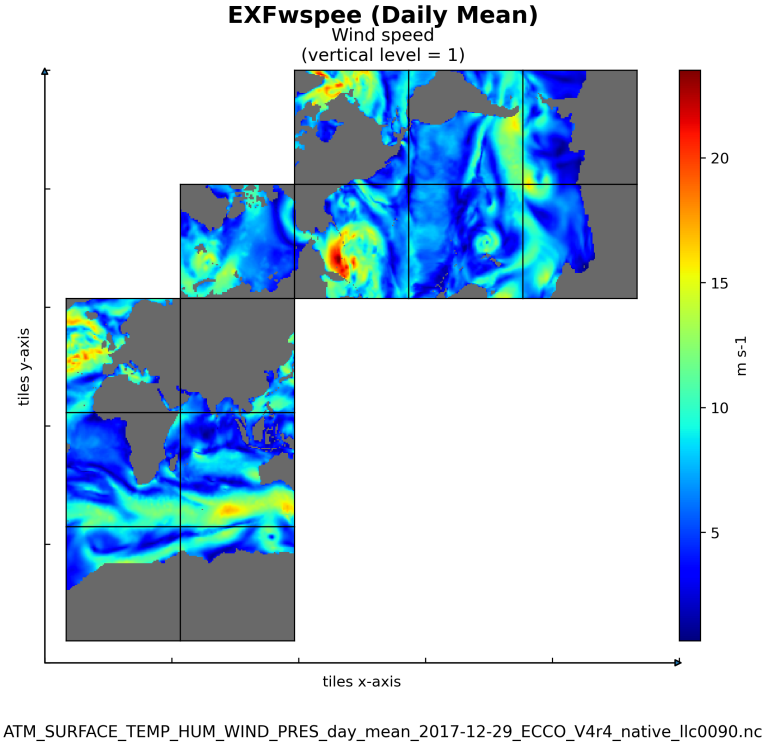


Figure 27: Dataset: ATM_SURFACE_TEMP_HUM_WIND_PRES, Variable: EXFwspee

11.2 Native dataset of OCEAN_3D_MIXING_COEFFS

11.2.1 Overview

This dataset provides 3D time-invariant coefficients for the Gent-McWilliams and Redi parameterizations and background vertical diffusivity on the lat-lon-cap 90 (llc90) native model grid from the ECCO Version 4 Release 4 (V4r4) ocean and sea-ice state estimate.

Table 11.8: Coordinates and Variables in the dataset OCEAN_3D_MIXING_COEFFS_ECCO

Coordinates	Description of data coordinates	Unit
i	Grid index in x for variables at tracer and 'v' locations	–none–
i_g	Grid index in x for variables at 'u' and 'g' locations	–none–
j	Grid index in y for variables at tracer and 'u' locations	–none–
j_g	Grid index in y for variables at 'v' and 'g' locations	–none–
k	Grid index in z for tracer variables	–none–
k_u	Grid index in z corresponding to the bottom face of tracer grid cells ('w' locations)	–none–
k_l	Grid index in z corresponding to the top face of tracer grid cells ('w' locations)	–none–
k_p1	Grid index in z for variables at 'w' locations	–none–
tile	Lat-lon-cap tile index	–none–
XC	Longitude of tracer grid cell center	degrees_east
YC	Latitude of tracer grid cell center	degrees_north
XG	Longitude of 'southwest' corner of tracer grid cell	degrees_east
YG	Latitude of 'southwest' corner of tracer grid cell	degrees_north
Z	Depth of tracer grid cell center	m
Zp1	Depth of top/bottom face of tracer grid cell	m
Zu	Depth of bottom face of tracer grid cell	m
Zl	Depth of top face of tracer grid cell	m
XC_bnds	Longitudes of tracer grid cell corners	–none–
YC_bnds	Latitudes of tracer grid cell corners	–none–
Z_bnds	Depths of top and bottom faces of tracer grid cell	–none–
Variables	**Description of data variables**	**Unit**
DIFFKR	Vertical diffusivity	m2 s-1
KAPGM	Gent-mcwilliams diffusivity	m2 s-1
KAPREDI	Along-isopycnal diffusivity	m2 s-1

11.2.2 Native Variable: DIFFKR

Table 11.9: Attributes description of the variable 'DIFFKR' from OCEAN_3D_MIXING_COEFFS's dataset.

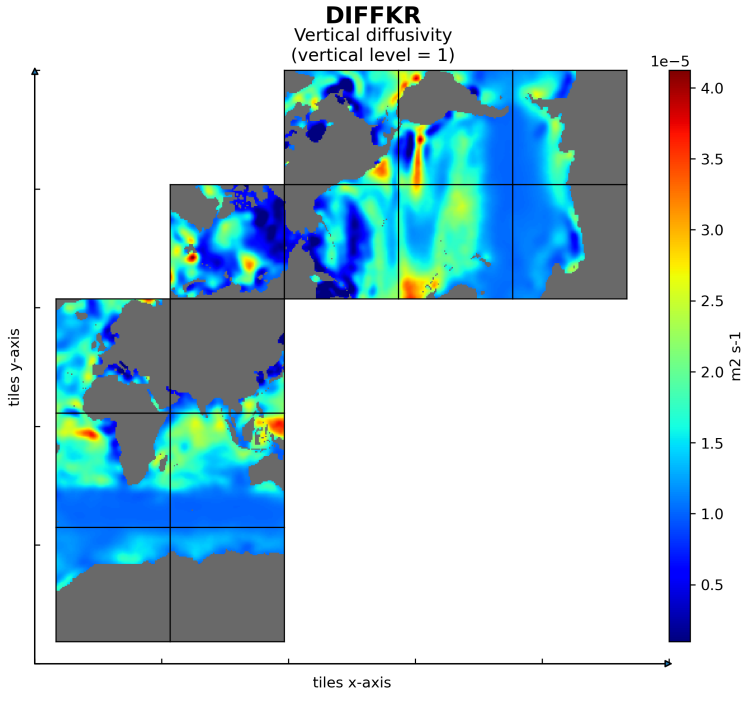
Storage Type	Variable Name	Description	Unit
float32	DIFFKR	Vertical diffusivity	m2 s-1

Description of the variable in Common Data language (CDL)

```
float32 DIFFKR(k, tile, j, i)
   DIFFKR: _FillValue = 9.96921e+36
   DIFFKR: coordinates = Z XC YC
   DIFFKR: coverage_content_type = modelResult
   DIFFKR: long_name = Vertical diffusivity
   DIFFKR: units = m2 s-1
   DIFFKR: valid_max = 0.0001854995
   DIFFKR: valid_min = 1e-06
```

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.



OCEAN_3D_MIXING_COEFFS_ECCO_V4r4_native_llc0090.nc

Figure 28: Dataset: OCEAN_3D_MIXING_COEFFS, Variable: DIFFKR

11.2.3 Native Variable: KAPGM

Table 11.10: Attributes description of the variable 'KAPGM' from OCEAN_3D_MIXING_COEFFS's dataset.

Storage Type	Variable Name	Description	Unit
float32	KAPGM	Gent-mcwilliams diffusivity	m2 s-1

Description of the variable in Common Data language (CDL)

```
float32 KAPGM(k, tile, j, i)
    KAPGM: _FillValue = 9.96921e+36
    KAPGM: coordinates = Z XC YC
    KAPGM: coverage_content_type = modelResult
    KAPGM: long_name = Gent-McWilliams diffusivity
    KAPGM: units = m2 s-1
    KAPGM: valid_max = 10000.0
    KAPGM: valid_min = 100.0
```

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.

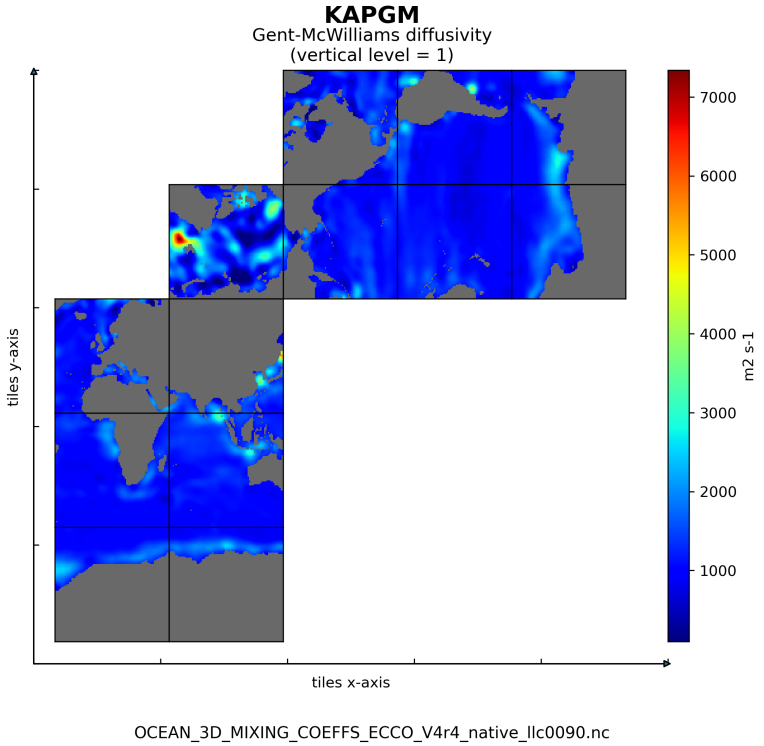


Figure 29: Dataset: OCEAN_3D_MIXING_COEFFS, Variable: KAPGM

11.2.4 Native Variable: KAPREDI

Table 11.11: Attributes description of the variable 'KAPREDI' from OCEAN_3D_MIXING_COEFFS's dataset.

Storage Type	Variable Name	Description	Unit
float32	KAPREDI	Along-isopycnal diffusivity	m2 s-1

Description of the variable in Common Data language (CDL)

```
float32 KAPREDI(k, tile, j, i)
    KAPREDI: _FillValue = 9.96921e+36
    KAPREDI: coordinates = Z XC YC
    KAPREDI: coverage_content_type = modelResult
    KAPREDI: long_name = Along-isopycnal diffusivity
    KAPREDI: units = m2 s-1
    KAPREDI: valid_max = 10000.0
    KAPREDI: valid_min = 100.0
```

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.

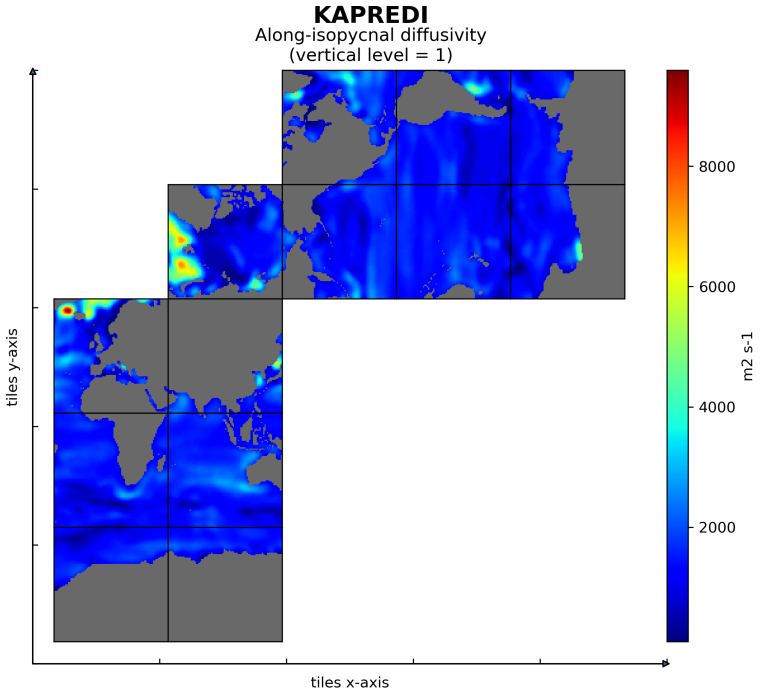


Figure 30: Dataset: OCEAN_3D_MIXING_COEFFS, Variable: KAPREDI

11.3 Native dataset of OCEAN_3D_MOMENTUM_TEND

11.3.1 Overview

This dataset provides three-dimensional ocean momentum tendency on the lat-lon-cap 90 (llc90) native model grid from the ECCO Version 4 Release 4 (V4r4) ocean and sea-ice state estimate. The dataset is provided on daily-average and monthly-average time resolution.

Table 11.12: Coordinates and Variables in the dataset OCEAN_3D_MOMENTUM_TEND

Coordinates	Description of data coordinates	Unit
i	Grid index in x for variables at tracer and 'v' locations	–none–
i_g	Grid index in x for variables at 'u' and 'g' locations	–none–
j	Grid index in y for variables at tracer and 'u' locations	–none–
j_g	Grid index in y for variables at 'v' and 'g' locations	–none–
k	Grid index in z for tracer variables	–none–
k_u	Grid index in z corresponding to the bottom face of tracer grid cells ('w' locations)	–none–
k_l	Grid index in z corresponding to the top face of tracer grid cells ('w' locations)	–none–
k_p1	Grid index in z for variables at 'w' locations	–none–
tile	Lat-lon-cap tile index	–none–
time	Center time of averaging period	–none–
XC	Longitude of tracer grid cell center	degrees_east
YC	Latitude of tracer grid cell center	degrees_north
XG	Longitude of 'southwest' corner of tracer grid cell	degrees_east
YG	Latitude of 'southwest' corner of tracer grid cell	degrees_north
Z	Depth of tracer grid cell center	m
Zp1	Depth of tracer grid cell interface	m
Zu	Depth of the bottom face of tracer grid cells	m
Zl	Depth of the top face of tracer grid cells	m
time_bnds	Time bounds of averaging period	–none–
XC_bnds	Longitudes of tracer grid cell corners	–none–
YC_bnds	Latitudes of tracer grid cell corners	–none–
Z_bnds	Depths of tracer grid cell upper and lower interfaces	–none–
Variables	**Description of data variables**	**Unit**
Um_dPHdx	Momentum tendency in the model +x direction	m s-2
Vm_dPHdy	Momentum tendency in the model +y direction	m s-2

11.3.2 Native Variable: Um_dPHdx

Table 11.13: Attributes description of the variable 'Um_dPHdx' from OCEAN_3D_MOMENTUM_TEND's dataset.

Storage Type	Variable Name	Description	Unit
float32	Um_dPHdx	Momentum tendency in the model +x direction	m s-2

Description of the variable in Common Data language (CDL)

```
float32 Um_dPHdx(time, k, tile, j, i_g)
    Um_dPHdx:  _FillValue = 9.96921e+36
    Um_dPHdx:  coordinates = time Z
    Um_dPHdx:  coverage_content_type = modelResult
    Um_dPHdx:  long_name = Momentum tendency in the model +x direction
    Um_dPHdx:  mate = Vm dPHdy
    Um_dPHdx:  units = m s-2
    Um_dPHdx:  valid_max = 0.0011411579325795174
    Um_dPHdx:  valid_min = -0.0010651482734829187
```

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.

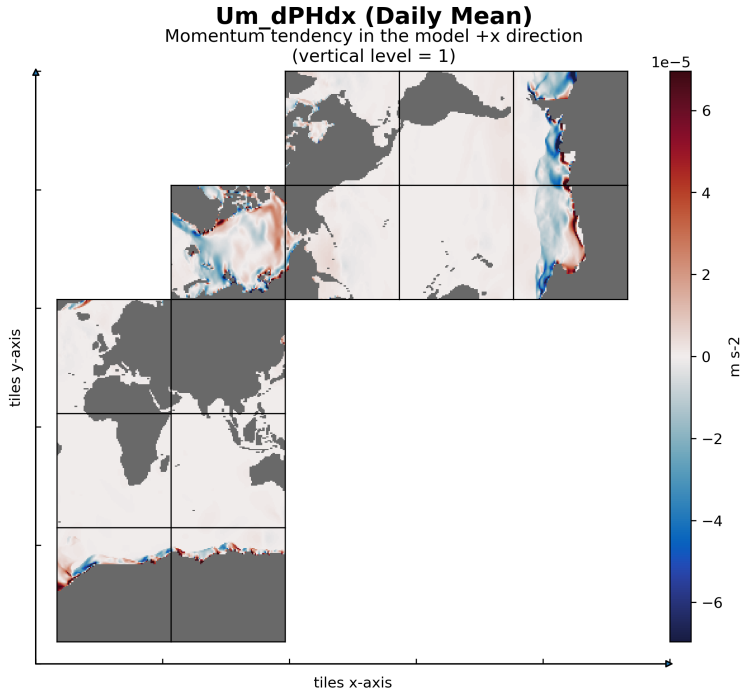


Figure 31: Dataset: OCEAN_3D_MOMENTUM_TEND, Variable: Um_dPHdx

11.3.3 Native Variable: Vm_dPHdy

Table 11.14: Attributes description of the variable 'Vm_dPHdy' from OCEAN_3D_MOMENTUM_TEND's dataset.

Storage Type	Variable Name	Description	Unit
float32	Vm_dPHdy	Momentum tendency in the model +y direction	m s-2

Description of the variable in Common Data language (CDL)

```
float32 Vm_dPHdy(time, k, tile, j_g, i)
    Vm_dPHdy:  _FillValue = 9.96921e+36
    Vm_dPHdy:  coordinates = time Z
    Vm_dPHdy:  coverage_content_type = modelResult
    Vm_dPHdy:  long_name = Momentum tendency in the model +y direction
    Vm_dPHdy:  mate = Um dPHdx
    Vm_dPHdy:  units = m s-2
    Vm_dPHdy:  valid_max = 0.0008858146029524505
    Vm_dPHdy:  valid_min = -0.0015932790702208877
```

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.

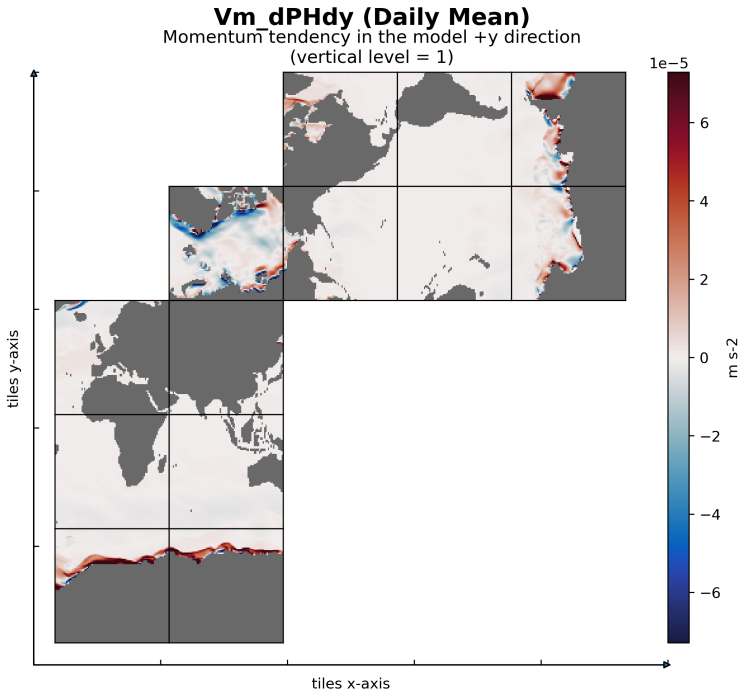


Figure 32: Dataset: OCEAN_3D_MOMENTUM_TEND, Variable: Vm_dPHdy

11.4 Native dataset of OCEAN_3D_SALINITY_FLUX

11.4.1 Overview

This dataset provides three-dimensional ocean salinity fluxes on the lat-lon-cap 90 (llc90) native model grid from the ECCO Version 4 Release 4 (V4r4) ocean and sea-ice state estimate. The dataset is provided on daily-average and monthly-average time resolution. ADV*_SLT and DF*_SLT terms are salinity fluxes. oceSPtnd is salt tendency per unit area (g m-2 s-1), not salinity flux.

Table 11.15: Coordinates and Variables in the dataset OCEAN_3D_SALINITY_FLUX

Coordinates	Description of data coordinates	Unit
i	Grid index in x for variables at tracer and 'v' locations	–none–
i_g	Grid index in x for variables at 'u' and 'g' locations	–none–
j	Grid index in y for variables at tracer and 'u' locations	–none–
j_g	Grid index in y for variables at 'v' and 'g' locations	–none–
k	Grid index in z for tracer variables	–none–
k_u	Grid index in z corresponding to the bottom face of tracer grid cells ('w' locations)	–none–
k_l	Grid index in z corresponding to the top face of tracer grid cells ('w' locations)	–none–
k_p1	Grid index in z for variables at 'w' locations	–none–
tile	Lat-lon-cap tile index	–none–
time	Center time of averaging period	–none–
XC	Longitude of tracer grid cell center	degrees_east
YC	Latitude of tracer grid cell center	degrees_north
XG	Longitude of 'southwest' corner of tracer grid cell	degrees_east
YG	Latitude of 'southwest' corner of tracer grid cell	degrees_north
Z	Depth of tracer grid cell center	m
Zp1	Depth of tracer grid cell interface	m
Zu	Depth of the bottom face of tracer grid cells	m
Zl	Depth of the top face of tracer grid cells	m
time_bnds	Time bounds of averaging period	–none–
XC_bnds	Longitudes of tracer grid cell corners	–none–
YC_bnds	Latitudes of tracer grid cell corners	–none–
Z_bnds	Depths of tracer grid cell upper and lower interfaces	–none–
Variables	**Description of data variables**	**Unit**
ADVx_SLT	Lateral advective flux of salinity in the model +x direction	1e-3 m3 s-1
DFxE_SLT	Lateral diffusive flux of salinity in the model +x direction	1e-3 m3 s-1
ADVy_SLT	Lateral advective flux of salinity in the model +y direction	1e-3 m3 s-1
DFyE_SLT	Lateral diffusive flux of salinity in the model +y direction	1e-3 m3 s-1
ADVr_SLT	Vertical advective flux of salinity	1e-3 m3 s-1
DFrE_SLT	Vertical diffusive flux of salinity (explicit term)	1e-3 m3 s-1
DFrI_SLT	Vertical diffusive flux of salinity (implicit term)	1e-3 m3 s-1
oceSPtnd	Salt tendency due to the vertical transport of salt in high-salinity brine plumes	g m-2 s-1

11.4.2 Native Variable: ADVr_SLT

Table 11.16: Attributes description of the variable 'ADVr_SLT' from OCEAN_3D_SALINITY_FLUX's dataset.

Storage Type	Variable Name	Description	Unit
float32	ADVr_SLT	Vertical advective flux of salinity	1e-3 m3 s-1

Description of the variable in Common Data language (CDL)

```
float32 ADVr_SLT(time, k_l, tile, j, i)
    ADVr_SLT: _FillValue = 9.96921e+36
    ADVr_SLT: coordinates = XC Z1 YC time
    ADVr_SLT: coverage_content_type = modelResult
    ADVr_SLT: direction = >0 decreases salinity (SALT)
    ADVr_SLT: long_name = Vertical advective flux of salinity
    ADVr_SLT: units = 1e-3 m3 s-1
    ADVr_SLT: valid_max = 263294624.0
    ADVr_SLT: valid_min = -324149856.0
```

Comments

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

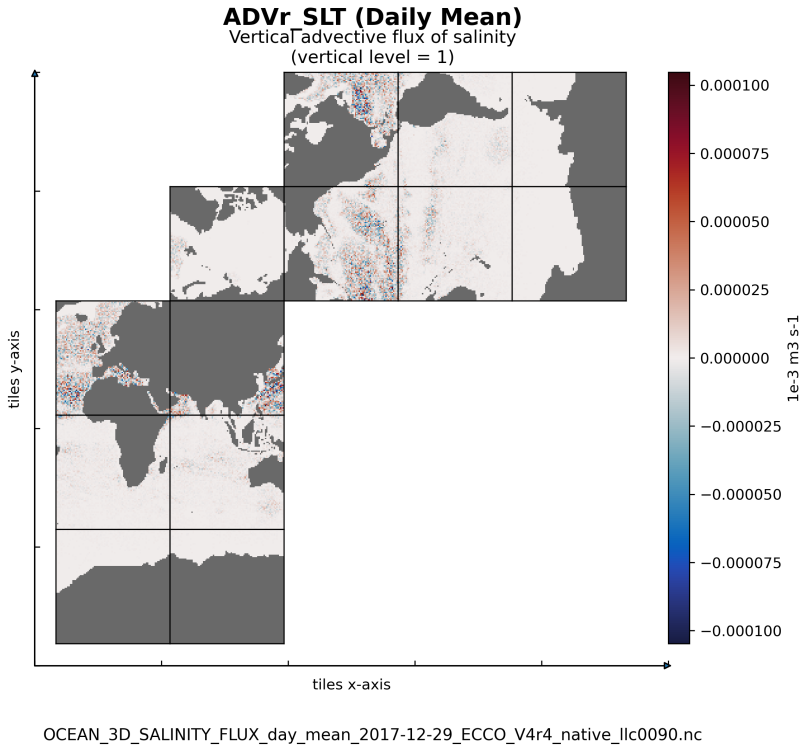


Figure 33: Dataset: OCEAN_3D_SALINITY_FLUX, Variable: ADVr_SLT

11.4.3 Native Variable: ADVx_SLT

Table 11.17: Attributes description of the variable 'ADVx_SLT' from OCEAN_3D_SALINITY_FLUX's dataset.

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

Description of the variable in Common Data language (CDL)

```
float32 ADVx_SLT(time, k, tile, j, i_g)
    ADVx_SLT: _FillValue = 9.96921e+36
    ADVx_SLT: coordinates = Z time
    ADVx_SLT: coverage_content_type = modelResult
    ADVx_SLT: direction = >0 increases salinity (SALT)
    ADVx_SLT: long_name = Lateral advective flux of salinity in the model +x direction
    ADVx_SLT: mate = ADVy SLT
    ADVx_SLT: units = 1e-3 m3 s-1
    ADVx_SLT: valid_max = 260411296.0
    ADVx_SLT: valid_min = -181830224.0
```

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

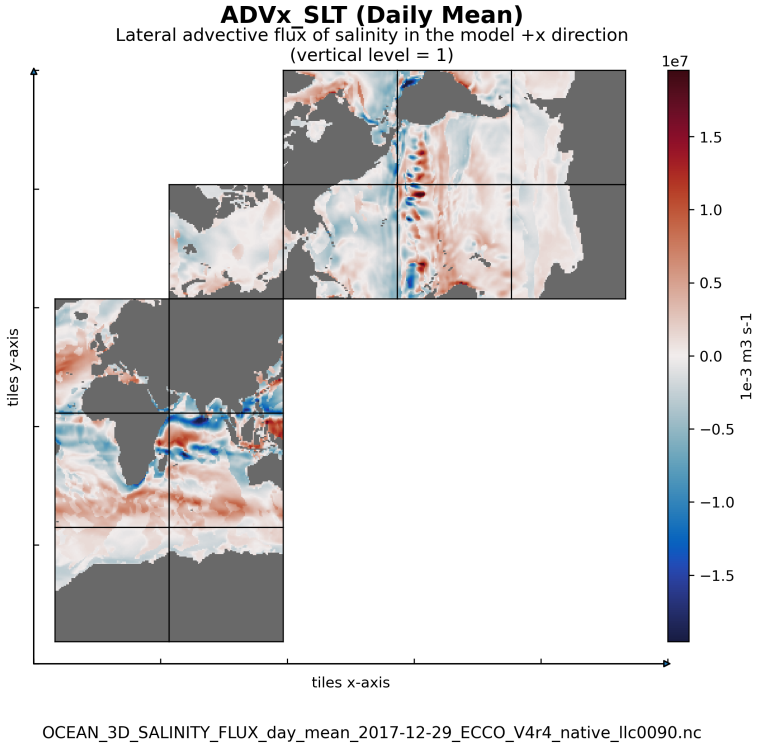


Figure 34: Dataset: OCEAN_3D_SALINITY_FLUX, Variable: ADVx_SLT

11.4.4 Native Variable: ADVy_SLT

Table 11.18: Attributes description of the variable 'ADVy_SLT' from OCEAN_3D_SALINITY_FLUX's dataset.

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

Description of the variable in Common Data language (CDL)

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

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

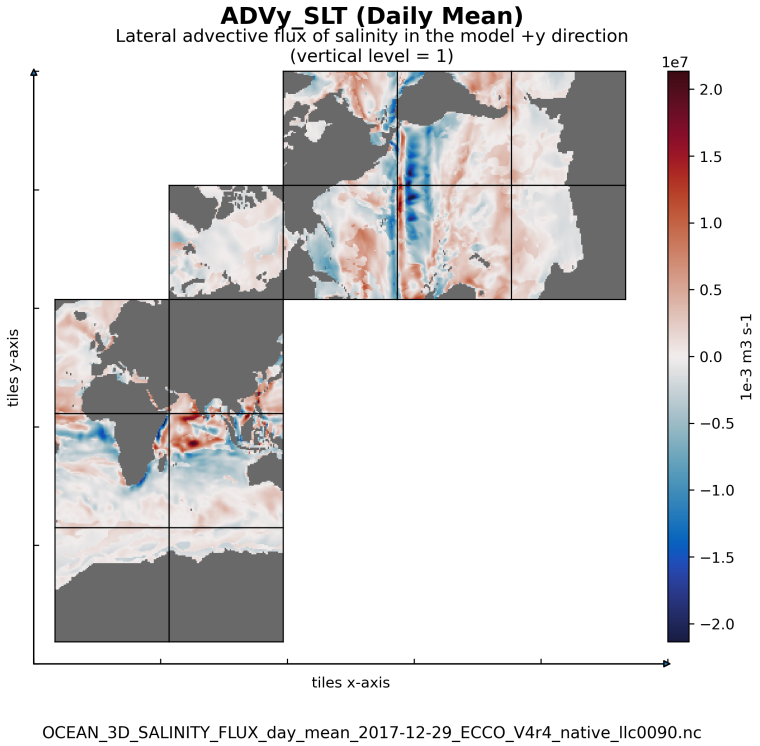


Figure 35: Dataset: OCEAN_3D_SALINITY_FLUX, Variable: ADVy_SLT

11.4.5 Native Variable: DFrE_SLT

Table 11.19: Attributes description of the variable 'DFrE_SLT' from OCEAN_3D_SALINITY_FLUX's dataset.

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

Description of the variable in Common Data language (CDL)

```
float32 DFrE_SLT(time, k_l, tile, j, i)
    DFrE_SLT: _FillValue = 9.96921e+36
    DFrE_SLT: coordinates = XC Z1 YC time
    DFrE_SLT: coverage_content_type = modelResult
    DFrE_SLT: direction = >0 decreases salinity (SALT)
    DFrE_SLT: long_name = Vertical diffusive flux of salinity (explicit term)
    DFrE_SLT: units = 1e-3 m3 s-1
    DFrE_SLT: valid_max = 471215.75
    DFrE_SLT: valid_min = -1074719.375
```

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

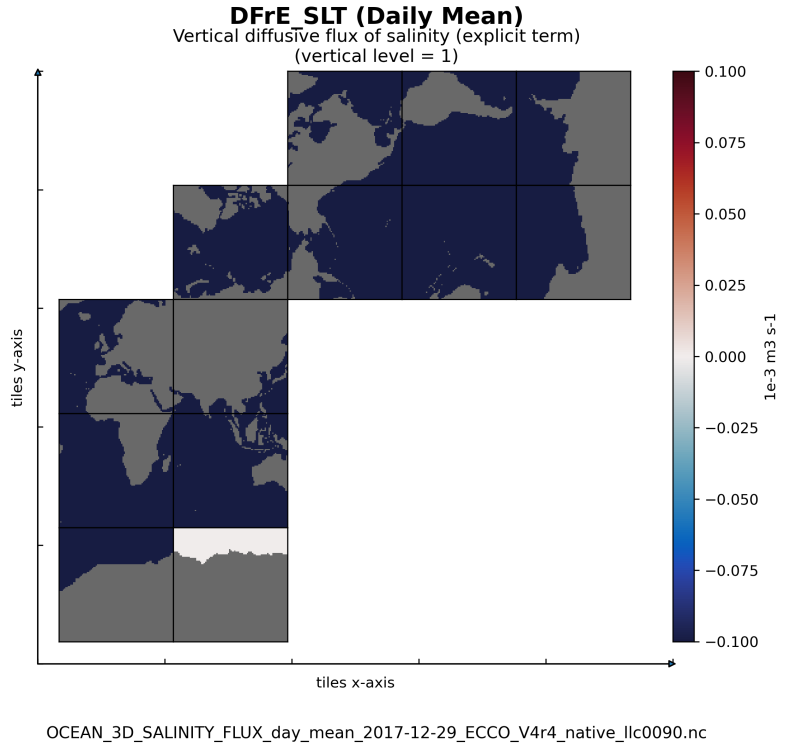


Figure 36: Dataset: OCEAN_3D_SALINITY_FLUX, Variable: DFrE_SLT

11.4.6 Native Variable: DFrI_SLT

Table 11.20: Attributes description of the variable 'DFrI_SLT' from OCEAN_3D_SALINITY_FLUX's dataset.

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

Description of the variable in Common Data language (CDL)

```
float32 DFrI_SLT(time, k_l, tile, j, i)
    DFrI_SLT: _FillValue = 9.96921e+36
    DFrI_SLT: coordinates = XC Z1 YC time
    DFrI_SLT: coverage_content_type = modelResult
    DFrI_SLT: direction = >0 decreases salinity (SALT)
    DFrI_SLT: long_name = Vertical diffusive flux of salinity (implicit term)
    DFrI_SLT: units = 1e-3 m3 s-1
    DFrI_SLT: valid_max = 3197643.0
    DFrI_SLT: valid_min = -30609048.0
```

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

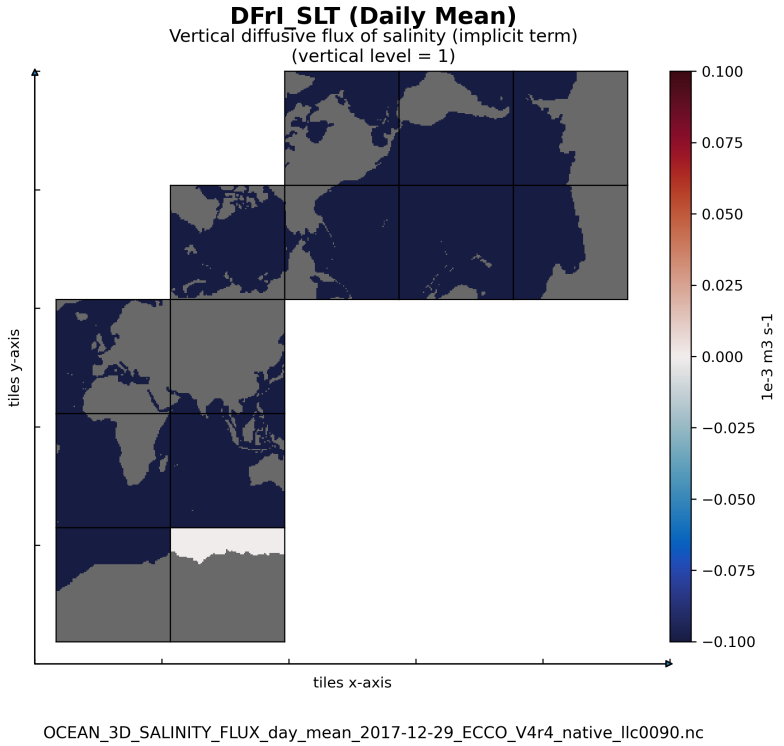


Figure 37: Dataset: OCEAN_3D_SALINITY_FLUX, Variable: DFrI_SLT

11.4.7 Native Variable: DFxE_SLT

Table 11.21: Attributes description of the variable 'DFxE_SLT' from OCEAN_3D_SALINITY_FLUX's dataset.

Storage Type	Variable Name	Description	Unit
float32	DFxE_SLT	Lateral diffusive flux of salinity in the model +x direction	1e-3 m3 s-1

Description of the variable in Common Data language (CDL)

```
float32 DFxE_SLT(time, k, tile, j, i_g)
    DFxE_SLT: _FillValue = 9.96921e+36
    DFxE_SLT: coordinates = Z time
    DFxE_SLT: coverage_content_type = modelResult
    DFxE_SLT: direction = >0 increases salinity (SALT)
    DFxE_SLT: long_name = Lateral diffusive flux of salinity in the model +x direction
    DFxE_SLT: mate = DFyE SLT
    DFxE_SLT: units = 1e-3 m3 s-1
    DFxE_SLT: valid_max = 192716.484375
    DFxE_SLT: valid_min = -125908.03125
```

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

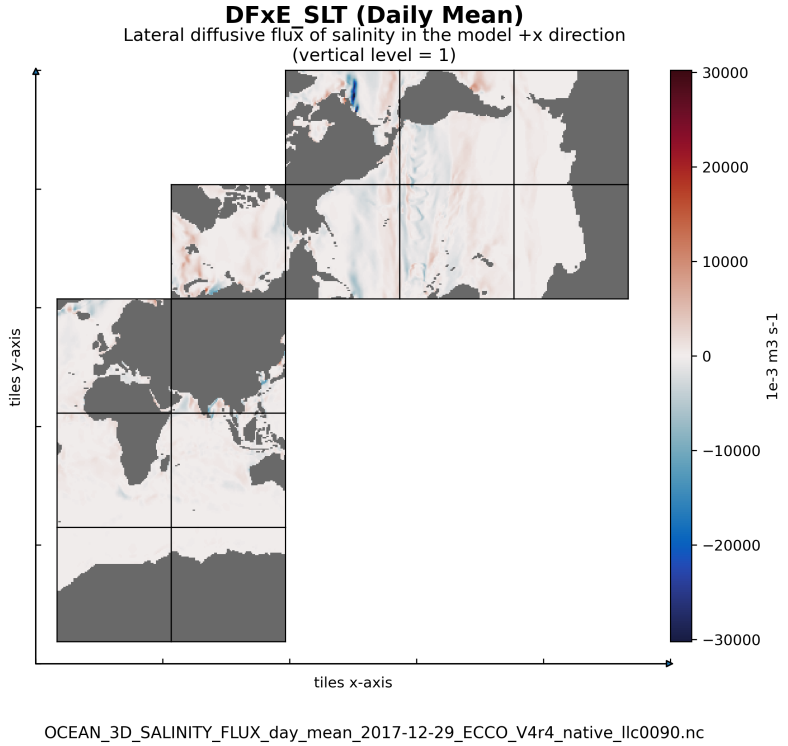


Figure 38: Dataset: OCEAN_3D_SALINITY_FLUX, Variable: DFxE_SLT

11.4.8 Native Variable: DFyE_SLT

Table 11.22: Attributes description of the variable 'DFyE_SLT' from OCEAN_3D_SALINITY_FLUX's dataset.

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

Description of the variable in Common Data language (CDL)

```
float32 DFyE_SLT(time, k, tile, j_g, i)
    DFyE_SLT: _FillValue = 9.96921e+36
    DFyE_SLT: coordinates = Z time
    DFyE_SLT: coverage_content_type = modelResult
    DFyE_SLT: direction = >0 increases salinity (SALT)
    DFyE_SLT: long_name = Lateral diffusive flux of salinity in the model +y direction
    DFyE_SLT: mate = DFxE SLT
    DFyE_SLT: units = 1e-3 m3 s-1
    DFyE_SLT: valid_max = 154227.140625
    DFyE_SLT: valid_min = -114959.2109375
```

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

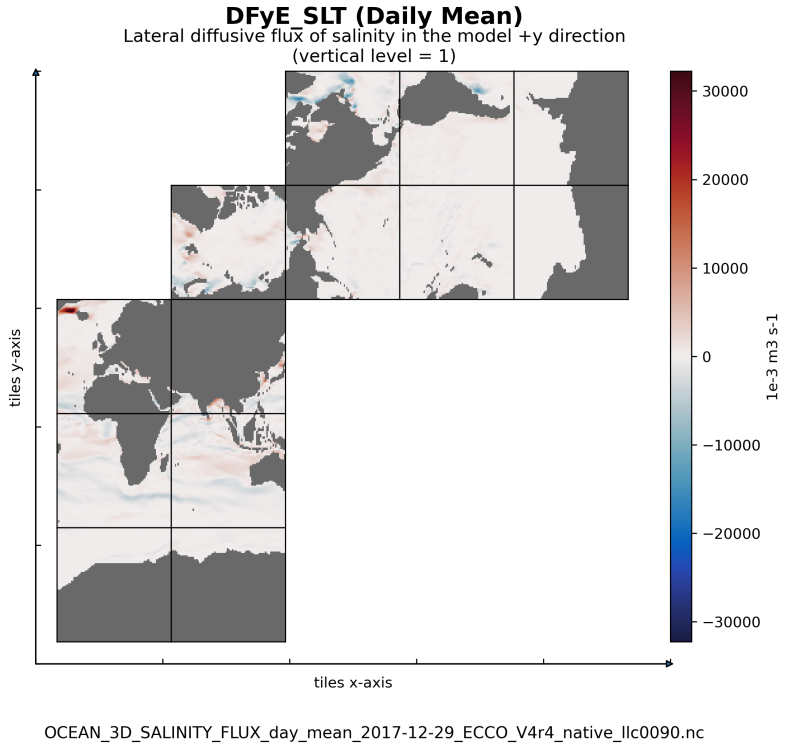


Figure 39: Dataset: OCEAN_3D_SALINITY_FLUX, Variable: DFyE_SLT

11.4.9 Native Variable: oceSPtnd

Table 11.23: Attributes description of the variable 'oceSPtnd' from OCEAN_3D_SALINITY_FLUX's dataset.

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

Description of the variable in Common Data language (CDL)

```
float32 oceSPtnd(time, k, tile, j, i)
    oceSPtnd:  _FillValue = 9.96921e+36
    oceSPtnd:  coordinates = XC Z YC time
    oceSPtnd:  coverage_content_type = modelResult
    oceSPtnd:  direction = >0 increases salinity (SALT)
    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:  valid_max = 0.021119138225913048
    oceSPtnd:  valid_min = 0.0
```

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.

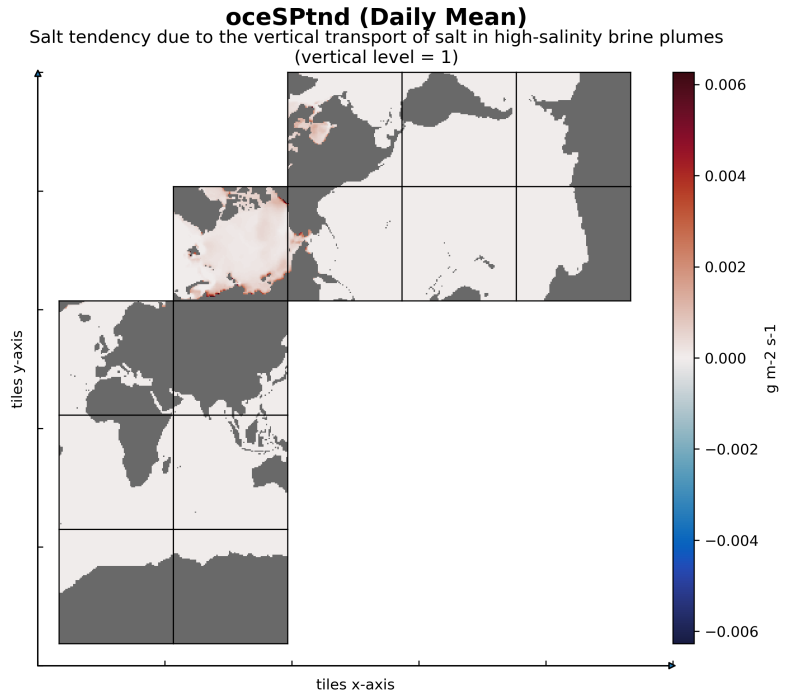


Figure 40: Dataset: OCEAN_3D_SALINITY_FLUX, Variable: oceSPtnd

11.5 Native dataset of OCEAN_3D_TEMPERATURE_FLUX

11.5.1 Overview

This dataset provides three-dimensional ocean potential temperature fluxes on the lat-lon-cap 90 (llc90) native model grid from the ECCO Version 4 Release 4 (V4r4) ocean and sea-ice state estimate. The dataset is provided on daily-average and monthly-average time resolution. ADV*_TH and DF*_TH terms are potential temperature fluxes.

Table 11.24: Coordinates and Variables in the dataset OCEAN_3D_TEMPERATURE_FLUX

Coordinates	Description of data coordinates	Unit
i	Grid index in x for variables at tracer and 'v' locations	–none–
i_g	Grid index in x for variables at 'u' and 'g' locations	–none–
j	Grid index in y for variables at tracer and 'u' locations	–none–
j_g	Grid index in y for variables at 'v' and 'g' locations	–none–
k	Grid index in z for tracer variables	–none–
k_u	Grid index in z corresponding to the bottom face of tracer grid cells ('w' locations)	–none–
k_l	Grid index in z corresponding to the top face of tracer grid cells ('w' locations)	–none–
k_p1	Grid index in z for variables at 'w' locations	–none–
tile	Lat-lon-cap tile index	–none–
time	Center time of averaging period	–none–
XC	Longitude of tracer grid cell center	degrees_east
YC	Latitude of tracer grid cell center	degrees_north
XG	Longitude of 'southwest' corner of tracer grid cell	degrees_east
YG	Latitude of 'southwest' corner of tracer grid cell	degrees_north
Z	Depth of tracer grid cell center	m
Zp1	Depth of tracer grid cell interface	m
Zu	Depth of the bottom face of tracer grid cells	m
Zl	Depth of the top face of tracer grid cells	m
time_bnds	Time bounds of averaging period	–none–
XC_bnds	Longitudes of tracer grid cell corners	–none–
YC_bnds	Latitudes of tracer grid cell corners	–none–
Z_bnds	Depths of tracer grid cell upper and lower interfaces	–none–
Variables	**Description of data variables**	**Unit**
ADVx_TH	Lateral advective flux of potential temperature in the model +x direction	degree_C m3 s-1
DFxE_TH	Lateral diffusive flux of potential temperature in the model +x direction	degree_C m3 s-1
ADVy_TH	Lateral advective flux of potential temperature in the model +y direction	degree_C m3 s-1
DFyE_TH	Lateral diffusive flux of potential temperature in the model +y direction.	degree_C m3 s-1
ADVr_TH	Vertical advective flux of potential temperature	degree_C m3 s-1
DFrE_TH	Vertical diffusive flux of potential temperature (explicit term)	degree_C m3 s-1
DFrI_TH	Vertical diffusive flux of potential temperature (implicit term)	degree_C m3 s-1

11.5.2 Native Variable: ADVr_TH

Table 11.25: Attributes description of the variable 'ADVr_TH' from OCEAN_3D_TEMPERATURE_FLUX's dataset.

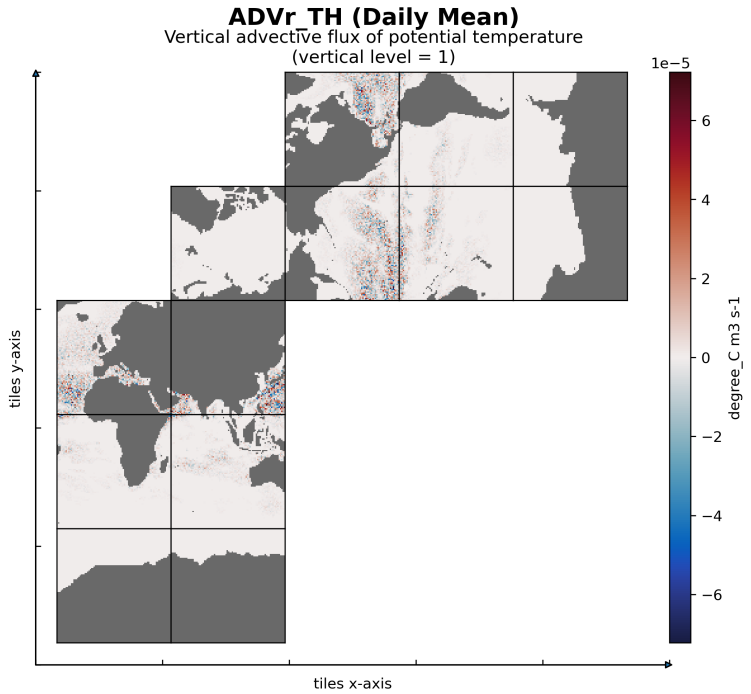
Storage Type	Variable Name	Description	Unit
float32	ADVr_TH	Vertical advective flux of potential temperature	degree_C m3 s-1

Description of the variable in Common Data language (CDL)

```
float32 ADVr_TH(time, k_l, tile, j, i)
    ADVr_TH: _FillValue = 9.96921e+36
    ADVr_TH: coordinates = XC YC time Zl
    ADVr_TH: coverage_content_type = modelResult
    ADVr_TH: direction = >0 decreases potential temperature (THETA)
    ADVr_TH: long_name = Vertical advective flux of potential temperature
    ADVr_TH: units = degree C m3 s-1
    ADVr_TH: valid_max = 179459344.0
    ADVr_TH: valid_min = -125094904.0
```

Comments

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)



OCEAN_3D_TEMPERATURE_FLUX_day_mean_2017-12-29_ECCO_V4r4_native_llc0090.nc

Figure 41: Dataset: OCEAN_3D_TEMPERATURE_FLUX, Variable: ADVr_TH

11.5.3 Native Variable: ADVx_TH

Table 11.26: Attributes description of the variable 'ADVx_TH' from OCEAN_3D_TEMPERATURE_FLUX's dataset.

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

Description of the variable in Common Data language (CDL)

```
float32 ADVx_TH(time, k, tile, j, i_g)
   ADVx_TH: _FillValue = 9.96921e+36
   ADVx_TH: coordinates = time Z
   ADVx_TH: coverage_content_type = modelResult
   ADVx_TH: direction = >0 increases potential temperature (THETA)
   ADVx_TH: long_name = Lateral advective flux of potential temperature in the model +x direction
   ADVx_TH: mate = ADVy TH
   ADVx_TH: units = degree C m3 s-1
   ADVx_TH: valid_max = 38049636.0
   ADVx_TH: valid_min = -38210700.0
```

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.

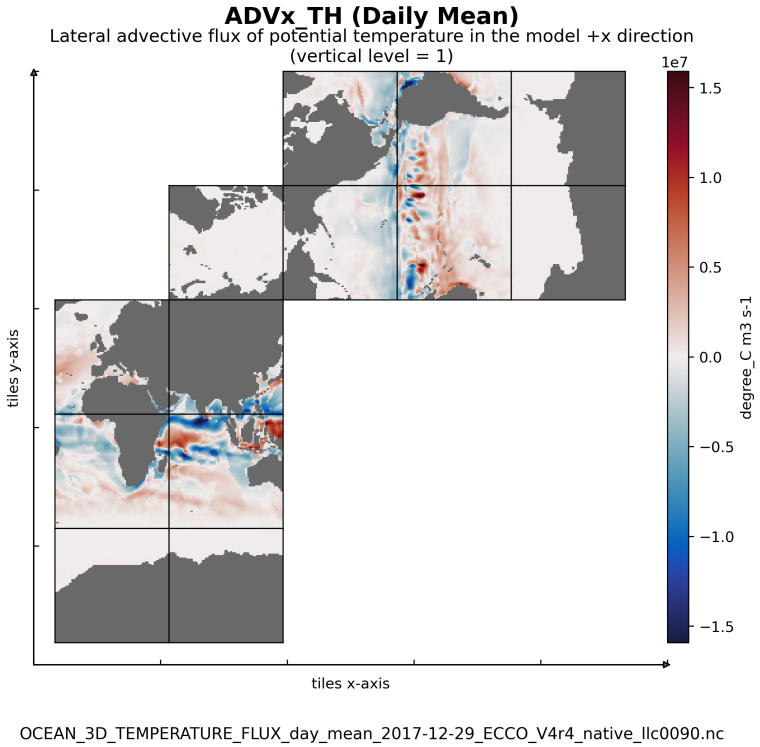


Figure 42: Dataset: OCEAN_3D_TEMPERATURE_FLUX, Variable: ADVx_TH

11.5.4 Native Variable: ADVy_TH

Table 11.27: Attributes description of the variable 'ADVy_TH' from OCEAN_3D_TEMPERATURE_FLUX's dataset.

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

Description of the variable in Common Data language (CDL)

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

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.

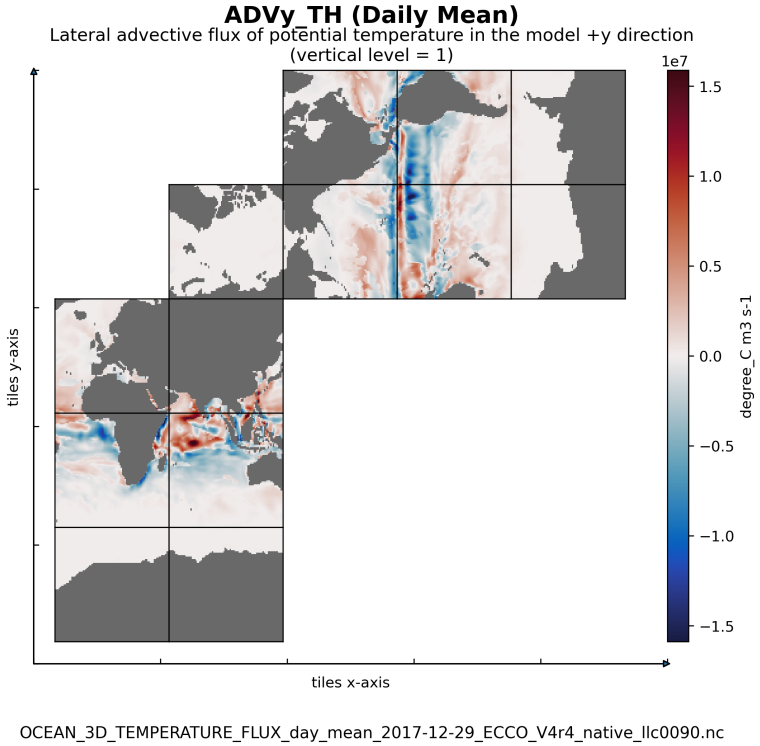


Figure 43: Dataset: OCEAN_3D_TEMPERATURE_FLUX, Variable: ADVy_TH

11.5.5 Native Variable: DFrE_TH

Table 11.28: Attributes description of the variable 'DFrE_TH' from OCEAN_3D_TEMPERATURE_FLUX's dataset.

Storage Type	Variable Name	Description	Unit
float32	DFrE_TH	Vertical diffusive flux of potential temperature (explicit term)	degree_C m3 s-1

Description of the variable in Common Data language (CDL)

```
float32 DFrE_TH(time, k_l, tile, j, i)
    DFrE_TH: _FillValue = 9.96921e+36
    DFrE_TH: coordinates = XC YC time Zl
    DFrE_TH: coverage_content_type = modelResult
    DFrE_TH: direction = >0 decreases potential temperature (THETA)
    DFrE_TH: long_name = Vertical diffusive flux of potential temperature (explicit term)
    DFrE_TH: units = degree C m3 s-1
    DFrE_TH: valid_max = 2659875.25
    DFrE_TH: valid_min = -2632379.75
```

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).

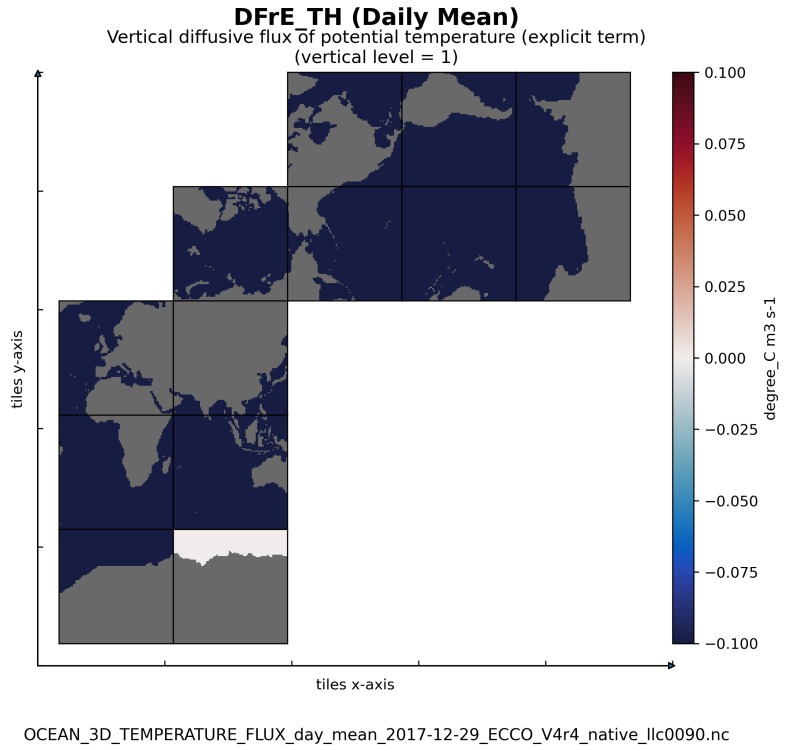


Figure 44: Dataset: OCEAN_3D_TEMPERATURE_FLUX, Variable: DFrE_TH

11.5.6 Native Variable: DFrI_TH

Table 11.29: Attributes description of the variable 'DFrI_TH' from OCEAN_3D_TEMPERATURE_FLUX's dataset.

Storage Type	Variable Name	Description	Unit
float32	DFrI_TH	Vertical diffusive flux of potential temperature (implicit term)	degree_C m3 s-1

Description of the variable in Common Data language (CDL)

```
float32 DFrI_TH(time, k_l, tile, j, i)
    DFrI_TH: _FillValue = 9.96921e+36
    DFrI_TH: coordinates = XC YC time Zl
    DFrI_TH: coverage_content_type = modelResult
    DFrI_TH: direction = >0 decreases potential temperature (THETA)
    DFrI_TH: long_name = Vertical diffusive flux of potential temperature (implicit term)
    DFrI_TH: units = degree C m3 s-1
    DFrI_TH: valid_max = 23574302.0
    DFrI_TH: valid_min = -104210688.0
```

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)

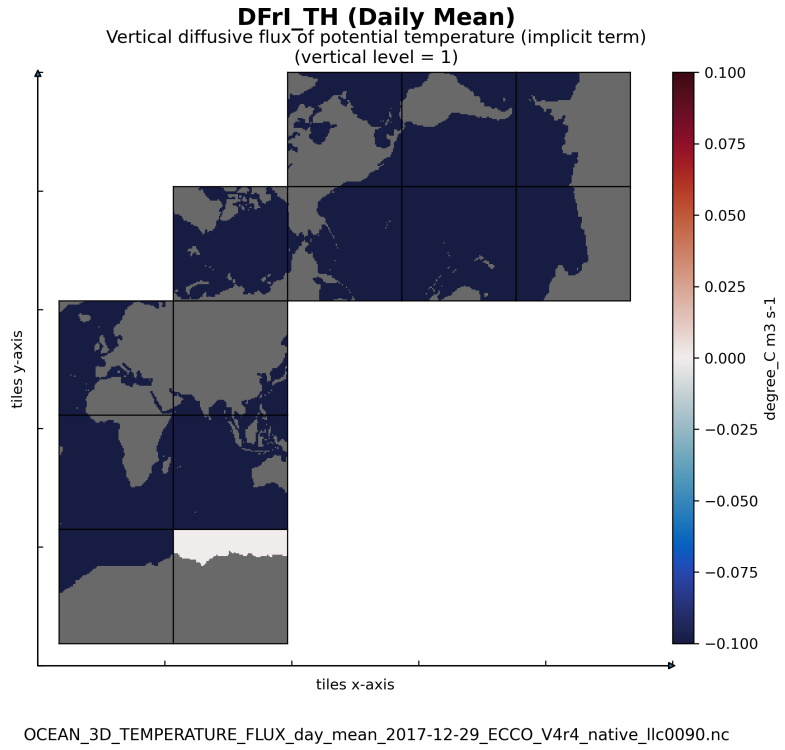


Figure 45: Dataset: OCEAN_3D_TEMPERATURE_FLUX, Variable: DFrI_TH

11.5.7 Native Variable: DFxE_TH

Table 11.30: Attributes description of the variable 'DFxE_TH' from OCEAN_3D_TEMPERATURE_FLUX's dataset.

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

Description of the variable in Common Data language (CDL)

```
float32 DFxE_TH(time, k, tile, j, i_g)
   DFxE_TH: _FillValue = 9.96921e+36
   DFxE_TH: coordinates = time Z
   DFxE_TH: coverage_content_type = modelResult
   DFxE_TH: direction = >0 increases potential temperature (THETA)
   DFxE_TH: long_name = Lateral diffusive flux of potential temperature in the model +x direction
   DFxE_TH: mate = DFyE TH
   DFxE_TH: units = degree C m3 s-1
   DFxE_TH: valid_max = 698695.75
   DFxE_TH: valid_min = -582494.125
```

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.

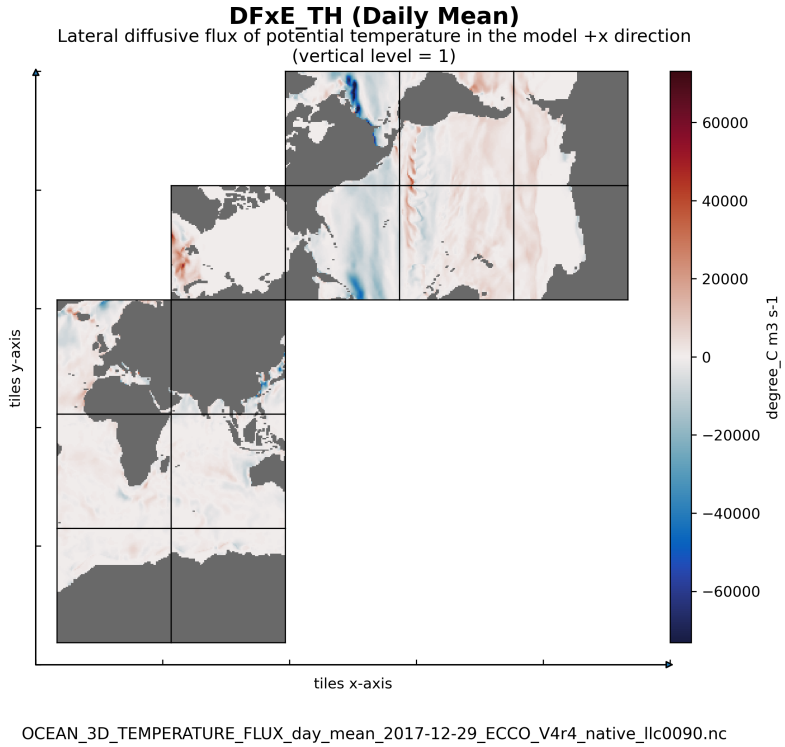


Figure 46: Dataset: OCEAN_3D_TEMPERATURE_FLUX, Variable: DFxE_TH

11.5.8 Native Variable: DFyE_TH

Table 11.31: Attributes description of the variable 'DFyE_TH' from OCEAN_3D_TEMPERATURE_FLUX's dataset.

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

Description of the variable in Common Data language (CDL)

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

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.

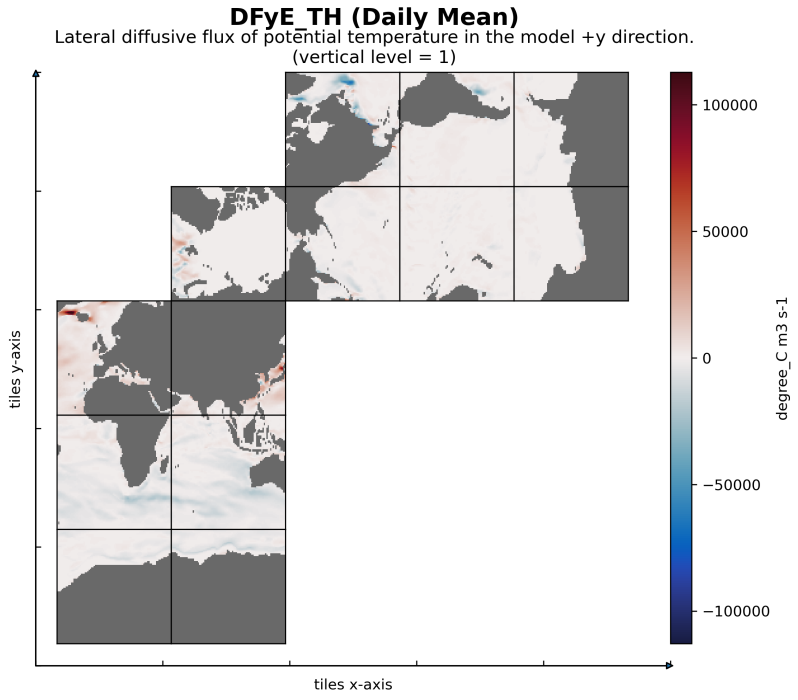


Figure 47: Dataset: OCEAN_3D_TEMPERATURE_FLUX, Variable: DFyE_TH

11.6 Native dataset of OCEAN_3D_VOLUME_FLUX

11.6.1 Overview

This dataset provides three-dimensional ocean volume fluxes on the lat-lon-cap 90 (llc90) native model grid from the ECCO Version 4 Release 4 (V4r4) ocean and sea-ice state estimate. The dataset is provided on daily-average and monthly-average time resolution. Volume flux in +x direction = UVELMASS drF dyG. Volume flux in +y direction = VVELMASS drF dxG. Volume flux in +z direction = WVELMASS drA.

Table 11.32: Coordinates and Variables in the dataset OCEAN_3D_VOLUME_FLUX

Coordinates	Description of data coordinates	Unit
i	Grid index in x for variables at tracer and 'v' locations	–none–
i_g	Grid index in x for variables at 'u' and 'g' locations	–none–
j	Grid index in y for variables at tracer and 'u' locations	–none–
j_g	Grid index in y for variables at 'v' and 'g' locations	–none–
k	Grid index in z for tracer variables	–none–
k_u	Grid index in z corresponding to the bottom face of tracer grid cells ('w' locations)	–none–
k_l	Grid index in z corresponding to the top face of tracer grid cells ('w' locations)	–none–
k_p1	Grid index in z for variables at 'w' locations	–none–
tile	Lat-lon-cap tile index	–none–
time	Center time of averaging period	–none–
XC	Longitude of tracer grid cell center	degrees_east
YC	Latitude of tracer grid cell center	degrees_north
XG	Longitude of 'southwest' corner of tracer grid cell	degrees_east
YG	Latitude of 'southwest' corner of tracer grid cell	degrees_north
Z	Depth of tracer grid cell center	m
Zp1	Depth of tracer grid cell interface	m
Zu	Depth of the bottom face of tracer grid cells	m
Zl	Depth of the top face of tracer grid cells	m
time_bnds	Time bounds of averaging period	–none–
XC_bnds	Longitudes of tracer grid cell corners	–none–
YC_bnds	Latitudes of tracer grid cell corners	–none–
Z_bnds	Depths of tracer grid cell upper and lower interfaces	–none–
Variables	**Description of data variables**	**Unit**
UVELMASS	Horizontal velocity in the model +x direction per unit area of the grid cell 'u' face	m s-1
VVELMASS	Horizontal velocity in the model +y direction per unit area of the grid cell 'v' face	m s-1 m3 m-3
WVELMASS	Grid cell face-averaged vertical velocity in the model +z direction.	m s-1

11.6.2 Native Variable: UVELMASS

Table 11.33: Attributes description of the variable 'UVELMASS' from OCEAN_3D_VOLUME_FLUX's dataset.

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

Description of the variable in Common Data language (CDL)

```
float32 UVELMASS(time, k, tile, j, i_g)
    UVELMASS: _FillValue = 9.96921e+36
    UVELMASS: coordinates = Z time
    UVELMASS: coverage_content_type = modelResult
    UVELMASS: direction = >0 increases volume
    UVELMASS: long_name = Horizontal velocity in the model +x direction per unit area of the grid cell u
face
    UVELMASS: mate = VVELMASS
    UVELMASS: units = m s-1
    UVELMASS: valid_max = 2.0377726554870605
    UVELMASS: valid_min = -2.115365505218506
```

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

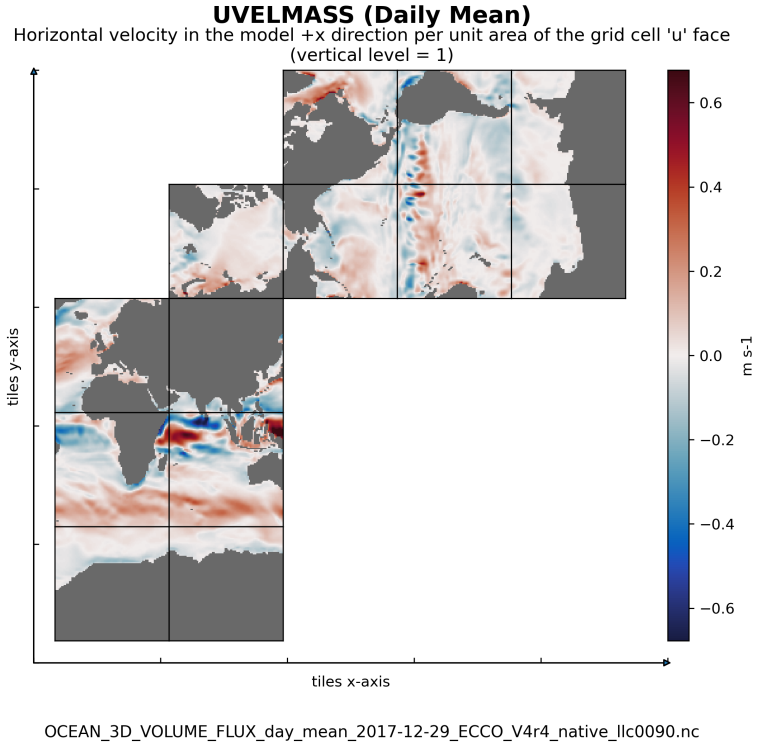


Figure 48: Dataset: OCEAN_3D_VOLUME_FLUX, Variable: UVELMASS

11.6.3 Native Variable: VVELMASS

Table 11.34: Attributes description of the variable 'VVELMASS' from OCEAN_3D_VOLUME_FLUX's dataset.

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

Description of the variable in Common Data language (CDL)

```
float32 VVELMASS(time, k, tile, j_g, i)
    VVELMASS: _FillValue = 9.96921e+36
    VVELMASS: coordinates = Z time
    VVELMASS: coverage_content_type = modelResult
    VVELMASS: direction = >0 increases volume
    VVELMASS: long_name = Horizontal velocity in the model +y direction per unit area of the grid cell v
face
    VVELMASS: mate = UVELMASS
    VVELMASS: units = m s-1 m3 m-3
    VVELMASS: valid_max = 1.9216758012771606
    VVELMASS: valid_min = -1.7897182703018188
```

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.

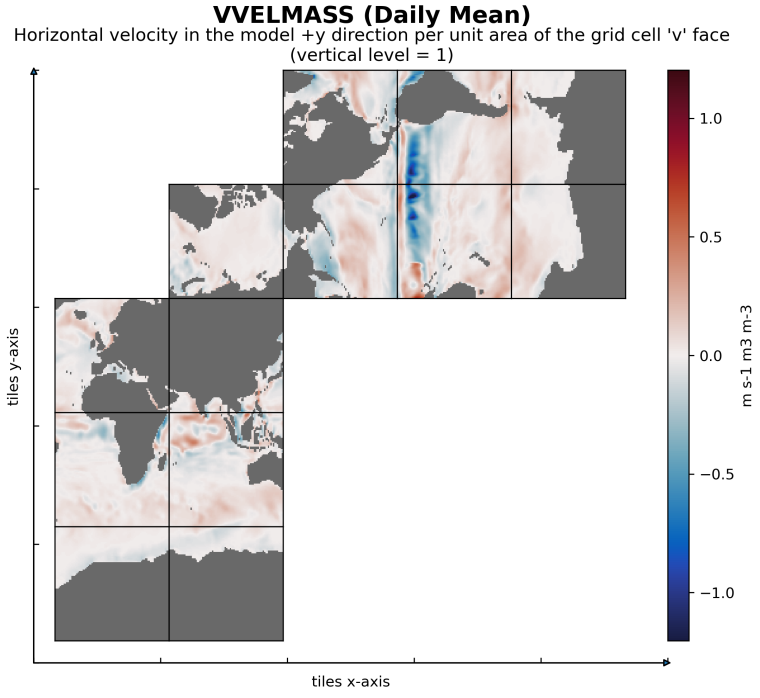


Figure 49: Dataset: OCEAN_3D_VOLUME_FLUX, Variable: VVELMASS

11.6.4 Native Variable: WVELMASS

Table 11.35: Attributes description of the variable 'WVELMASS' from OCEAN_3D_VOLUME_FLUX's dataset.

Storage Type	Variable Name	Description	Unit
float32	WVELMASS	Grid cell face-averaged vertical velocity in the model +z direction.	m s-1

Description of the variable in Common Data language (CDL)

```
float32 WVELMASS(time, k_l, tile, j, i)
    WVELMASS: _FillValue = 9.96921e+36
    WVELMASS: coordinates = YC Z1 time XC
    WVELMASS: coverage_content_type = modelResult
    WVELMASS: direction = >0 decreases volume
    WVELMASS: long_name = Grid cell face-averaged vertical velocity in the model +z direction.
    WVELMASS: standard_name = upward sea water velocity
    WVELMASS: units = m s-1
    WVELMASS: valid_max = 0.0016380994347855449
    WVELMASS: valid_min = -0.0023150660563260317
```

Comments

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.

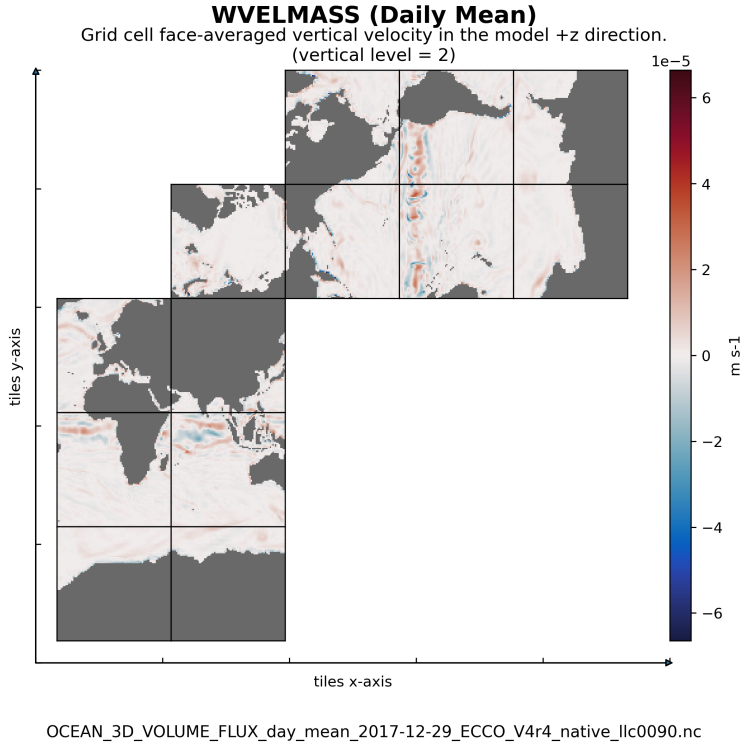


Figure 50: Dataset: OCEAN_3D_VOLUME_FLUX, Variable: WVELMASS

11.7 Native dataset of OCEAN_AND_ICE_SURFACE_FW_FLUX

11.7.1 Overview

This dataset provides 2D fields of ocean and sea-ice surface freshwater fluxes on the lat-lon-cap 90 (llc90) native model grid from the ECCO Version 4 Release 4 (V4r4) ocean and sea-ice state estimate. The dataset is provided on daily-average and monthly-average time resolution.

Table 11.36: Coordinates and Variables in the dataset OCEAN_AND_ICE_SURFACE_FW_FLUX

Coordinates	Description of data coordinates	Unit
i	Grid index in x for variables at tracer and 'v' locations	–none–
i_g	Grid index in x for variables at 'u' and 'g' locations	–none–
j	Grid index in y for variables at tracer and 'u' locations	–none–
j_g	Grid index in y for variables at 'v' and 'g' locations	–none–
tile	Lat-lon-cap tile index	–none–
time	Center time of averaging period	–none–
XC	Longitude of tracer grid cell center	degrees_east
YC	Latitude of tracer grid cell center	degrees_north
XG	Longitude of 'southwest' corner of tracer grid cell	degrees_east
YG	Latitude of 'southwest' corner of tracer grid cell	degrees_north
time_bnds	Time bounds of averaging period	–none–
XC_bnds	Longitudes of tracer grid cell corners	–none–
YC_bnds	Latitudes of tracer grid cell corners	–none–
Variables	**Description of data variables**	**Unit**
EXFpreci	Precipitation rate	m s-1
EXFevap	Open ocean evaporation rate	m s-1
EXFroff	River runoff	m s-1
SIsnPrcp	Snow precipitation on sea-ice	kg m-2 s-1
EXFempmr	Open ocean net surface freshwater flux from precipitation, evaporation, and runoff	m s-1
oceFWflx	Net freshwater flux into the ocean	kg m-2 s-1
SIatmFW	Net freshwater flux into the open ocean, sea-ice, and snow	kg m-2 s-1
SFLUX	Rate of change of total ocean salinity per m2 accounting for mass fluxes.	g m-2 s-1
SIacSubl	Freshwater flux to the atmosphere due to sublimation-deposition of snow or ice	kg m-2 s-1
SIrsSubl	Residual sublimation freshwater flux	kg m-2 s-1
SIfwThru	Precipitation through sea-ice	kg m-2 s-1

11.7.2 Native Variable: EXFempmr

Table 11.37: Attributes description of the variable 'EXFempmr' from OCEAN_AND_ICE_SURFACE_FW_FLUX's dataset.

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

Description of the variable in Common Data language (CDL)

```
float32 EXFempmr(time, tile, j, i)
    EXFempmr:  _FillValue = 9.96921e+36
    EXFempmr:  coordinates = YC XC time
    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:  valid_max = 5.400421514423215e-07
    EXFempmr:  valid_min = -8.299433829961345e-06
```

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.

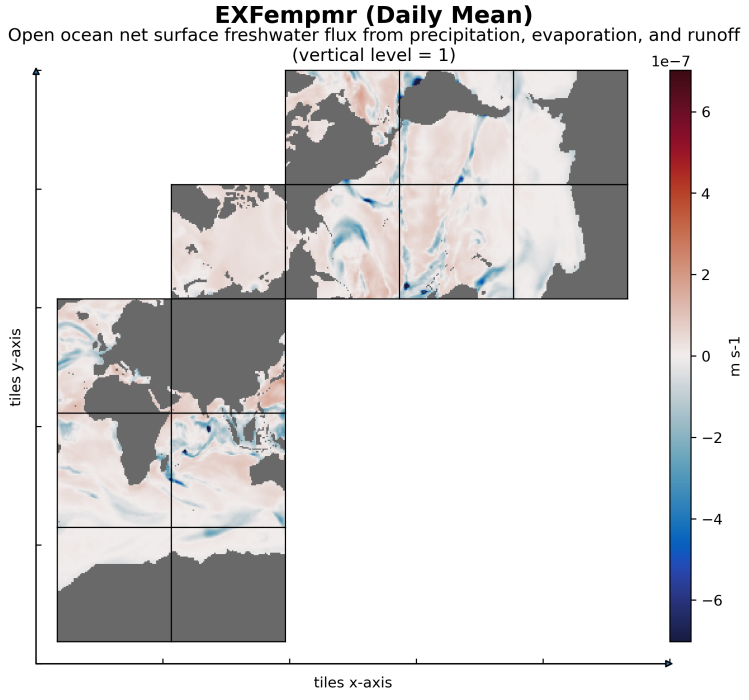


Figure 51: Dataset: OCEAN_AND_ICE_SURFACE_FW_FLUX, Variable: EXFempmr

11.7.3 Native Variable: EXFevap

Table 11.38: Attributes description of the variable 'EXFevap' from OCEAN_AND_ICE_SURFACE_FW_FLUX's dataset.

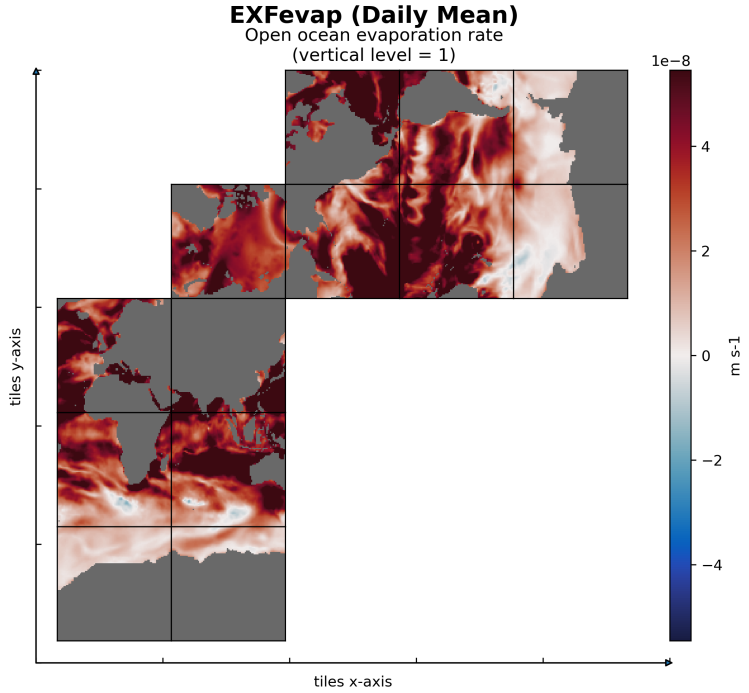
Storage Type	Variable Name	Description	Unit
float32	EXFevap	Open ocean evaporation rate	m s-1

Description of the variable in Common Data language (CDL)

```
float32 EXFevap(time, tile, j, i)
    EXFevap:  _FillValue = 9.96921e+36
    EXFevap:  coordinates = YC XC time
    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:  valid_max = 7.090054623404285e-07
    EXFevap:  valid_min = -1.0958113705328287e-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.



OCEAN_AND_ICE_SURFACE_FW_FLUX_day_mean_2017-12-29_ECCO_V4r4_native_llc0090.nc

Figure 52: Dataset: OCEAN_AND_ICE_SURFACE_FW_FLUX, Variable: EXFevap

11.7.4 Native Variable: EXFpreci

Table 11.39: Attributes description of the variable 'EXFpreci' from OCEAN_AND_ICE_SURFACE_FW_FLUX's dataset.

Storage Type	Variable Name	Description	Unit
float32	EXFpreci	Precipitation rate	m s-1

Description of the variable in Common Data language (CDL)

```
float32 EXFpreci(time, tile, j, i)
   EXFpreci:  _FillValue = 9.96921e+36
   EXFpreci:  coordinates = YC XC time
   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:  valid_max = 8.317776519106701e-06
   EXFpreci:  valid_min = -1.4860395936011628e-07
```

Comments

Precipitation rate. note: sum of era-interim precipitation and the control adjustment from ocean state estimation.

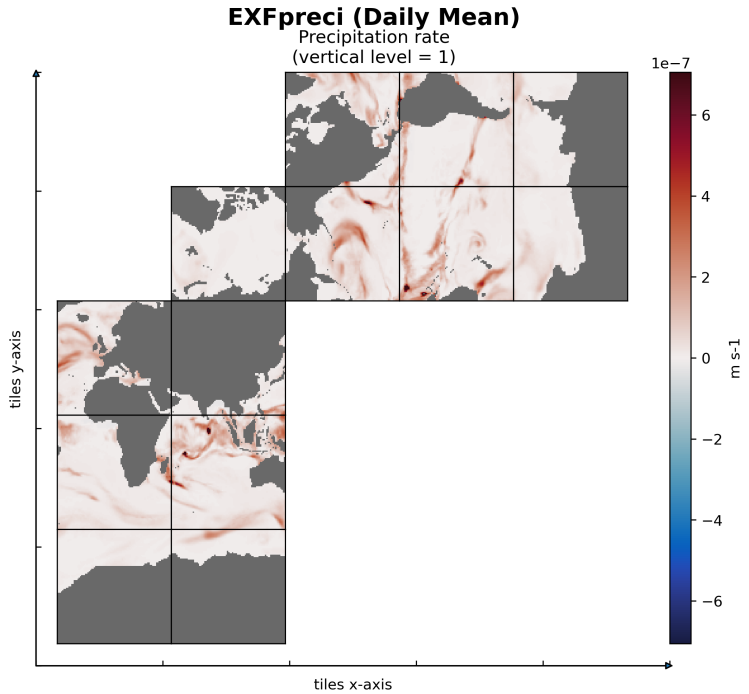


Figure 53: Dataset: OCEAN_AND_ICE_SURFACE_FW_FLUX, Variable: EXFpreci

11.7.5 Native Variable: EXFroff

Table 11.40: Attributes description of the variable 'EXFroff' from OCEAN_AND_ICE_SURFACE_FW_FLUX's dataset.

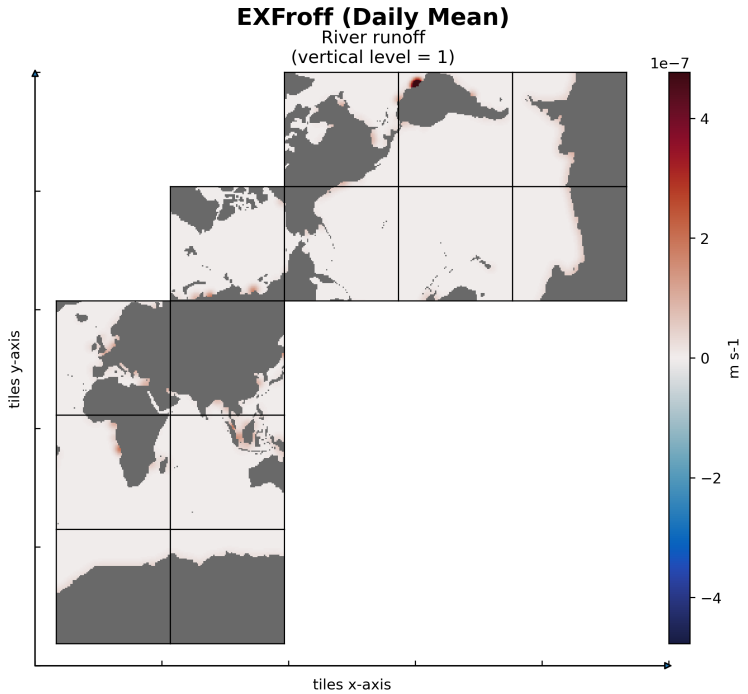
Storage Type	Variable Name	Description	Unit
float32	EXFroff	River runoff	m s-1

Description of the variable in Common Data language (CDL)

```
float32 EXFroff(time, tile, j, i)
    EXFroff:  _FillValue = 9.96921e+36
    EXFroff:  coordinates = YC XC time
    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:  valid_max = 4.185612397122895e-06
    EXFroff:  valid_min = 0.0
```

Comments

River runoff freshwater flux. note: not adjusted by the optimization.



OCEAN_AND_ICE_SURFACE_FW_FLUX_day_mean_2017-12-29_ECCO_V4r4_native_llc0090.nc

Figure 54: Dataset: OCEAN_AND_ICE_SURFACE_FW_FLUX, Variable: EXFroff

11.7.6 Native Variable: SFLUX

Table 11.41: Attributes description of the variable 'SFLUX' from OCEAN_AND_ICE_SURFACE_FW_FLUX's dataset.

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

Description of the variable in Common Data language (CDL)

```
float32 SFLUX(time, tile, j, i)
    SFLUX: _FillValue = 9.96921e+36
    SFLUX: coordinates = YC XC time
    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: valid_max = 0.010607733391225338
    SFLUX: valid_min = -0.07353577762842178
```

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).

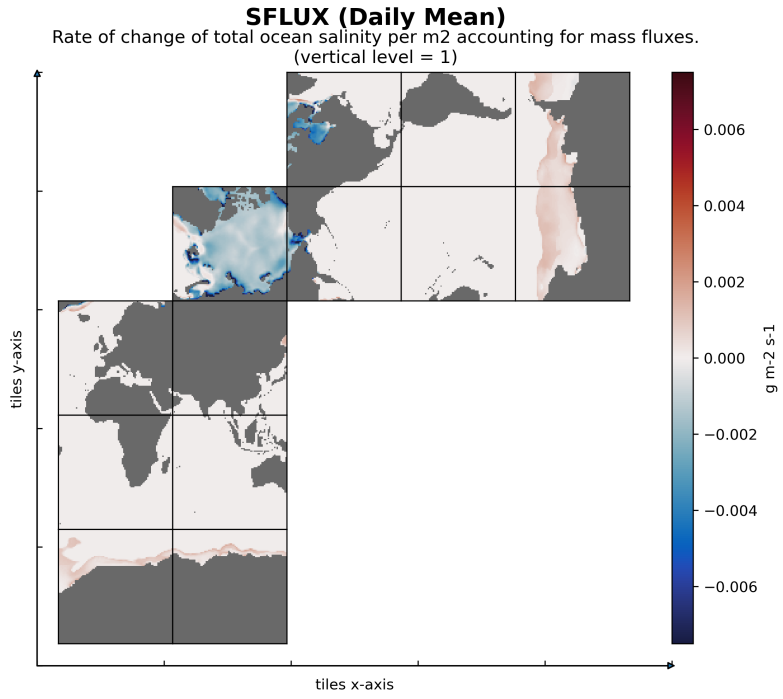


Figure 55: Dataset: OCEAN_AND_ICE_SURFACE_FW_FLUX, Variable: SFLUX

11.7.7 Native Variable: SIacSubl

Table 11.42: Attributes description of the variable 'SIacSubl' from OCEAN_AND_ICE_SURFACE_FW_FLUX's dataset.

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

Description of the variable in Common Data language (CDL)

```
float32 SIacSubl(time, tile, j, i)
    SIacSubl:  _FillValue = 9.96921e+36
    SIacSubl:  coordinates = YC XC time
    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:  valid_max = 8.154580427799374e-05
    SIacSubl:  valid_min = 0.0
```

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

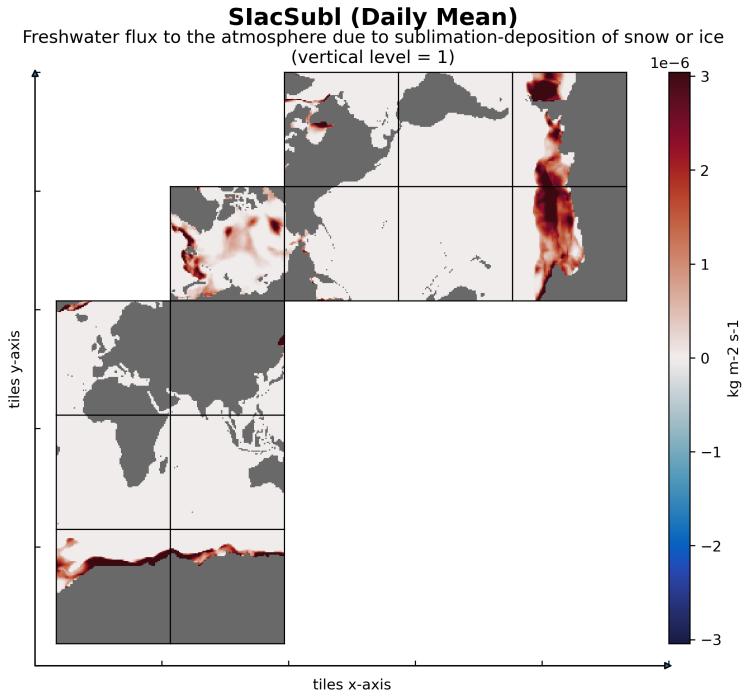


Figure 56: Dataset: OCEAN_AND_ICE_SURFACE_FW_FLUX, Variable: SIacSubl

11.7.8 Native Variable: SIatmFW

Table 11.43: Attributes description of the variable 'SIatmFW' from OCEAN_AND_ICE_SURFACE_FW_FLUX's dataset.

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

Description of the variable in Common Data language (CDL)

```
float32 SIatmFW(time, tile, j, i)
   SIatmFW: _FillValue = 9.96921e+36
   SIatmFW: coordinates = YC XC time
   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: valid_max = 0.008299433626234531
   SIatmFW: valid_min = -0.00043017856660299003
```

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.

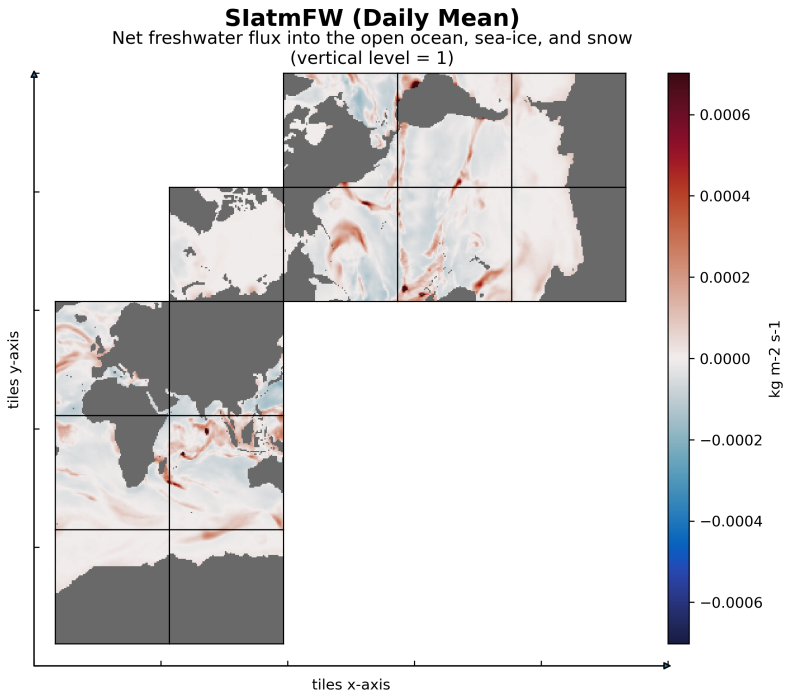


Figure 57: Dataset: OCEAN_AND_ICE_SURFACE_FW_FLUX, Variable: SIatmFW

11.7.9 Native Variable: SIfwThru

Table 11.44: Attributes description of the variable 'SIfwThru' from OCEAN_AND_ICE_SURFACE_FW_FLUX's dataset.

Storage Type	Variable Name	Description	Unit
float32	SIfwThru	Precipitation through sea-ice	kg m-2 s-1

Description of the variable in Common Data language (CDL)

```
float32 SIfwThru(time, tile, j, i)
    SIfwThru:  _FillValue = 9.96921e+36
    SIfwThru:  coordinates = YC XC time
    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:  valid_max = 0.0010632629273459315
    SIfwThru:  valid_min = -1.695218452368863e-05
```

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.

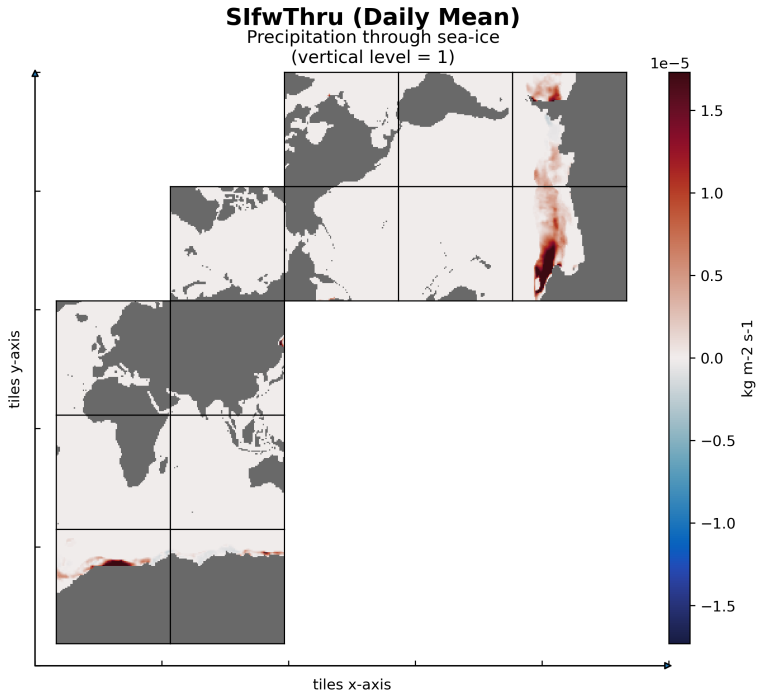


Figure 58: Dataset: OCEAN_AND_ICE_SURFACE_FW_FLUX, Variable: SIfwThru

11.7.10 Native Variable: SIrsSubl

Table 11.45: Attributes description of the variable 'SIrsSubl' from OCEAN_AND_ICE_SURFACE_FW_FLUX's dataset.

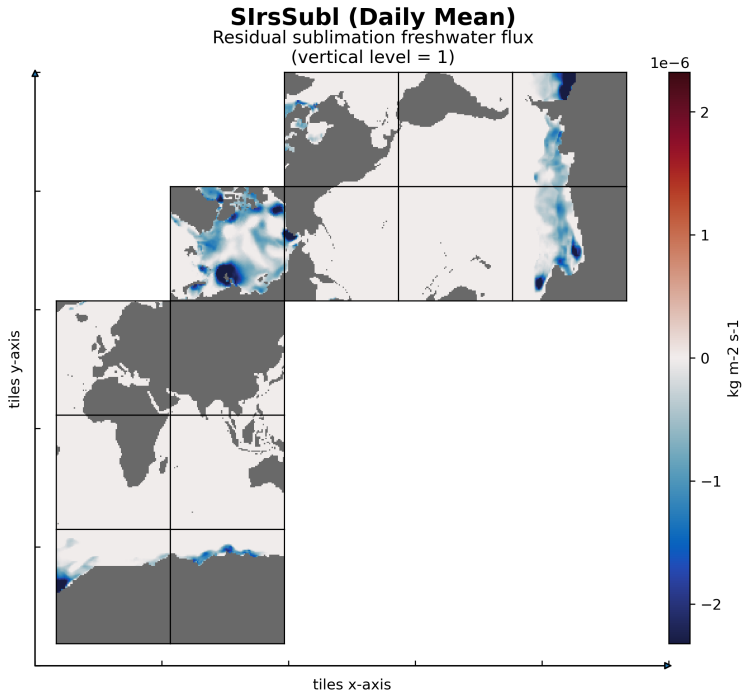
Storage Type	Variable Name	Description	Unit
float32	SIrsSubl	Residual sublimation freshwater flux	kg m-2 s-1

Description of the variable in Common Data language (CDL)

```
float32 SIrsSubl(time, tile, j, i)
    SIrsSubl:  _FillValue = 9.96921e+36
    SIrsSubl:  coordinates = YC XC time
    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:  valid_max = 8.640533451398369e-06
    SIrsSubl:  valid_min = -0.0001067528864950873
```

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.



OCEAN_AND_ICE_SURFACE_FW_FLUX_day_mean_2017-12-29_ECCO_V4r4_native_llc0090.nc

Figure 59: Dataset: OCEAN_AND_ICE_SURFACE_FW_FLUX, Variable: SIrsSubl

11.7.11 Native Variable: SIsnPrcp

Table 11.46: Attributes description of the variable 'SIsnPrcp' from OCEAN_AND_ICE_SURFACE_FW_FLUX's dataset.

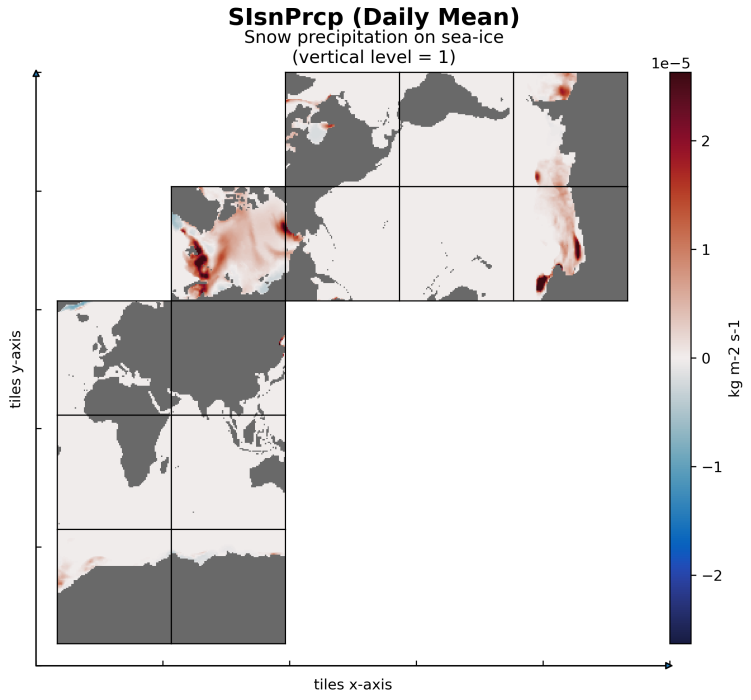
Storage Type	Variable Name	Description	Unit
float32	SIsnPrcp	Snow precipitation on sea-ice	kg m-2 s-1

Description of the variable in Common Data language (CDL)

```
float32 SIsnPrcp(time, tile, j, i)
   SIsnPrcp:  _FillValue = 9.96921e+36
   SIsnPrcp:  coordinates = YC XC time
   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:  valid_max = 0.0009354020585305989
   SIsnPrcp:  valid_min = -4.334669574745931e-05
```

Comments

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



OCEAN_AND_ICE_SURFACE_FW_FLUX_day_mean_2017-12-29_ECCO_V4r4_native_llc0090.nc

Figure 60: Dataset: OCEAN_AND_ICE_SURFACE_FW_FLUX, Variable: SIsnPrcp

11.7.12 Native Variable: oceFWflx

Table 11.47: Attributes description of the variable 'oceFWflx' from OCEAN_AND_ICE_SURFACE_FW_FLUX's dataset.

Storage Type	Variable Name	Description	Unit
float32	oceFWflx	Net freshwater flux into the ocean	kg m-2 s-1

Description of the variable in Common Data language (CDL)

```
float32 oceFWflx(time, tile, j, i)
    oceFWflx:  _FillValue = 9.96921e+36
    oceFWflx:  coordinates = YC XC time
    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:  valid_max = 0.008299433626234531
    oceFWflx:  valid_min = -0.003914969973266125
```

Comments

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.

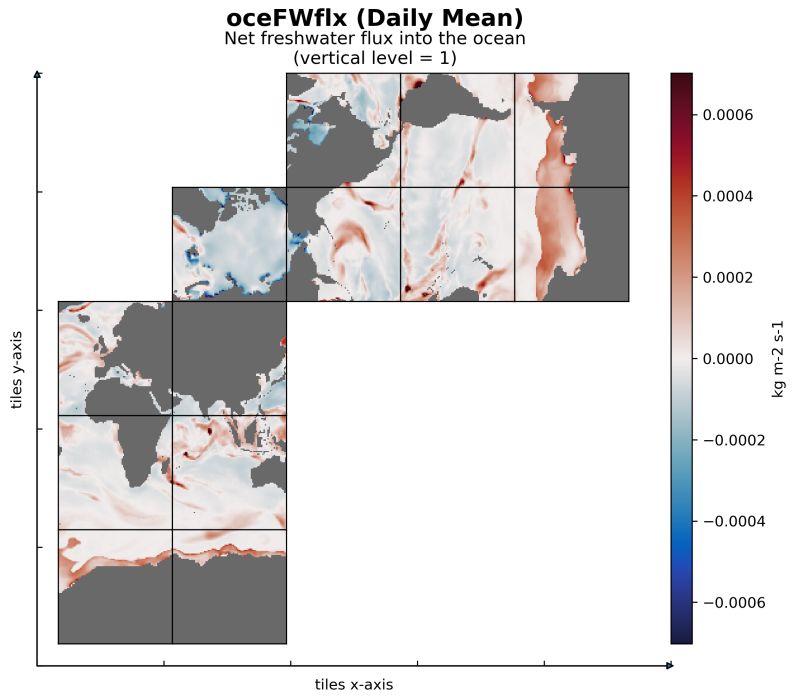


Figure 61: Dataset: OCEAN_AND_ICE_SURFACE_FW_FLUX, Variable: oceFWflx

11.8 Native dataset of OCEAN_AND_ICE_SURFACE_HEAT_FLUX

11.8.1 Overview

This dataset provides 2D fields of ocean and sea-ice surface heat fluxes on the lat-lon-cap 90 (llc90) native model grid from the ECCO Version 4 Release 4 (V4r4) ocean and sea-ice state estimate. The dataset is provided on daily-average and monthly-average time resolution.

Table 11.48: Coordinates and Variables in the dataset OCEAN_AND_ICE_SURFACE_HEAT_FLUX

Coordinates	Description of data coordinates	Unit
i	Grid index in x for variables at tracer and 'v' locations	–none–
i_g	Grid index in x for variables at 'u' and 'g' locations	–none–
j	Grid index in y for variables at tracer and 'u' locations	–none–
j_g	Grid index in y for variables at 'v' and 'g' locations	–none–
tile	Lat-lon-cap tile index	–none–
time	Center time of averaging period	–none–
XC	Longitude of tracer grid cell center	degrees_east
YC	Latitude of tracer grid cell center	degrees_north
XG	Longitude of 'southwest' corner of tracer grid cell	degrees_east
YG	Latitude of 'southwest' corner of tracer grid cell	degrees_north
time_bnds	Time bounds of averaging period	–none–
XC_bnds	Longitudes of tracer grid cell corners	–none–
YC_bnds	Latitudes of tracer grid cell corners	–none–
Variables	**Description of data variables**	**Unit**
EXFhl	Open ocean air-sea latent heat flux	W m-2
EXFhs	Open ocean air-sea sensible heat flux	W m-2
EXFlwdn	Downward longwave radiative flux	W m-2
EXFswdn	Downwelling shortwave radiative flux	W m-2
EXFqnet	Open ocean net air-sea heat flux	W m-2
oceQnet	Net heat flux into the ocean surface	W m-2
SIatmQnt	Net upward heat flux to the atmosphere	W m-2
TFLUX	Rate of change of ocean heat content per m2 accounting for mass fluxes.	W m-2
EXFswnet	Open ocean net shortwave radiative flux	W m-2
EXFlwnet	Net open ocean longwave radiative flux	W m-2
oceQsw	Net shortwave radiative flux across the ocean surface	W m-2
SIaaflux	Conservative ocean and sea-ice advective heat flux adjustment	W m-2

11.8.2 Native Variable: EXFhl

Table 11.49: Attributes description of the variable 'EXFhl' from OCEAN_AND_ICE_SURFACE_HEAT_FLUX's dataset.

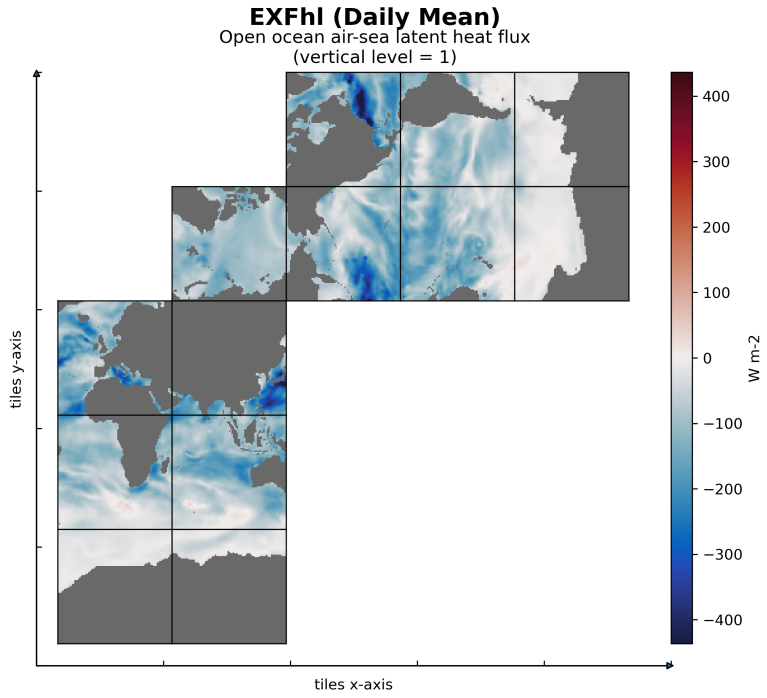
Storage Type	Variable Name	Description	Unit
float32	EXFhl	Open ocean air-sea latent heat flux	W m-2

Description of the variable in Common Data language (CDL)

```
float32 EXFhl(time, tile, j, i)
    EXFhl:  _FillValue = 9.96921e+36
    EXFhl:  coordinates = XC time YC
    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:  valid_max = 273.9528503417969
    EXFhl:  valid_min = -1772.513671875
```

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.



OCEAN_AND_ICE_SURFACE_HEAT_FLUX_day_mean_2017-12-29_ECCO_V4r4_native_llc0090.nc

Figure 62: Dataset: OCEAN_AND_ICE_SURFACE_HEAT_FLUX, Variable: EXFhl

11.8.3 Native Variable: EXFhs

Table 11.50: Attributes description of the variable 'EXFhs' from OCEAN_AND_ICE_SURFACE_HEAT_FLUX's dataset.

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

Description of the variable in Common Data language (CDL)

```
float32 EXFhs(time, tile, j, i)
    EXFhs:  _FillValue = 9.96921e+36
    EXFhs:  coordinates = XC time YC
    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:  valid_max = 362.8300476074219
    EXFhs:  valid_min = -2478.766357421875
```

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.

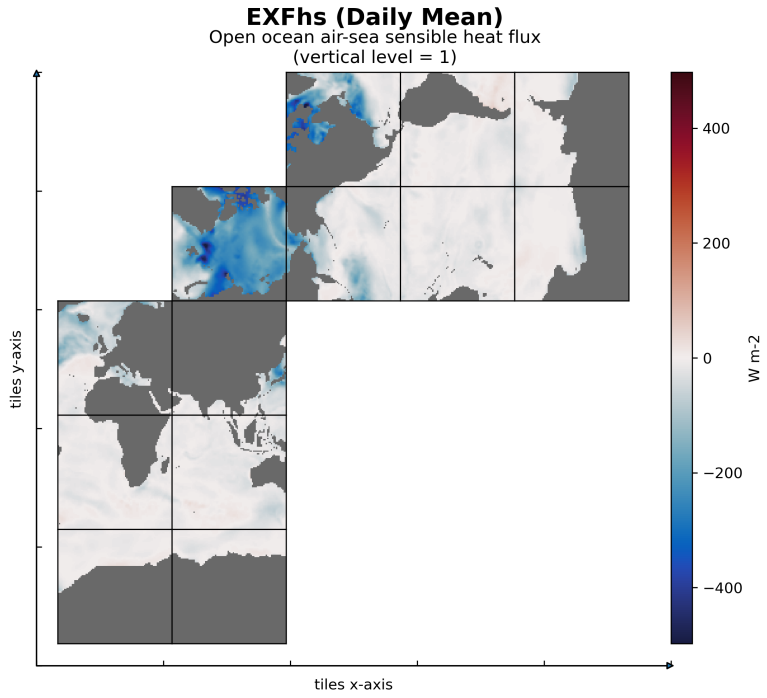


Figure 63: Dataset: OCEAN_AND_ICE_SURFACE_HEAT_FLUX, Variable: EXFhs

11.8.4 Native Variable: EXFlwdn

Table 11.51: Attributes description of the variable 'EXFlwdn' from OCEAN_AND_ICE_SURFACE_HEAT_FLUX's dataset.

Storage Type	Variable Name	Description	Unit
float32	EXFlwdn	Downward longwave radiative flux	W m-2

Description of the variable in Common Data language (CDL)

```
float32 EXFlwdn(time, tile, j, i)
    EXFlwdn:  _FillValue = 9.96921e+36
    EXFlwdn:  coordinates = XC time YC
    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:  valid_max = 513.3919067382812
    EXFlwdn:  valid_min = 4.188045501708984
```

Comments

Downward longwave radiative flux. note: sum of era-interim downward longwave radiation and the control adjustment from ocean state estimation.

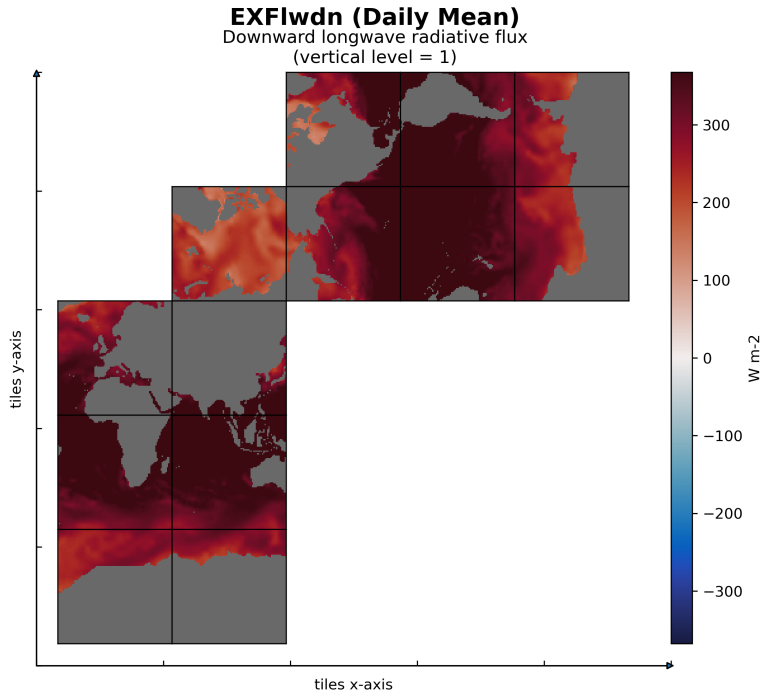


Figure 64: Dataset: OCEAN_AND_ICE_SURFACE_HEAT_FLUX, Variable: EXFlwdn

11.8.5 Native Variable: EXFlwnet

Table 11.52: Attributes description of the variable 'EXFlwnet' from OCEAN_AND_ICE_SURFACE_HEAT_FLUX's dataset.

Storage Type	Variable Name	Description	Unit
float32	EXFlwnet	Net open ocean longwave radiative flux	W m-2

Description of the variable in Common Data language (CDL)

```
float32 EXFlwnet(time, tile, j, i)
    EXFlwnet:  _FillValue = 9.96921e+36
    EXFlwnet:  coordinates = XC time YC
    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:  valid_max = 293.4114990234375
    EXFlwnet:  valid_min = -144.3661346435547
```

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).

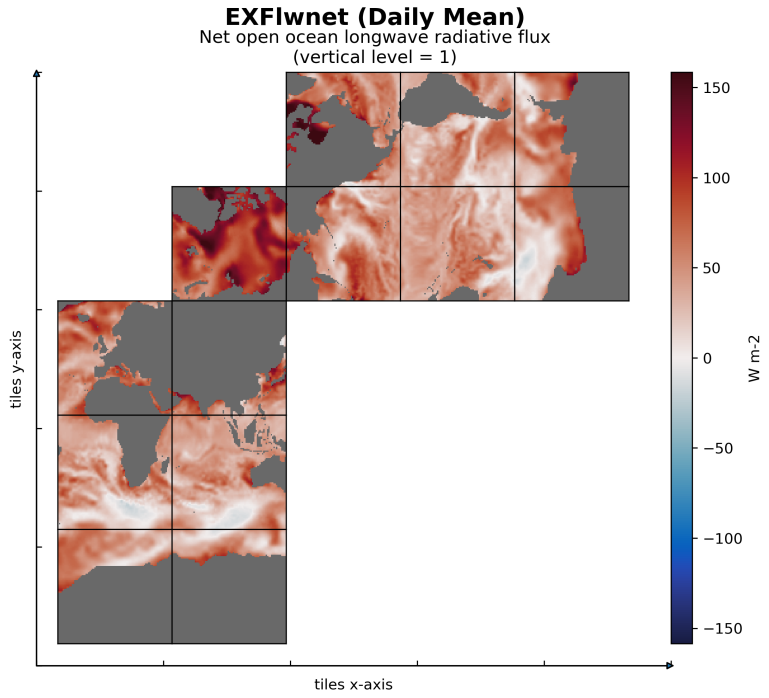


Figure 65: Dataset: OCEAN_AND_ICE_SURFACE_HEAT_FLUX, Variable: EXFlwnet

11.8.6 Native Variable: EXFqnet

Table 11.53: Attributes description of the variable 'EXFqnet' from OCEAN_AND_ICE_SURFACE_HEAT_FLUX's dataset.

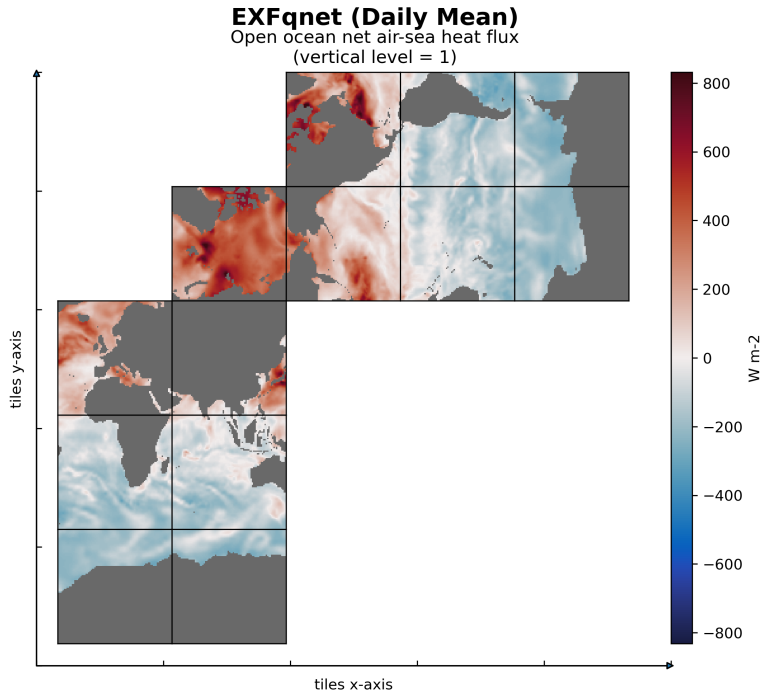
Storage Type	Variable Name	Description	Unit
float32	EXFqnet	Open ocean net air-sea heat flux	W m-2

Description of the variable in Common Data language (CDL)

```
float32 EXFqnet(time, tile, j, i)
    EXFqnet:  _FillValue = 9.96921e+36
    EXFqnet:  coordinates = XC time YC
    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:  valid_max = 3408.977783203125
    EXFqnet:  valid_min = -687.8736572265625
```

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.



OCEAN_AND_ICE_SURFACE_HEAT_FLUX_day_mean_2017-12-29_ECCO_V4r4_native_llc0090.nc

Figure 66: Dataset: OCEAN_AND_ICE_SURFACE_HEAT_FLUX, Variable: EXFqnet

11.8.7 Native Variable: EXFswdn

Table 11.54: Attributes description of the variable 'EXFswdn' from OCEAN_AND_ICE_SURFACE_HEAT_FLUX's dataset.

Storage Type	Variable Name	Description	Unit
float32	EXFswdn	Downwelling shortwave radiative flux	W m-2

Description of the variable in Common Data language (CDL)

```
float32 EXFswdn(time, tile, j, i)
    EXFswdn:  _FillValue = 9.96921e+36
    EXFswdn:  coordinates = XC time YC
    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:  valid_max = 707.345947265625
    EXFswdn:  valid_min = -224.63368225097656
```

Comments

Downward shortwave radiative flux. note: sum of era-interim downward shortwave radiation and the control adjustment from ocean state estimation.

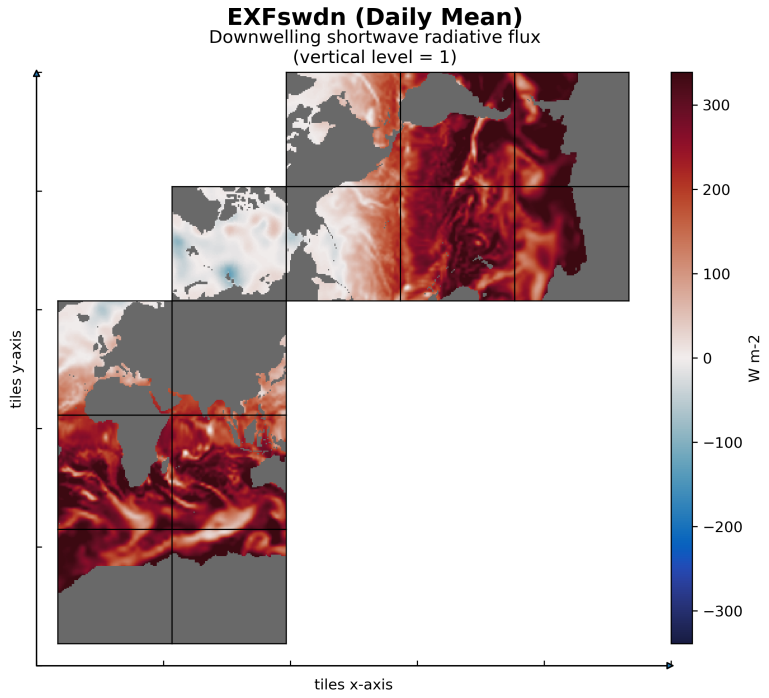


Figure 67: Dataset: OCEAN_AND_ICE_SURFACE_HEAT_FLUX, Variable: EXFswdn

11.8.8 Native Variable: EXFswnet

Table 11.55: Attributes description of the variable 'EXFswnet' from OCEAN_AND_ICE_SURFACE_HEAT_FLUX's dataset.

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

Description of the variable in Common Data language (CDL)

```
float32 EXFswnet(time, tile, j, i)
    EXFswnet:  _FillValue = 9.96921e+36
    EXFswnet:  coordinates = XC time YC
    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:  valid_max = 194.18458557128906
    EXFswnet:  valid_min = -655.6171264648438
```

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.

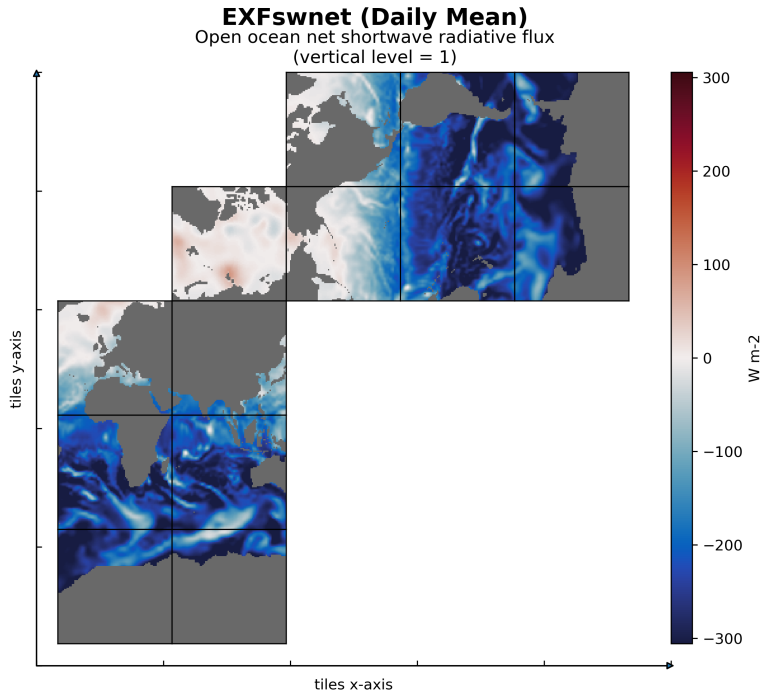


Figure 68: Dataset: OCEAN_AND_ICE_SURFACE_HEAT_FLUX, Variable: EXFswnet

11.8.9 Native Variable: SIaaflux

Table 11.56: Attributes description of the variable 'SIaaflux' from OCEAN_AND_ICE_SURFACE_HEAT_FLUX's dataset.

Storage Type	Variable Name	Description	Unit
float32	SIaaflux	Conservative ocean and sea-ice advective heat flux adjustment	W m-2

Description of the variable in Common Data language (CDL)

```
float32 SIaaflux(time, tile, j, i)
    SIaaflux:  _FillValue = 9.96921e+36
    SIaaflux:  coordinates = XC time YC
    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:  valid_max = 50.35451889038086
    SIaaflux:  valid_min = -16.214622497558594
```

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.

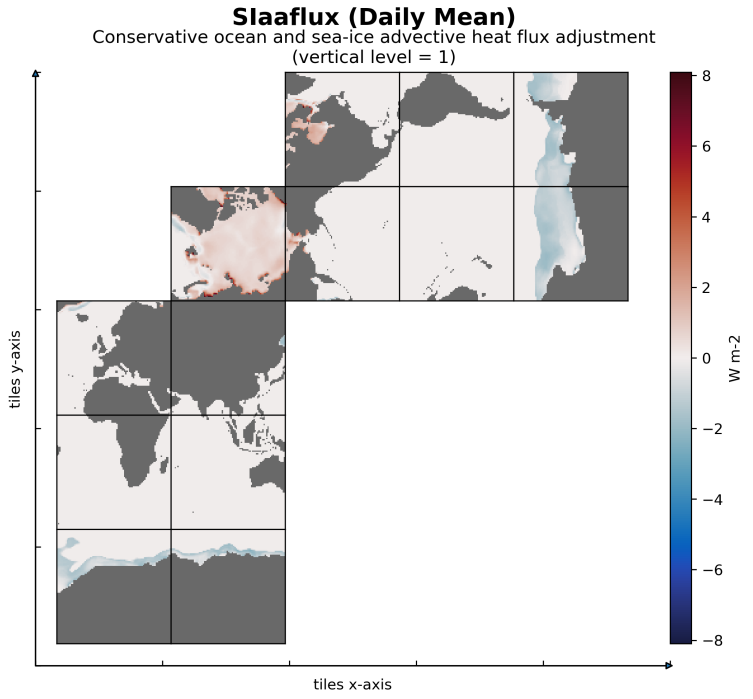


Figure 69: Dataset: OCEAN_AND_ICE_SURFACE_HEAT_FLUX, Variable: SIaaflux

11.8.10 Native Variable: SIatmQnt

Table 11.57: Attributes description of the variable 'SIatmQnt' from OCEAN_AND_ICE_SURFACE_HEAT_FLUX's dataset.

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

Description of the variable in Common Data language (CDL)

```
float32 SIatmQnt(time, tile, j, i)
    SIatmQnt:  _FillValue = 9.96921e+36
    SIatmQnt:  coordinates = XC time YC
    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:  valid_max = 1704.7703857421875
    SIatmQnt:  valid_min = -756.0607299804688
```

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).

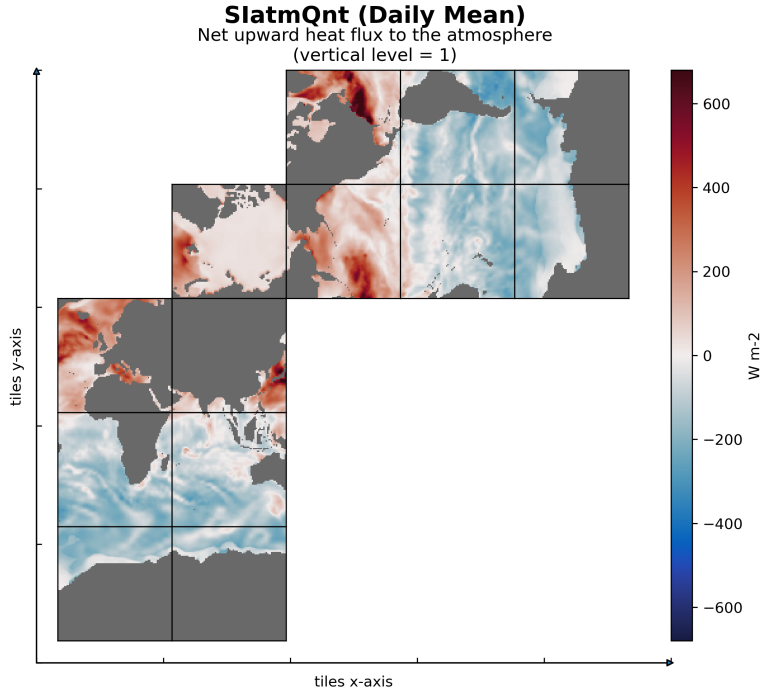


Figure 70: Dataset: OCEAN_AND_ICE_SURFACE_HEAT_FLUX, Variable: SIatmQnt

11.8.11 Native Variable: TFLUX

Table 11.58: Attributes description of the variable 'TFLUX' from OCEAN_AND_ICE_SURFACE_HEAT_FLUX's dataset.

Storage Type	Variable Name	Description	Unit
float32	TFLUX	Rate of change of ocean heat content per m2 accounting for mass fluxes.	W m-2

Description of the variable in Common Data language (CDL)

```
float32 TFLUX(time, tile, j, i)
    TFLUX: _FillValue = 9.96921e+36
    TFLUX: coordinates = XC time YC
    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: valid_max = 870.3130493164062
    TFLUX: valid_min = -1713.51220703125
```

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).

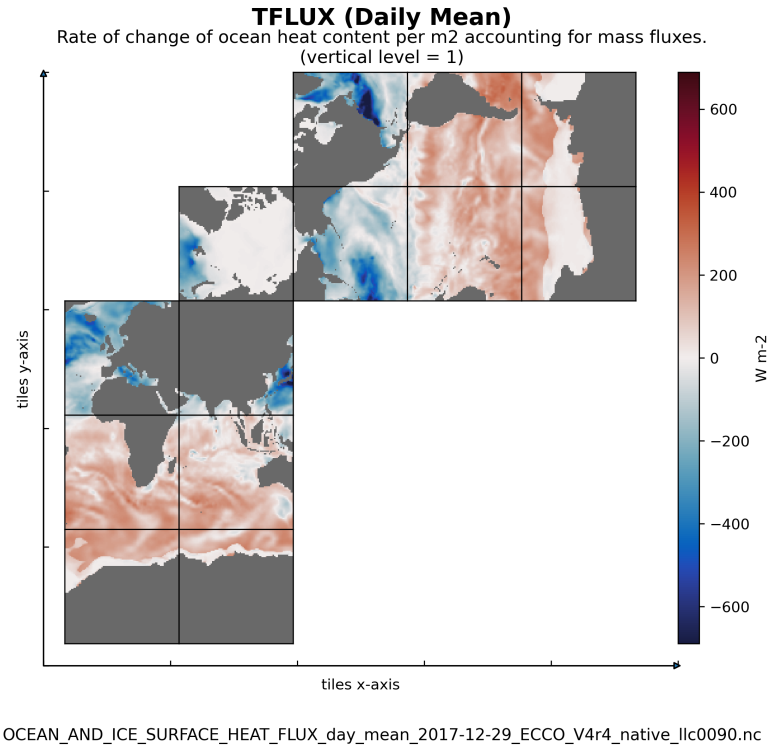


Figure 71: Dataset: OCEAN_AND_ICE_SURFACE_HEAT_FLUX, Variable: TFLUX

11.8.12 Native Variable: oceQnet

Table 11.59: Attributes description of the variable 'oceQnet' from OCEAN_AND_ICE_SURFACE_HEAT_FLUX's dataset.

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

Description of the variable in Common Data language (CDL)

```
float32 oceQnet(time, tile, j, i)
    oceQnet:  _FillValue = 9.96921e+36
    oceQnet:  coordinates = XC time YC
    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:  valid_max = 675.3716430664062
    oceQnet:  valid_min = -1708.8460693359375
```

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.

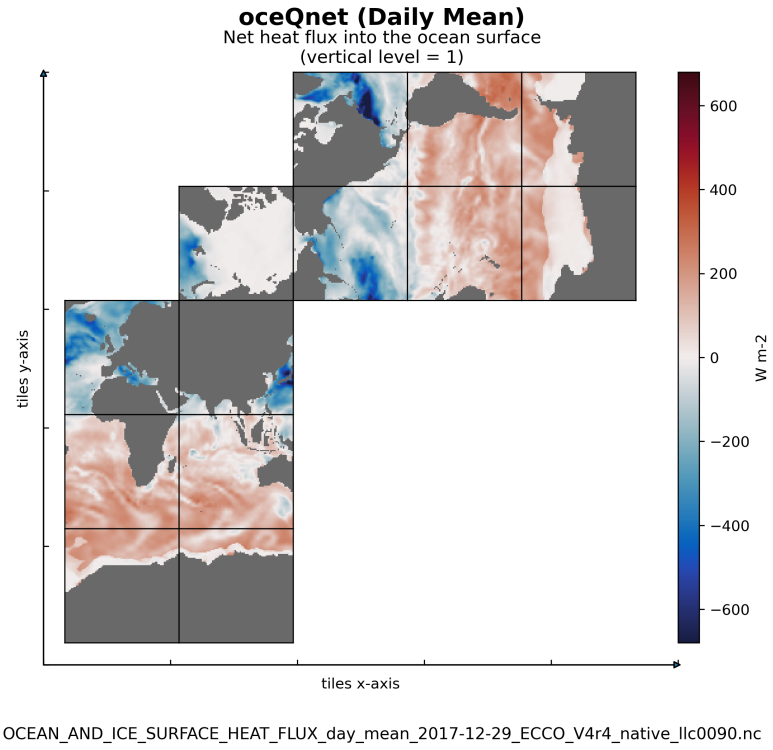


Figure 72: Dataset: OCEAN_AND_ICE_SURFACE_HEAT_FLUX, Variable: oceQnet

11.8.13 Native Variable: oceQsw

Table 11.60: Attributes description of the variable 'oceQsw' from OCEAN_AND_ICE_SURFACE_HEAT_FLUX's dataset.

Storage Type	Variable Name	Description	Unit
float32	oceQsw	Net shortwave radiative flux across the ocean surface	W m-2

Description of the variable in Common Data language (CDL)

```
float32 oceQsw(time, tile, j, i)
    oceQsw:  _FillValue = 9.96921e+36
    oceQsw:  coordinates = XC time YC
    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:  valid_max = 655.6171264648438
    oceQsw:  valid_min = -134.39808654785156
```

Comments

Net shortwave radiative flux across the ocean surface. note: shortwave radiation penetrates below the surface grid cell.

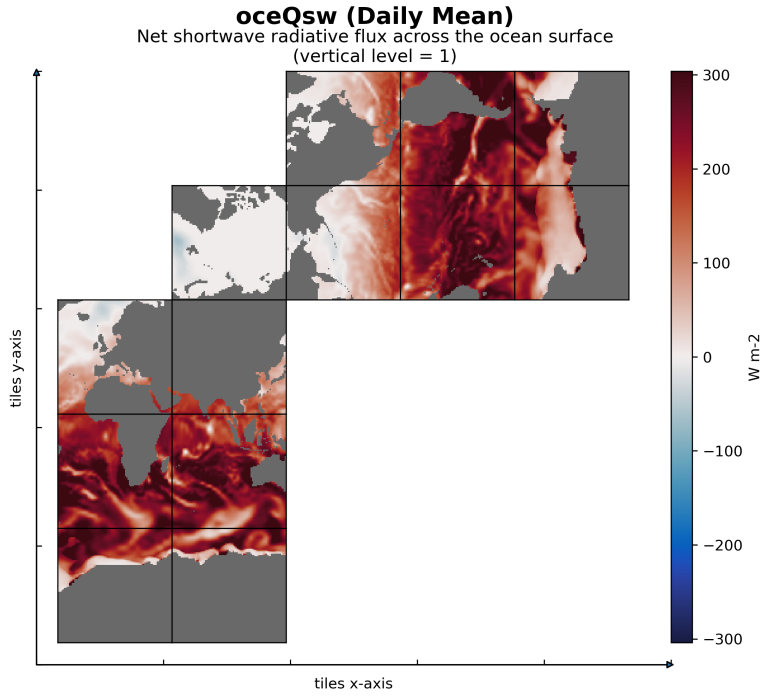


Figure 73: Dataset: OCEAN_AND_ICE_SURFACE_HEAT_FLUX, Variable: oceQsw

11.9 Native dataset of OCEAN_AND_ICE_SURFACE_STRESS

11.9.1 Overview

This dataset provides 2D fields of ocean and sea-ice surface stress on the lat-lon-cap 90 (llc90) native model grid from the ECCO Version 4 Release 4 (V4r4) ocean and sea-ice state estimate. The dataset is provided on daily-average and monthly-average time resolution.

Table 11.61: Coordinates and Variables in the dataset OCEAN_AND_ICE_SURFACE_STRESS

Coordinates	Description of data coordinates	Unit
i	Grid index in x for variables at tracer and 'v' locations	–none–
i_g	Grid index in x for variables at 'u' and 'g' locations	–none–
j	Grid index in y for variables at tracer and 'u' locations	–none–
j_g	Grid index in y for variables at 'v' and 'g' locations	–none–
tile	Lat-lon-cap tile index	–none–
time	Center time of averaging period	–none–
XC	Longitude of tracer grid cell center	degrees_east
YC	Latitude of tracer grid cell center	degrees_north
XG	Longitude of 'southwest' corner of tracer grid cell	degrees_east
YG	Latitude of 'southwest' corner of tracer grid cell	degrees_north
time_bnds	Time bounds of averaging period	–none–
XC_bnds	Longitudes of tracer grid cell corners	–none–
YC_bnds	Latitudes of tracer grid cell corners	–none–
Variables	**Description of data variables**	**Unit**
EXFtaux	Wind stress in the model +x direction	N m-2
EXFtauy	Wind stress in the model +y direction	N m-2
oceTAUX	Ocean surface stress in the model +x direction	N m-2
oceTAUY	Ocean surface stress in the model +y direction	N m-2

11.9.2 Native Variable: EXFtaux

Table 11.62: Attributes description of the variable 'EXFtaux' from OCEAN_AND_ICE_SURFACE_STRESS's dataset.

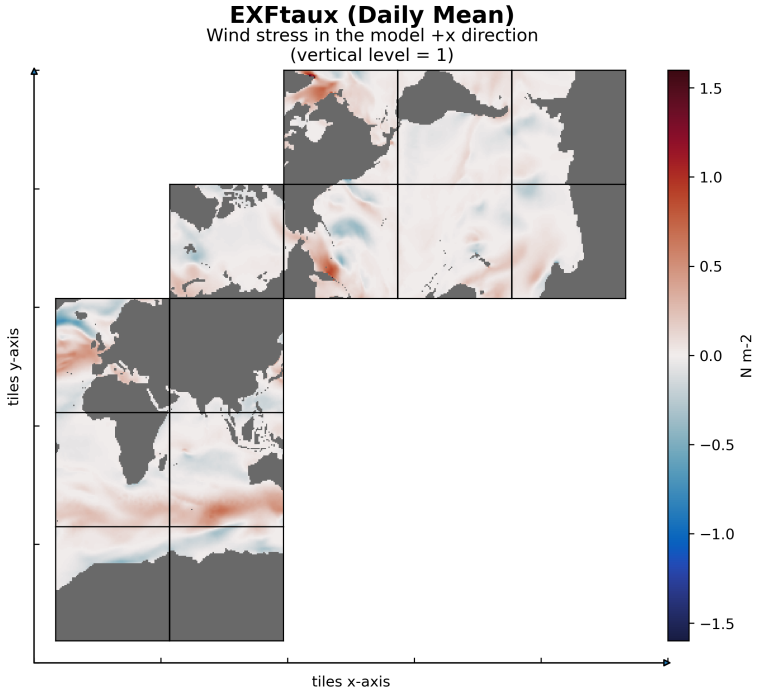
Storage Type	Variable Name	Description	Unit
float32	EXFtaux	Wind stress in the model +x direction	N m-2

Description of the variable in Common Data language (CDL)

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

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.



OCEAN_AND_ICE_SURFACE_STRESS_day_mean_2017-12-29_ECCO_V4r4_native_llc0090.nc

Figure 74: Dataset: OCEAN_AND_ICE_SURFACE_STRESS, Variable: EXFtaux

11.9.3 Native Variable: EXFtauy

Table 11.63: Attributes description of the variable 'EXFtauy' from OCEAN_AND_ICE_SURFACE_STRESS's dataset.

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

Description of the variable in Common Data language (CDL)

```
float32 EXFtauy(time, tile, j, i)
    EXFtauy:  _FillValue = 9.96921e+36
    EXFtauy:  coordinates = time YC XC
    EXFtauy:  coverage_content_type = modelResult
    EXFtauy:  direction = >0 increases horizontal velocity in the +y direction (VVEL)
    EXFtauy:  long_name = Wind stress in the model +y direction
    EXFtauy:  standard_name = surface downward y stress
    EXFtauy:  units = N m-2
    EXFtauy:  valid_max = 3.7044837474823
    EXFtauy:  valid_min = -3.71972918510437
```

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.

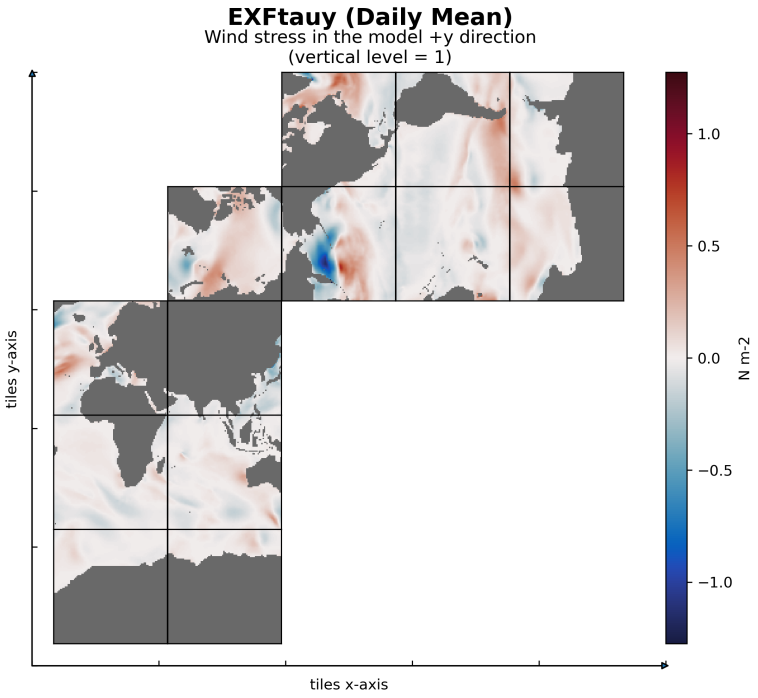


Figure 75: Dataset: OCEAN_AND_ICE_SURFACE_STRESS, Variable: EXFtauy

11.9.4 Native Variable: oceTAUX

Table 11.64: Attributes description of the variable 'oceTAUX' from OCEAN_AND_ICE_SURFACE_STRESS's dataset.

Storage Type	Variable Name	Description	Unit
float32	oceTAUX	Ocean surface stress in the model +x direction	N m-2

Description of the variable in Common Data language (CDL)

```
float32 oceTAUX(time, tile, j, i_g)
    oceTAUX: _FillValue = 9.96921e+36
    oceTAUX: coordinates = time
    oceTAUX: coverage_content_type = modelResult
    oceTAUX: direction = >0 increases horizontal velocity in the +x direction (UVEL)
    oceTAUX: long_name = Ocean surface stress in the model +x direction
    oceTAUX: mate = oceTAUY
    oceTAUX: standard_name = downward x stress at sea water surface
    oceTAUX: units = N m-2
    oceTAUX: valid_max = 1.9993581771850586
    oceTAUX: valid_min = -2.2317698001861572
```

Comments

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.

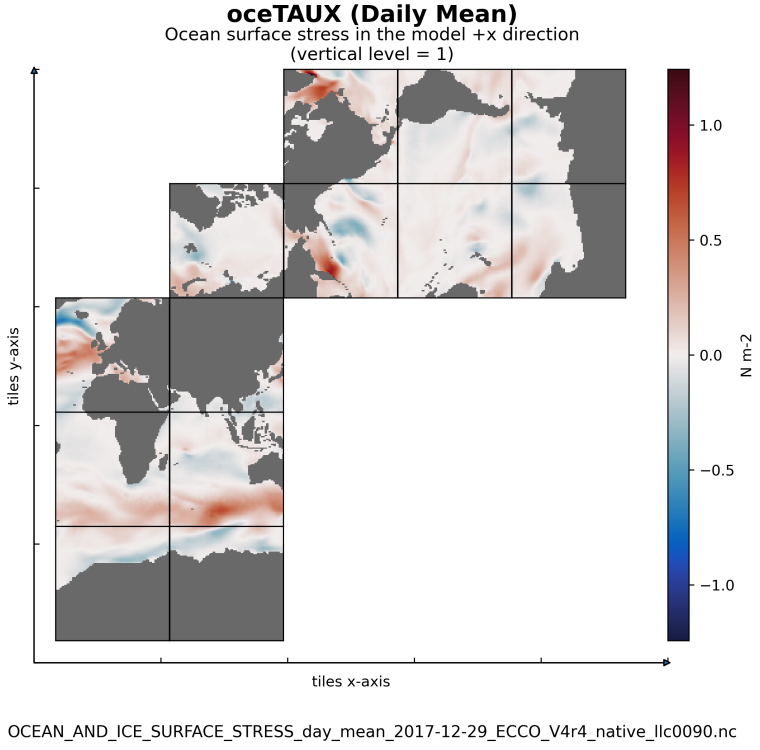


Figure 76: Dataset: OCEAN_AND_ICE_SURFACE_STRESS, Variable: oceTAUX

11.9.5 Native Variable: oceTAUY

Table 11.65: Attributes description of the variable 'oceTAUY' from OCEAN_AND_ICE_SURFACE_STRESS's dataset.

Storage Type	Variable Name	Description	Unit
float32	oceTAUY	Ocean surface stress in the model +y direction	N m-2

Description of the variable in Common Data language (CDL)

```
float32 oceTAUY(time, tile, j_g, i)
    oceTAUY: _FillValue = 9.96921e+36
    oceTAUY: coordinates = time
    oceTAUY: coverage_content_type = modelResult
    oceTAUY: direction = >0 increases horizontal velocity in the +y direction (VVEL)
    oceTAUY: long_name = Ocean surface stress in the model +y direction
    oceTAUY: mate = oceTAUX
    oceTAUY: standard_name = downward y stress at sea water surface
    oceTAUY: units = N m-2
    oceTAUY: valid_max = 1.9999693632125854
    oceTAUY: valid_min = -2.0606131553649902
```

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.

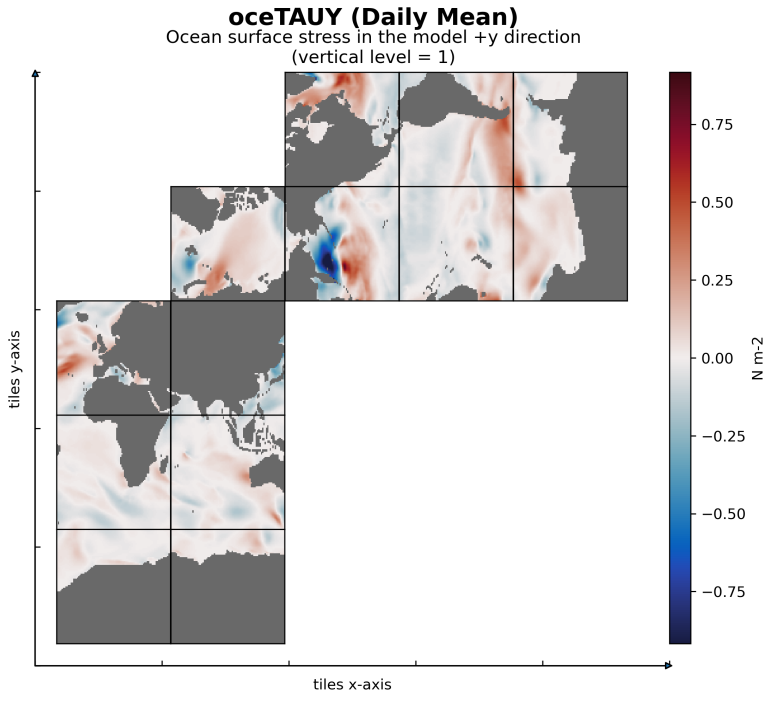


Figure 77: Dataset: OCEAN_AND_ICE_SURFACE_STRESS, Variable: oceTAUY

11.10 Native dataset of OCEAN_BOLUS_STREAMFUNCTION

11.10.1 Overview

This dataset provides 3D fields of Gent-McWilliams ocean bolus transport streamfunctions on the lat-lon-cap 90 (llc90) native model grid from the ECCO Version 4 Release 4 (V4r4) ocean and sea-ice state estimate. The dataset is provided on daily-average and monthly-average time resolution.

Table 11.66: Coordinates and Variables in the dataset OCEAN_BOLUS_STREAMFUNCTION

Coordinates	Description of data coordinates	Unit
i	Grid index in x for variables at tracer and 'v' locations	–none–
i_g	Grid index in x for variables at 'u' and 'g' locations	–none–
j	Grid index in y for variables at tracer and 'u' locations	–none–
j_g	Grid index in y for variables at 'v' and 'g' locations	–none–
k	Grid index in z for tracer variables	–none–
k_u	Grid index in z corresponding to the bottom face of tracer grid cells ('w' locations)	–none–
k_l	Grid index in z corresponding to the top face of tracer grid cells ('w' locations)	–none–
k_p1	Grid index in z for variables at 'w' locations	–none–
tile	Lat-lon-cap tile index	–none–
time	Center time of averaging period	–none–
XC	Longitude of tracer grid cell center	degrees_east
YC	Latitude of tracer grid cell center	degrees_north
XG	Longitude of 'southwest' corner of tracer grid cell	degrees_east
YG	Latitude of 'southwest' corner of tracer grid cell	degrees_north
Z	Depth of tracer grid cell center	m
Zp1	Depth of tracer grid cell interface	m
Zu	Depth of the bottom face of tracer grid cells	m
Zl	Depth of the top face of tracer grid cells	m
time_bnds	Time bounds of averaging period	–none–
XC_bnds	Longitudes of tracer grid cell corners	–none–
YC_bnds	Latitudes of tracer grid cell corners	–none–
Z_bnds	Depths of tracer grid cell upper and lower interfaces	–none–
Variables	**Description of data variables**	**Unit**
GM_PsiX	Gent-mcwilliams bolus transport streamfunction in the model +x direction	m2 s-1
GM_PsiY	Gent-mcwilliams bolus transport streamfunction in the model +y direction	m2 s-1

11.10.2 Native Variable: GM_PsiX

Table 11.67: Attributes description of the variable 'GM_PsiX' from OCEAN_BOLUS_STREAMFUNCTION's dataset.

Storage Type	Variable Name	Description	Unit
float32	GM_PsiX	Gent-mcwilliams bolus transport streamfunction in the model +x direction	m2 s-1

Description of the variable in Common Data language (CDL)

```
float32 GM_PsiX(time, k_l, tile, j, i_g)
   GM_PsiX: _FillValue = 9.96921e+36
   GM_PsiX: coordinates = Zl time
   GM_PsiX: coverage_content_type = modelResult
   GM_PsiX: long_name = Gent-Mcwilliams bolus transport streamfunction in the model +x direction
   GM_PsiX: mate = GM PsiY
   GM_PsiX: units = m2 s-1
   GM_PsiX: valid_max = 4.963776111602783
   GM_PsiX: valid_min = -4.9964470863342285
```

Comments

Gent-mcwilliams bolus transport streamfunction 'u' component. any comments welcome

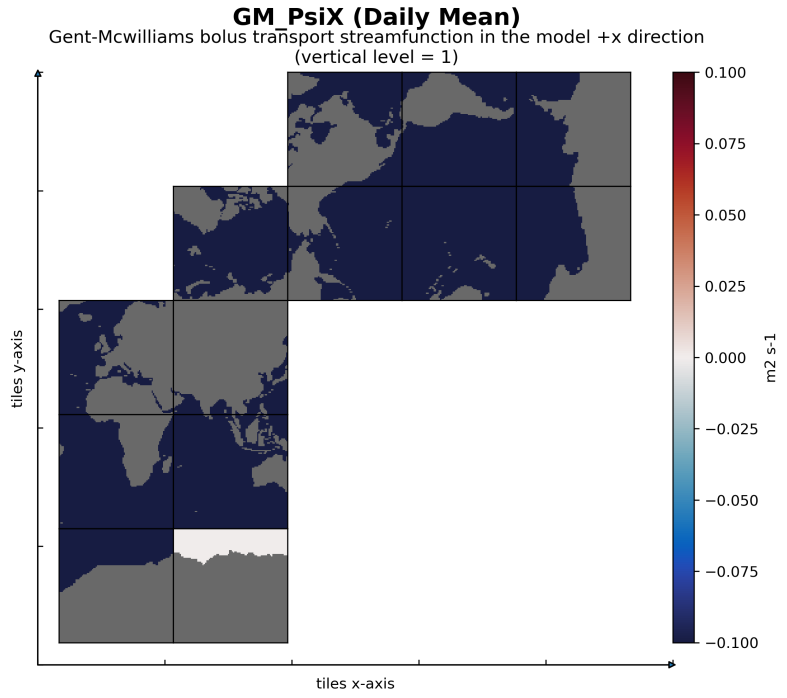


Figure 78: Dataset: OCEAN_BOLUS_STREAMFUNCTION, Variable: GM_PsiX

11.10.3 Native Variable: GM_PsiY

Table 11.68: Attributes description of the variable 'GM_PsiY' from OCEAN_BOLUS_STREAMFUNCTION's dataset.

Storage Type	Variable Name	Description	Unit
float32	GM_PsiY	Gent-mcwilliams bolus transport streamfunction in the model +y direction	m2 s-1

Description of the variable in Common Data language (CDL)

```
float32 GM_PsiY(time, k_l, tile, j_g, i)
   GM_PsiY: _FillValue = 9.96921e+36
   GM_PsiY: coordinates = Zl time
   GM_PsiY: coverage_content_type = modelResult
   GM_PsiY: long_name = Gent-Mcwilliams bolus transport streamfunction in the model +y direction
   GM_PsiY: mate = GM PsiX
   GM_PsiY: units = m2 s-1
   GM_PsiY: valid_max = 4.949861526489258
   GM_PsiY: valid_min = -5.0
```

Comments

Gent-mcwilliams bolus transport streamfunction 'v' component. any comments welcome

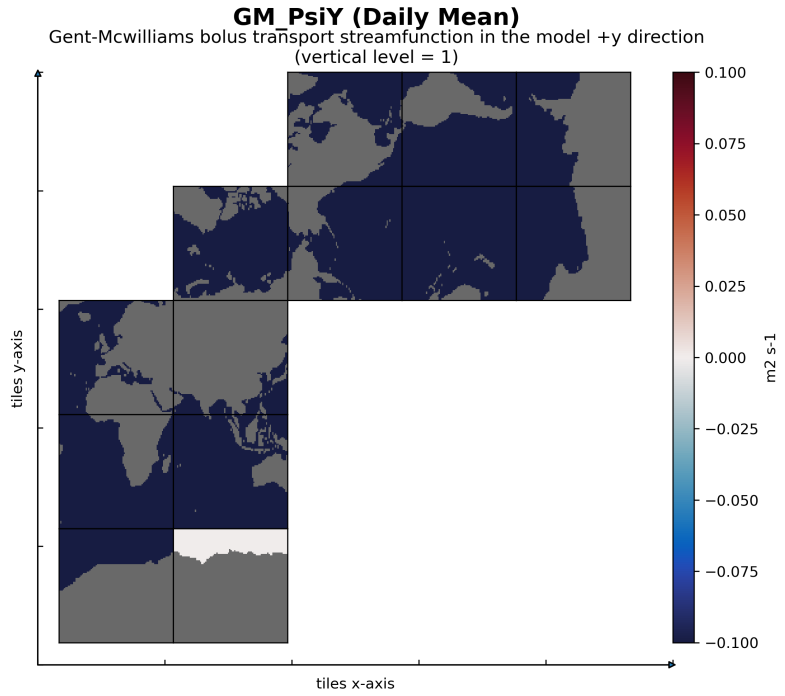


Figure 79: Dataset: OCEAN_BOLUS_STREAMFUNCTION, Variable: GM_PsiY

11.11 Native dataset of OCEAN_BOLUS_VELOCITY

11.11.1 Overview

This dataset provides 3D fields of Gent-McWilliams ocean bolus velocity on the lat-lon-cap 90 (llc90) native model grid from the ECCO Version 4 Release 4 (V4r4) ocean and sea-ice state estimate. The dataset is provided on daily-average and monthly-average time resolution.

Table 11.69: Coordinates and Variables in the dataset OCEAN_BOLUS_VELOCITY

Coordinates	Description of data coordinates	Unit
i	Grid index in x for variables at tracer and 'v' locations	–none–
i_g	Grid index in x for variables at 'u' and 'g' locations	–none–
j	Grid index in y for variables at tracer and 'u' locations	–none–
j_g	Grid index in y for variables at 'v' and 'g' locations	–none–
k	Grid index in z for tracer variables	–none–
k_u	Grid index in z corresponding to the bottom face of tracer grid cells ('w' locations)	–none–
k_l	Grid index in z corresponding to the top face of tracer grid cells ('w' locations)	–none–
k_p1	Grid index in z for variables at 'w' locations	–none–
tile	Lat-lon-cap tile index	–none–
time	Center time of averaging period	–none–
XC	Longitude of tracer grid cell center	degrees_east
YC	Latitude of tracer grid cell center	degrees_north
XG	Longitude of 'southwest' corner of tracer grid cell	degrees_east
YG	Latitude of 'southwest' corner of tracer grid cell	degrees_north
Z	Depth of tracer grid cell center	m
Zp1	Depth of tracer grid cell interface	m
Zu	Depth of the bottom face of tracer grid cells	m
Zl	Depth of the top face of tracer grid cells	m
time_bnds	Time bounds of averaging period	–none–
XC_bnds	Longitudes of tracer grid cell corners	–none–
YC_bnds	Latitudes of tracer grid cell corners	–none–
Z_bnds	Depths of tracer grid cell upper and lower interfaces	–none–
Variables	**Description of data variables**	**Unit**
UVELSTAR	Gent-mcwilliams velocity in the model +x direction scaled by time-varying grid cell thickness	m s-1
VVELSTAR	Gent-mcwilliams velocity in the model +y direction scaled by time-varying grid cell thickness	m s-1
WVELSTAR	Gent-mcwilliams velocity in the model +z direction	m s-1

11.11.2 Native Variable: UVELSTAR

Table 11.70: Attributes description of the variable 'UVELSTAR' from OCEAN_BOLUS_VELOCITY's dataset.

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

Description of the variable in Common Data language (CDL)

```
float32 UVELSTAR(time, k, tile, j, i_g)
   UVELSTAR: _FillValue = 9.96921e+36
   UVELSTAR: coordinates = Z time
   UVELSTAR: coverage_content_type = modelResult
   UVELSTAR: long_name = Gent-McWilliams velocity in the model +x direction scaled by time-varying grid
cell thickness
   UVELSTAR: mate = VVELSTAR
   UVELSTAR: standard_name = sea water x velocity due to parameterized mesoscale eddies
   UVELSTAR: units = m s-1
   UVELSTAR: valid_max = 0.7762293219566345
   UVELSTAR: valid_min = -0.7960150241851807
```

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.

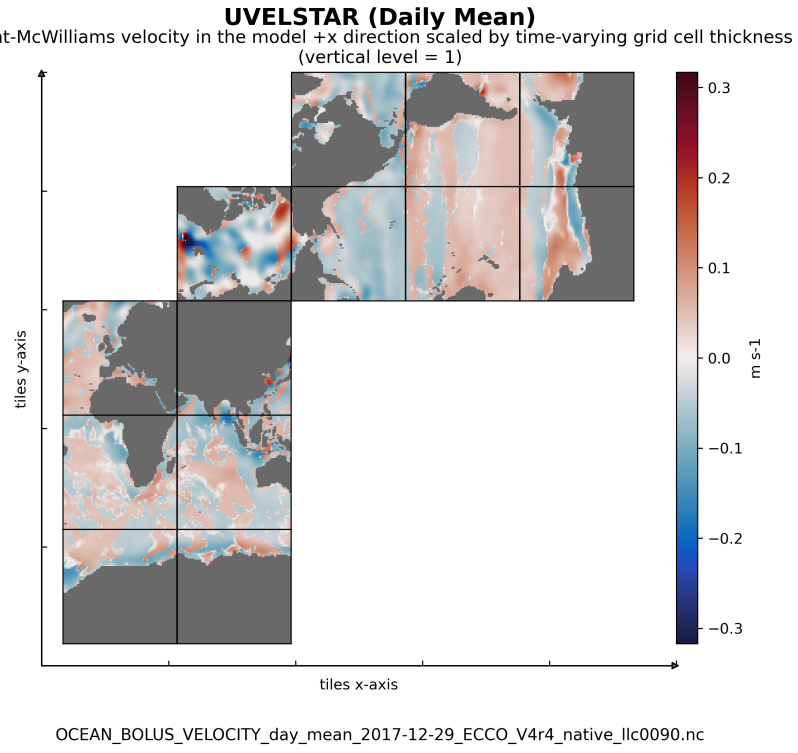


Figure 80: Dataset: OCEAN_BOLUS_VELOCITY, Variable: UVELSTAR

11.11.3 Native Variable: VVELSTAR

Table 11.71: Attributes description of the variable 'VVELSTAR' from OCEAN_BOLUS_VELOCITY's dataset.

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

Description of the variable in Common Data language (CDL)

```
float32 VVELSTAR(time, k, tile, j_g, i)
    VVELSTAR: _FillValue = 9.96921e+36
    VVELSTAR: coordinates = Z time
    VVELSTAR: coverage_content_type = modelResult
    VVELSTAR: long_name = Gent-McWilliams velocity in the model +y direction scaled by time-varying grid
cell thickness
    VVELSTAR: mate = UVELSTAR
    VVELSTAR: standard_name = sea water y velocity due to parameterized mesoscale eddies
    VVELSTAR: units = m s-1
    VVELSTAR: valid_max = 0.7200774550437927
    VVELSTAR: valid_min = -0.8495296239852905
```

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.

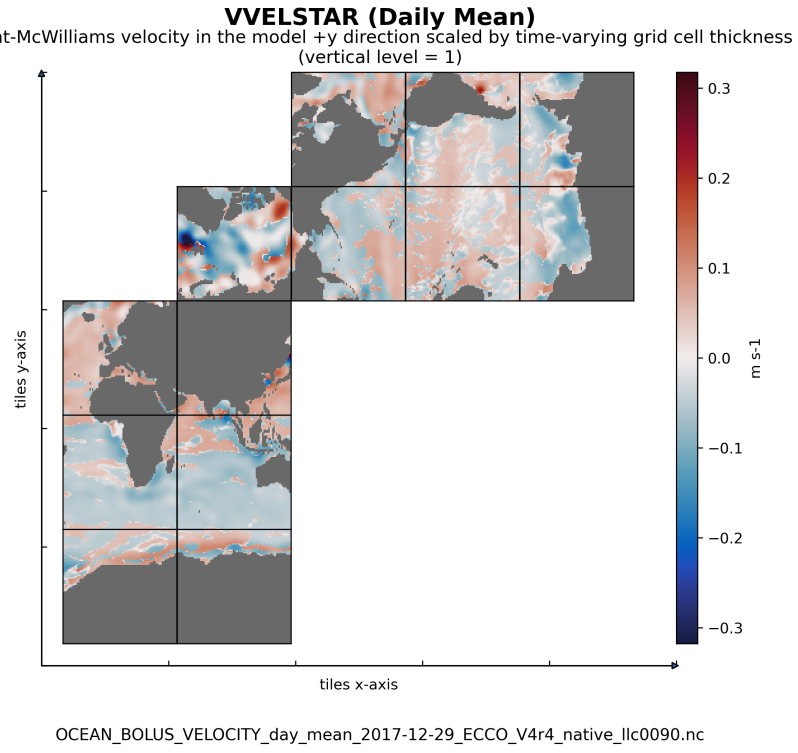


Figure 81: Dataset: OCEAN_BOLUS_VELOCITY, Variable: VVELSTAR

11.11.4 Native Variable: WVELSTAR

Table 11.72: Attributes description of the variable 'WVELSTAR' from OCEAN_BOLUS_VELOCITY's dataset.

Storage Type	Variable Name	Description	Unit
float32	WVELSTAR	Gent-mcwilliams velocity in the model +z direction	m s-1

Description of the variable in Common Data language (CDL)

```
float32 WVELSTAR(time, k_l, tile, j, i)
    WVELSTAR: _FillValue = 9.96921e+36
    WVELSTAR: coordinates = XC YC time Zl
    WVELSTAR: coverage_content_type = modelResult
    WVELSTAR: direction = >0 decreases volume
    WVELSTAR: long_name = Gent-McWilliams velocity in the model +z direction
    WVELSTAR: standard_name = upward sea water velocity due to parameterized mesoscale eddies
    WVELSTAR: units = m s-1
    WVELSTAR: valid_max = 0.000465469085611403
    WVELSTAR: valid_min = -0.00037936007720418274
```

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).

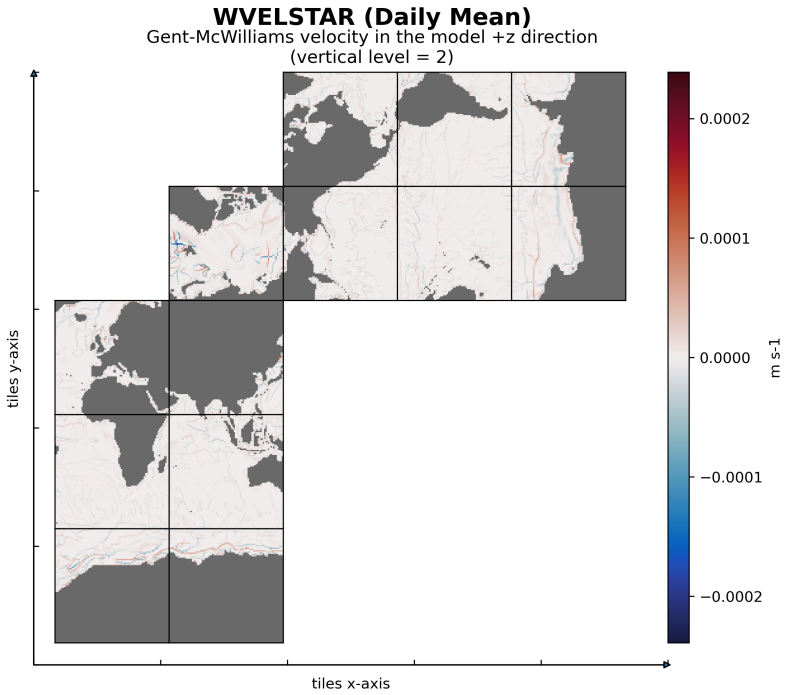


Figure 82: Dataset: OCEAN_BOLUS_VELOCITY, Variable: WVELSTAR

11.12 Native dataset of OCEAN_BOTTOM_PRESSURE

11.12.1 Overview

This dataset provides 2D fields of ocean bottom pressure and model ocean bottom pressure anomaly on the lat-lon-cap 90 (llc90) native model grid from the ECCO Version 4 Release 4 (V4r4) ocean and sea-ice state estimate. The dataset is provided on daily-average and monthly-average time resolution. Snapshot data of ocean bottom pressure and model ocean bottom pressure anomaly are also provided. Ocean bottom pressure is provided in three forms: 1) ocean bottom pressure including global mean atmosphereic pressure (OGPGMAP), 2) ocean bottom pressure excluding global mean atmosphereic pressure (OGP), and 3) the model's hydrostatic bottom pressure anomaly before the Greatbatch correction (PHIBOT). Note: the ocean bottom pressure field PHIBOT should not be compared with satellite bottom pressure products (e.g., from GRACE and GRACE-FO), see the variable descriptions of OBP and PHIBOT for more details.

Table 11.73: Coordinates and Variables in the dataset OCEAN_BOTTOM_PRESSURE

Coordinates	Description of data coordinates	Unit
i	Grid index in x for variables at tracer and 'v' locations	–none–
i_g	Grid index in x for variables at 'u' and 'g' locations	–none–
j	Grid index in y for variables at tracer and 'u' locations	–none–
j_g	Grid index in y for variables at 'v' and 'g' locations	–none–
tile	Lat-lon-cap tile index	–none–
time	Center time of averaging period	–none–
XC	Longitude of tracer grid cell center	degrees_east
YC	Latitude of tracer grid cell center	degrees_north
XG	Longitude of 'southwest' corner of tracer grid cell	degrees_east
YG	Latitude of 'southwest' corner of tracer grid cell	degrees_north
time_bnds	Time bounds of averaging period	–none–
XC_bnds	Longitudes of tracer grid cell corners	–none–
YC_bnds	Latitudes of tracer grid cell corners	–none–
Variables	**Description of data variables**	**Unit**
OBP	Ocean bottom pressure given as equivalent water thickness	m
OBPGMAP	Ocean bottom pressure given as equivalent water thickness, includes global mean atmospheric pressure	m
PHIBOT	Ocean hydrostatic bottom pressure anomaly	m2 s-2

11.12.2 Native Variable: OBP

Table 11.74: Attributes description of the variable 'OBP' from OCEAN_BOTTOM_PRESSURE's dataset.

Storage Type	Variable Name	Description	Unit
float32	OBP	Ocean bottom pressure given as equivalent water thickness	m

Description of the variable in Common Data language (CDL)

```
float32 OBP(time, tile, j, i)
    OBP: _FillValue = 9.96921e+36
    OBP: coordinates = time XC YC
    OBP: coverage_content_type = modelResult
    OBP: long_name = Ocean bottom pressure given as equivalent water thickness
    OBP: units = m
    OBP: valid_max = 72.1243667602539
    OBP: valid_min = -2.544442892074585
```

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.

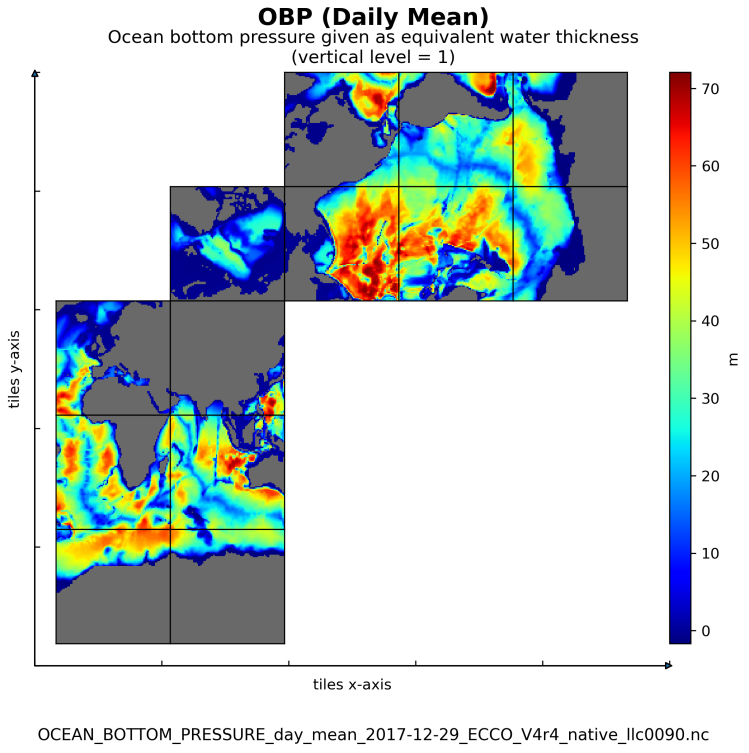


Figure 83: Dataset: OCEAN_BOTTOM_PRESSURE, Variable: OBP

11.12.3 Native Variable: OBPGMAP

Table 11.75: Attributes description of the variable 'OBPGMAP' from OCEAN_BOTTOM_PRESSURE's dataset.

Storage Type	Variable Name	Description	Unit
float32	OBPGMAP	Ocean bottom pressure given as equivalent water thickness, includes global mean atmospheric pressure	m

Description of the variable in Common Data language (CDL)

```
float32 OBPGMAP(time, tile, j, i)
   OBPGMAP: _FillValue = 9.96921e+36
   OBPGMAP: coordinates = time XC YC
   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: valid_max = 82.14805603027344
   OBPGMAP: valid_min = 7.395928859710693
```

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.

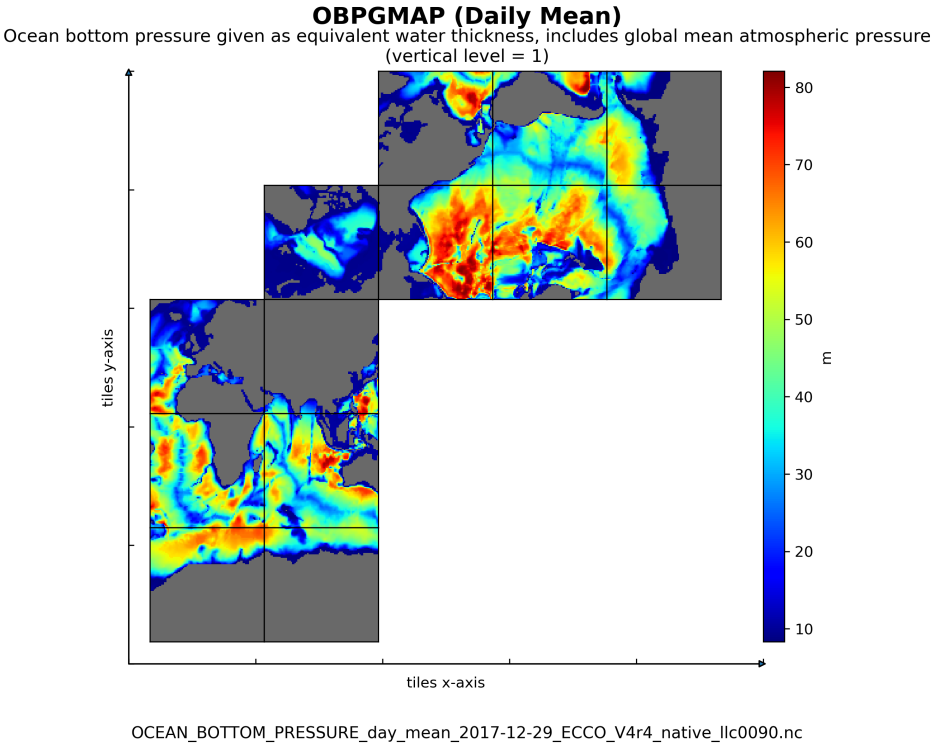


Figure 84: Dataset: OCEAN_BOTTOM_PRESSURE, Variable: OBPGMAP

11.12.4 Native Variable: PHIBOT

Table 11.76: Attributes description of the variable 'PHIBOT' from OCEAN_BOTTOM_PRESSURE's dataset.

Storage Type	Variable Name	Description	Unit
float32	PHIBOT	Ocean hydrostatic bottom pressure anomaly	m2 s-2

Description of the variable in Common Data language (CDL)

```
float32 PHIBOT(time, tile, j, i)
   PHIBOT: _FillValue = 9.96921e+36
   PHIBOT: coordinates = time XC YC
   PHIBOT: coverage_content_type = modelResult
   PHIBOT: long_name = Ocean hydrostatic bottom pressure anomaly
   PHIBOT: units = m2 s-2
   PHIBOT: valid_max = 805.7855224609375
   PHIBOT: valid_min = 73.01050567626953
```

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.

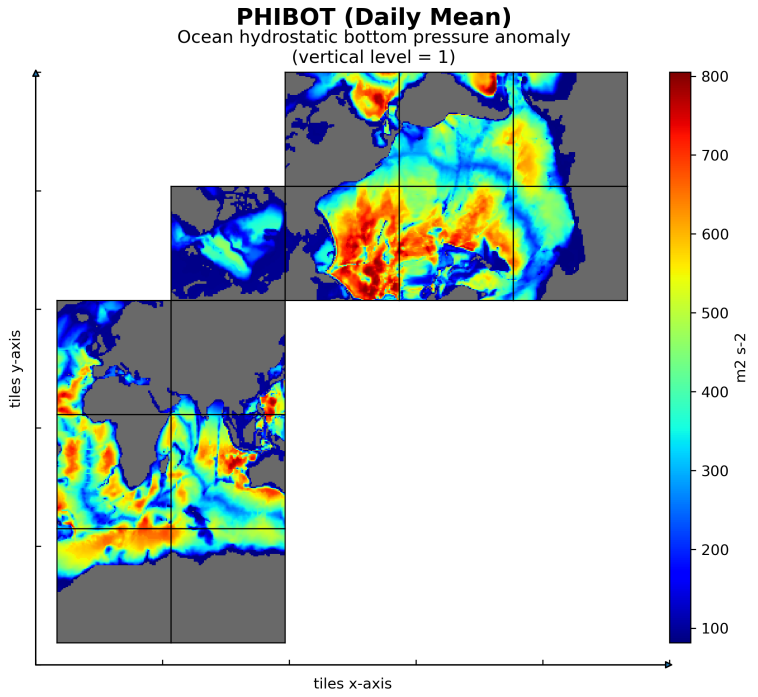


Figure 85: Dataset: OCEAN_BOTTOM_PRESSURE, Variable: PHIBOT

11.13 Native dataset of OCEAN_DENS_STRAT_PRESS

11.13.1 Overview

This dataset provides 3D fields of ocean density, stratification, and hydrostatic pressure on the lat-lon-cap 90 (llc90) native model grid from the ECCO Version 4 Release 4 (V4r4) ocean and sea-ice state estimate. The dataset is provided on daily-average and monthly-average time resolution. Hydrostatic pressure is provided in two forms: 1) using constant vertical grid spacing (PHIHYDcR) and 2) using time-varying grid spacing from the model's z* coordinate system (PHIHYD).

Table 11.77: Coordinates and Variables in the dataset OCEAN_DENS_STRAT_PRESS

Coordinates	Description of data coordinates	Unit
i	Grid index in x for variables at tracer and 'v' locations	–none–
i_g	Grid index in x for variables at 'u' and 'g' locations	–none–
j	Grid index in y for variables at tracer and 'u' locations	–none–
j_g	Grid index in y for variables at 'v' and 'g' locations	–none–
k	Grid index in z for tracer variables	–none–
k_u	Grid index in z corresponding to the bottom face of tracer grid cells ('w' locations)	–none–
k_l	Grid index in z corresponding to the top face of tracer grid cells ('w' locations)	–none–
k_p1	Grid index in z for variables at 'w' locations	–none–
tile	Lat-lon-cap tile index	–none–
time	Center time of averaging period	–none–
XC	Longitude of tracer grid cell center	degrees_east
YC	Latitude of tracer grid cell center	degrees_north
XG	Longitude of 'southwest' corner of tracer grid cell	degrees_east
YG	Latitude of 'southwest' corner of tracer grid cell	degrees_north
Z	Depth of tracer grid cell center	m
Zp1	Depth of tracer grid cell interface	m
Zu	Depth of the bottom face of tracer grid cells	m
Zl	Depth of the top face of tracer grid cells	m
time_bnds	Time bounds of averaging period	–none–
XC_bnds	Longitudes of tracer grid cell corners	–none–
YC_bnds	Latitudes of tracer grid cell corners	–none–
Z_bnds	Depths of tracer grid cell upper and lower interfaces	–none–
Variables	**Description of data variables**	**Unit**
RHOAnoma	In-situ seawater density anomaly	kg m-3
DRHODR	Density stratification	kg m-3 m-1
PHIHYD	Ocean hydrostatic pressure anomaly	m2 s-2
PHIHYDcR	Ocean hydrostatic pressure anomaly at constant depths	m2 s-2

11.13.2 Native Variable: DRHODR

Table 11.78: Attributes description of the variable 'DRHODR' from OCEAN_DENS_STRAT_PRESS's dataset.

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

Description of the variable in Common Data language (CDL)

```
float32 DRHODR(time, k_l, tile, j, i)
    DRHODR: _FillValue = 9.96921e+36
    DRHODR: coordinates = YC XC time Zl
    DRHODR: coverage_content_type = modelResult
    DRHODR: long_name = Density stratification
    DRHODR: units = kg m-3 m-1
    DRHODR: valid_max = 0.011617615818977356
    DRHODR: valid_min = -0.8687265515327454
```

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 $p_0=-g ho_{0} z$.

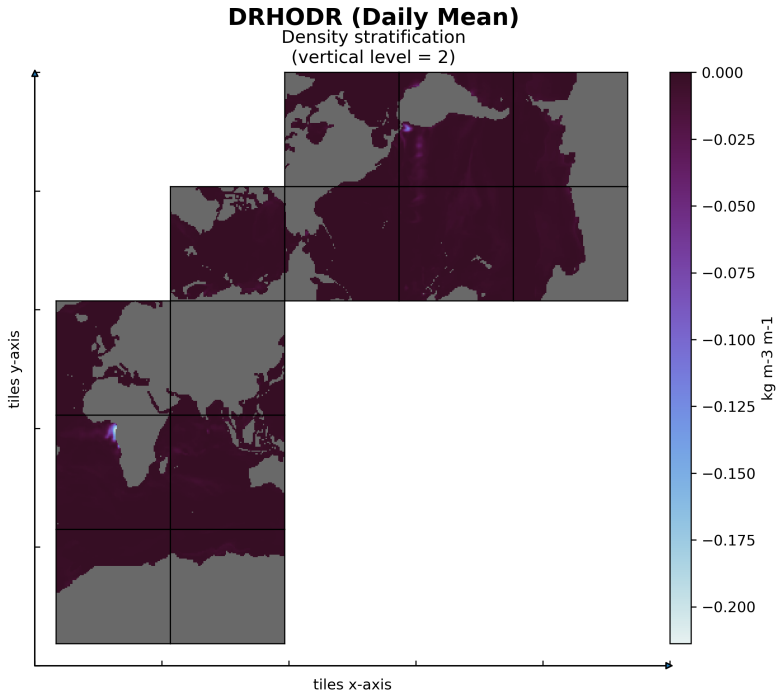


Figure 86: Dataset: OCEAN_DENS_STRAT_PRESS, Variable: DRHODR

11.13.3 Native Variable: PHIHYD

Table 11.79: Attributes description of the variable 'PHIHYD' from OCEAN_DENS_STRAT_PRESS's dataset.

Storage Type	Variable Name	Description	Unit
float32	PHIHYD	Ocean hydrostatic pressure anomaly	m2 s-2

Description of the variable in Common Data language (CDL)

```
float32 PHIHYD(time, k, tile, j, i)
   PHIHYD: _FillValue = 9.96921e+36
   PHIHYD: coordinates = YC Z XC time
   PHIHYD: coverage_content_type = modelResult
   PHIHYD: long_name = Ocean hydrostatic pressure anomaly
   PHIHYD: units = m2 s-2
   PHIHYD: valid_max = 783.9188232421875
   PHIHYD: valid_min = 74.71473693847656
```

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).

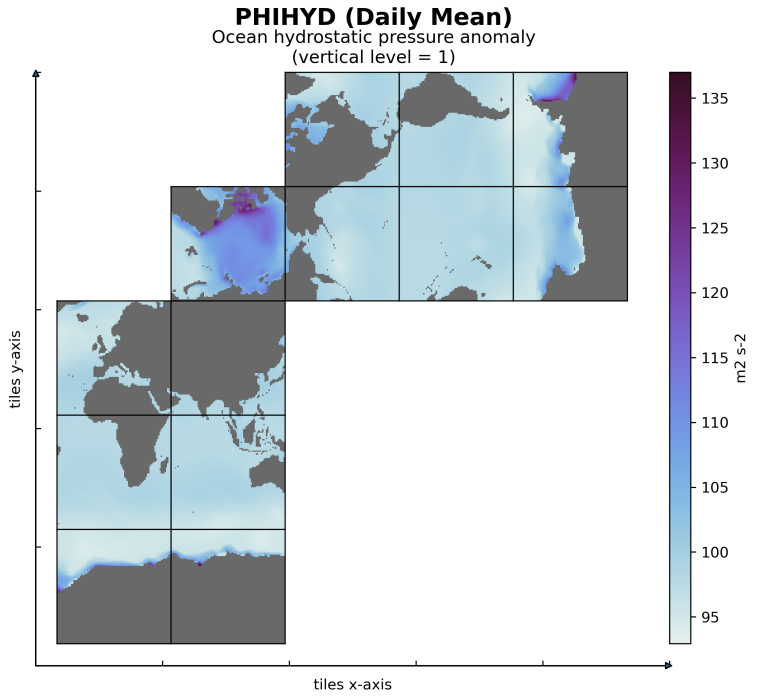


Figure 87: Dataset: OCEAN_DENS_STRAT_PRESS, Variable: PHIHYD

11.13.4 Native Variable: PHIHYDcR

Table 11.80: Attributes description of the variable 'PHIHYDcR' from OCEAN_DENS_STRAT_PRESS's dataset.

Storage Type	Variable Name	Description	Unit
float32	PHIHYDcR	Ocean hydrostatic pressure anomaly at constant depths	m2 s-2

Description of the variable in Common Data language (CDL)

```
float32 PHIHYDcR(time, k, tile, j, i)
    PHIHYDcR: _FillValue = 9.96921e+36
    PHIHYDcR: coordinates = YC Z XC time
    PHIHYDcR: coverage_content_type = modelResult
    PHIHYDcR: long_name = Ocean hydrostatic pressure anomaly at constant depths
    PHIHYDcR: units = m2 s-2
    PHIHYDcR: valid_max = 784.4268188476562
    PHIHYDcR: valid_min = 73.08939361572266
```

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 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).

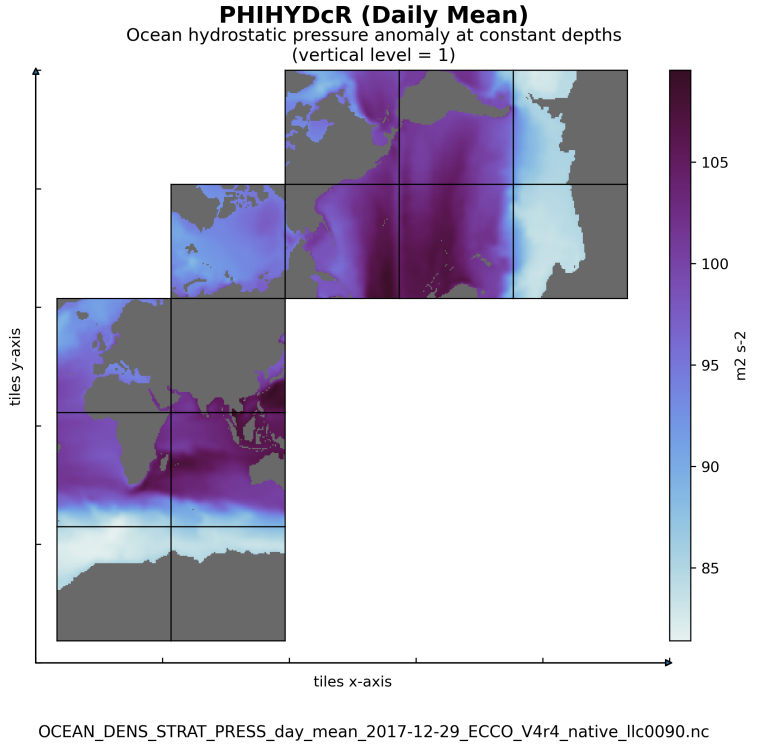


Figure 88: Dataset: OCEAN_DENS_STRAT_PRESS, Variable: PHIHYDcR

11.13.5 Native Variable: RHOAnoma

Table 11.81: Attributes description of the variable 'RHOAnoma' from OCEAN_DENS_STRAT_PRESS's dataset.

Storage Type	Variable Name	Description	Unit
float32	RHOAnoma	In-situ seawater density anomaly	kg m-3

Description of the variable in Common Data language (CDL)

```
float32 RHOAnoma(time, k, tile, j, i)
    RHOAnoma:  _FillValue = 9.96921e+36
    RHOAnoma:  coordinates = YC Z XC time
    RHOAnoma:  coverage_content_type = modelResult
    RHOAnoma:  long_name = In-situ seawater density anomaly
    RHOAnoma:  units = kg m-3
    RHOAnoma:  valid_max = 25.540647506713867
    RHOAnoma:  valid_min = -19.919862747192383
```

Comments

In-situ seawater density anomaly relative to the reference density, rhoconst. rhoconst = 1029 kg m-3

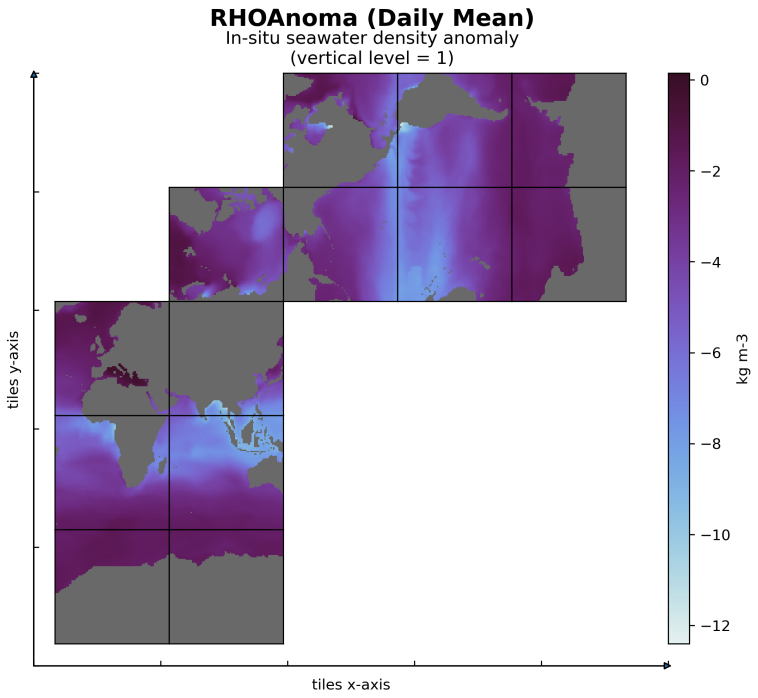


Figure 89: Dataset: OCEAN_DENS_STRAT_PRESS, Variable: RHOAnoma

11.14 Native dataset of OCEAN_MIXED_LAYER_DEPTH

11.14.1 Overview

This dataset provides 2D fields of ocean mixed layer depth on the lat-lon-cap 90 (llc90) native model grid from the ECCO Version 4 Release 4 (V4r4) ocean and sea-ice state estimate. The dataset is provided on daily-average and monthly-average time resolution.

Table 11.82: Coordinates and Variables in the dataset OCEAN_MIXED_LAYER_DEPTH

Coordinates	Description of data coordinates	Unit
i	Grid index in x for variables at tracer and 'v' locations	–none–
i_g	Grid index in x for variables at 'u' and 'g' locations	–none–
j	Grid index in y for variables at tracer and 'u' locations	–none–
j_g	Grid index in y for variables at 'v' and 'g' locations	–none–
tile	Lat-lon-cap tile index	–none–
time	Center time of averaging period	–none–
XC	Longitude of tracer grid cell center	degrees_east
YC	Latitude of tracer grid cell center	degrees_north
XG	Longitude of 'southwest' corner of tracer grid cell	degrees_east
YG	Latitude of 'southwest' corner of tracer grid cell	degrees_north
time_bnds	Time bounds of averaging period	–none–
XC_bnds	Longitudes of tracer grid cell corners	–none–
YC_bnds	Latitudes of tracer grid cell corners	–none–
Variables	**Description of data variables**	**Unit**
MXLDEPTH	Mixed-layer depth diagnosed using the temperature difference criterion of kara et al., 2000	m

11.14.2 Native Variable: MXLDEPTH

Table 11.83: Attributes description of the variable 'MXLDEPTH' from OCEAN_MIXED_LAYER_DEPTH's dataset.

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

Description of the variable in Common Data language (CDL)

```
float32 MXLDEPTH(time, tile, j, i)
    MXLDEPTH: _FillValue = 9.96921e+36
    MXLDEPTH: coordinates = time XC YC
    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: valid_max = 5331.2001953125
    MXLDEPTH: valid_min = 5.000001430511475
```

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).

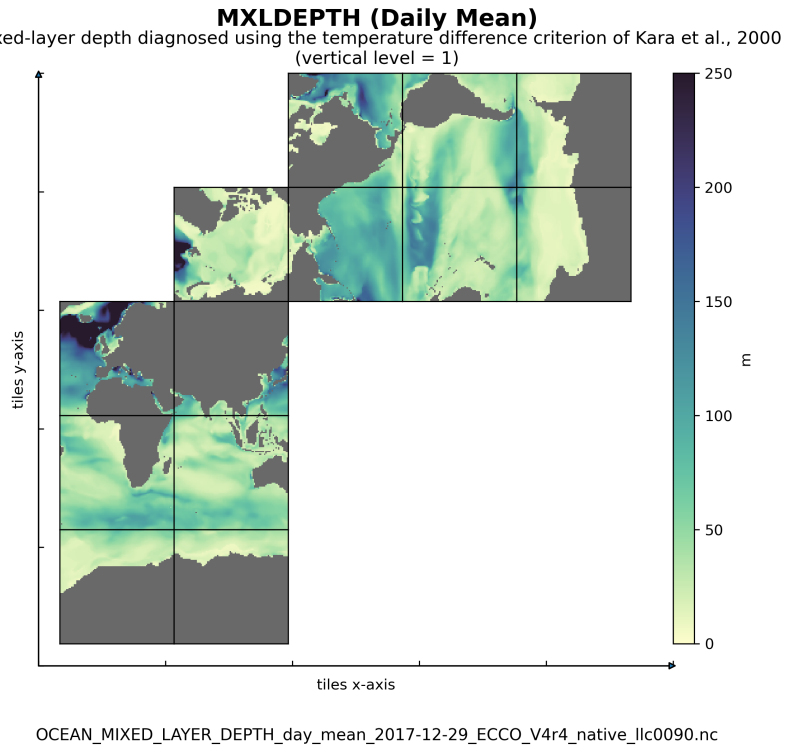


Figure 90: Dataset: OCEAN_MIXED_LAYER_DEPTH, Variable: MXLDEPTH

11.15 Native dataset of OCEAN_TEMPERATURE_SALINITY

11.15.1 Overview

This dataset provides 3D fields of ocean potential temperature and salinity on the lat-lon-cap 90 (llc90) native model grid from the ECCO Version 4 Release 4 (V4r4) ocean and sea-ice state estimate. The dataset is provided on daily-average and monthly-average time resolution. Snapshot data of ocean potential temperature and salinity are also provided.

Table 11.84: Coordinates and Variables in the dataset OCEAN_TEMPERATURE_SALINITY

Coordinates	Description of data coordinates	Unit
i	Grid index in x for variables at tracer and 'v' locations	–none–
i_g	Grid index in x for variables at 'u' and 'g' locations	–none–
j	Grid index in y for variables at tracer and 'u' locations	–none–
j_g	Grid index in y for variables at 'v' and 'g' locations	–none–
k	Grid index in z for tracer variables	–none–
k_u	Grid index in z corresponding to the bottom face of tracer grid cells ('w' locations)	–none–
k_l	Grid index in z corresponding to the top face of tracer grid cells ('w' locations)	–none–
k_p1	Grid index in z for variables at 'w' locations	–none–
tile	Lat-lon-cap tile index	–none–
time	Center time of averaging period	–none–
XC	Longitude of tracer grid cell center	degrees_east
YC	Latitude of tracer grid cell center	degrees_north
XG	Longitude of 'southwest' corner of tracer grid cell	degrees_east
YG	Latitude of 'southwest' corner of tracer grid cell	degrees_north
Z	Depth of tracer grid cell center	m
Zp1	Depth of tracer grid cell interface	m
Zu	Depth of the bottom face of tracer grid cells	m
Zl	Depth of the top face of tracer grid cells	m
time_bnds	Time bounds of averaging period	–none–
XC_bnds	Longitudes of tracer grid cell corners	–none–
YC_bnds	Latitudes of tracer grid cell corners	–none–
Z_bnds	Depths of tracer grid cell upper and lower interfaces	–none–
Variables	**Description of data variables**	**Unit**
THETA	Potential temperature	degree_C
SALT	Salinity	1e-3

11.15.2 Native Variable: SALT

Table 11.85: Attributes description of the variable 'SALT' from OCEAN_TEMPERATURE_SALINITY's dataset.

Storage Type	Variable Name	Description	Unit
float32	SALT	Salinity	1e-3

Description of the variable in Common Data language (CDL)

```
float32 SALT(time, k, tile, j, i)
    SALT: _FillValue = 9.96921e+36
    SALT: coordinates = YC Z XC time
    SALT: coverage_content_type = modelResult
    SALT: long_name = Salinity
    SALT: standard_name = sea water salinity
    SALT: units = 1e-3
    SALT: valid_max = 41.321231842041016
    SALT: valid_min = 16.73577880859375
```

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

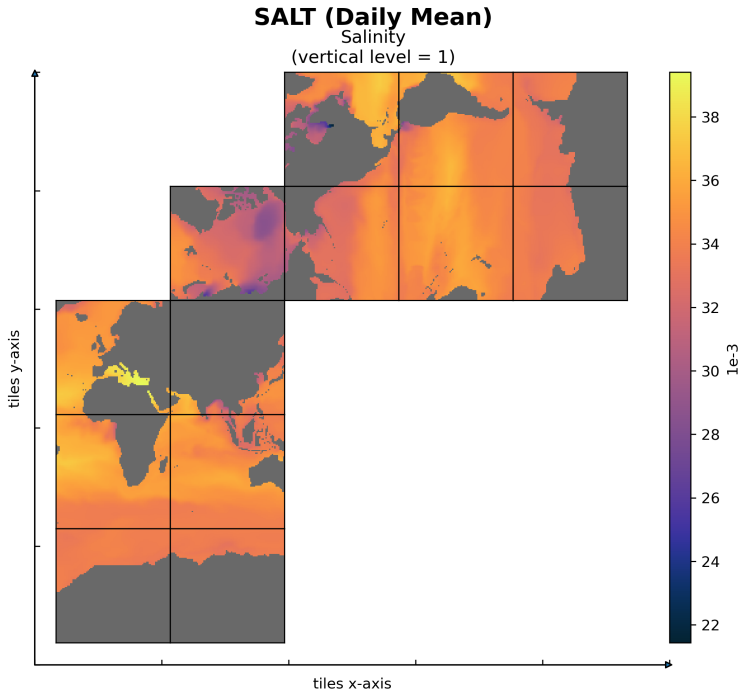


Figure 91: Dataset: OCEAN_TEMPERATURE_SALINITY, Variable: SALT

11.15.3 Native Variable: THETA

Table 11.86: Attributes description of the variable 'THETA' from OCEAN_TEMPERATURE_SALINITY's dataset.

Storage Type	Variable Name	Description	Unit
float32	THETA	Potential temperature	degree_C

Description of the variable in Common Data language (CDL)

```
float32 THETA(time, k, tile, j, i)
    THETA: _FillValue = 9.96921e+36
    THETA: coordinates = YC Z XC time
    THETA: coverage_content_type = modelResult
    THETA: long_name = Potential temperature
    THETA: standard_name = sea water potential temperature
    THETA: units = degree C
    THETA: valid_max = 36.425140380859375
    THETA: valid_min = -2.9179372787475586
```

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 $p_0=-g ho_{0} z$.

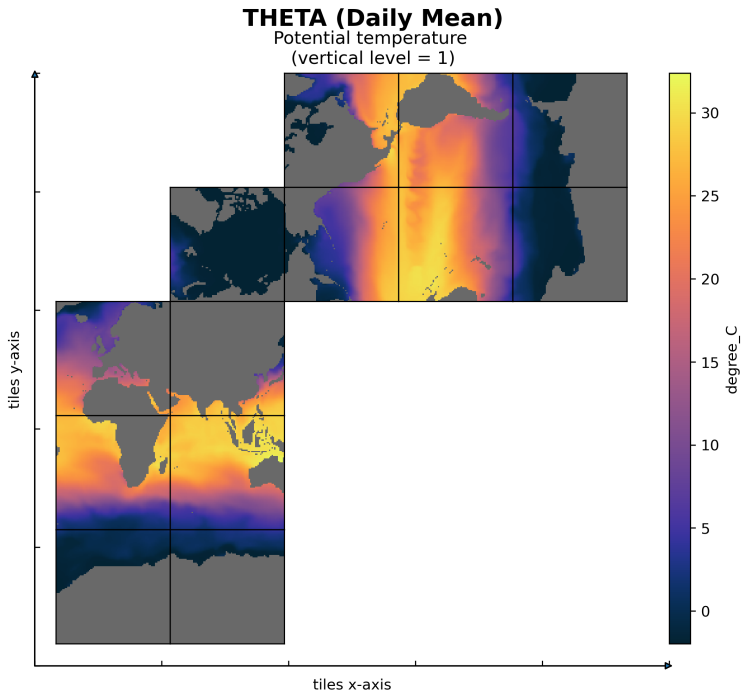


Figure 92: Dataset: OCEAN_TEMPERATURE_SALINITY, Variable: THETA

11.16 Native dataset of OCEAN_VELOCITY

11.16.1 Overview

This dataset provides 3D fields of ocean velocity (3D fields: zonal, meridional and vertical velocity components) on the lat-lon-cap 90 (llc90) native model grid from the ECCO Version 4 Release 4 (V4r4) ocean and sea-ice state estimate. The dataset is provided on daily-average and monthly-average time resolution.

Table 11.87: Coordinates and Variables in the dataset OCEAN_VELOCITY

Coordinates	Description of data coordinates	Unit
i	Grid index in x for variables at tracer and 'v' locations	–none–
i_g	Grid index in x for variables at 'u' and 'g' locations	–none–
j	Grid index in y for variables at tracer and 'u' locations	–none–
j_g	Grid index in y for variables at 'v' and 'g' locations	–none–
k	Grid index in z for tracer variables	–none–
k_u	Grid index in z corresponding to the bottom face of tracer grid cells ('w' locations)	–none–
k_l	Grid index in z corresponding to the top face of tracer grid cells ('w' locations)	–none–
k_p1	Grid index in z for variables at 'w' locations	–none–
tile	Lat-lon-cap tile index	–none–
time	Center time of averaging period	–none–
XC	Longitude of tracer grid cell center	degrees_east
YC	Latitude of tracer grid cell center	degrees_north
XG	Longitude of 'southwest' corner of tracer grid cell	degrees_east
YG	Latitude of 'southwest' corner of tracer grid cell	degrees_north
Z	Depth of tracer grid cell center	m
Zp1	Depth of tracer grid cell interface	m
Zu	Depth of the bottom face of tracer grid cells	m
Zl	Depth of the top face of tracer grid cells	m
time_bnds	Time bounds of averaging period	–none–
XC_bnds	Longitudes of tracer grid cell corners	–none–
YC_bnds	Latitudes of tracer grid cell corners	–none–
Z_bnds	Depths of tracer grid cell upper and lower interfaces	–none–
Variables	**Description of data variables**	**Unit**
UVEL	Horizontal velocity in the model +x direction	m s-1
VVEL	Horizontal velocity in the model +y direction	m s-1
WVEL	Vertical velocity	m s-1

11.16.2 Native Variable: UVEL

Table 11.88: Attributes description of the variable 'UVEL' from OCEAN_VELOCITY's dataset.

Storage Type	Variable Name	Description	Unit
float32	UVEL	Horizontal velocity in the model +x direction	m s-1

Description of the variable in Common Data language (CDL)

```
float32 UVEL(time, k, tile, j, i_g)
   UVEL: _FillValue = 9.96921e+36
   UVEL: coordinates = Z time
   UVEL: coverage_content_type = modelResult
   UVEL: direction = >0 increases volume
   UVEL: long_name = Horizontal velocity in the model +x direction
   UVEL: mate = VVEL
   UVEL: standard_name = sea water x velocity
   UVEL: units = m s-1
   UVEL: valid_max = 2.038635015487671
   UVEL: valid_min = -2.139253616333008
```

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.

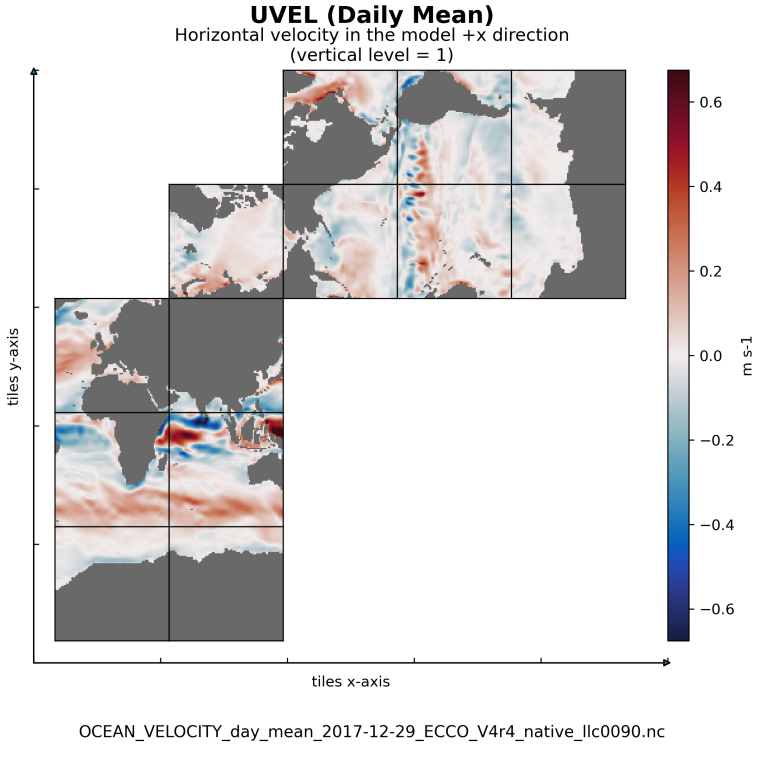


Figure 93: Dataset: OCEAN_VELOCITY, Variable: UVEL

11.16.3 Native Variable: VVEL

Table 11.89: Attributes description of the variable 'VVEL' from OCEAN_VELOCITY's dataset.

Storage Type	Variable Name	Description	Unit
float32	VVEL	Horizontal velocity in the model +y direction	m s-1

Description of the variable in Common Data language (CDL)

```
float32 VVEL(time, k, tile, j_g, i)
    VVEL: _FillValue = 9.96921e+36
    VVEL: coordinates = Z time
    VVEL: coverage_content_type = modelResult
    VVEL: direction = >0 increases volume
    VVEL: long_name = Horizontal velocity in the model +y direction
    VVEL: mate = UVEL
    VVEL: standard_name = sea water y velocity
    VVEL: units = m s-1
    VVEL: valid_max = 1.9089667797088623
    VVEL: valid_min = -1.7877743244171143
```

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.

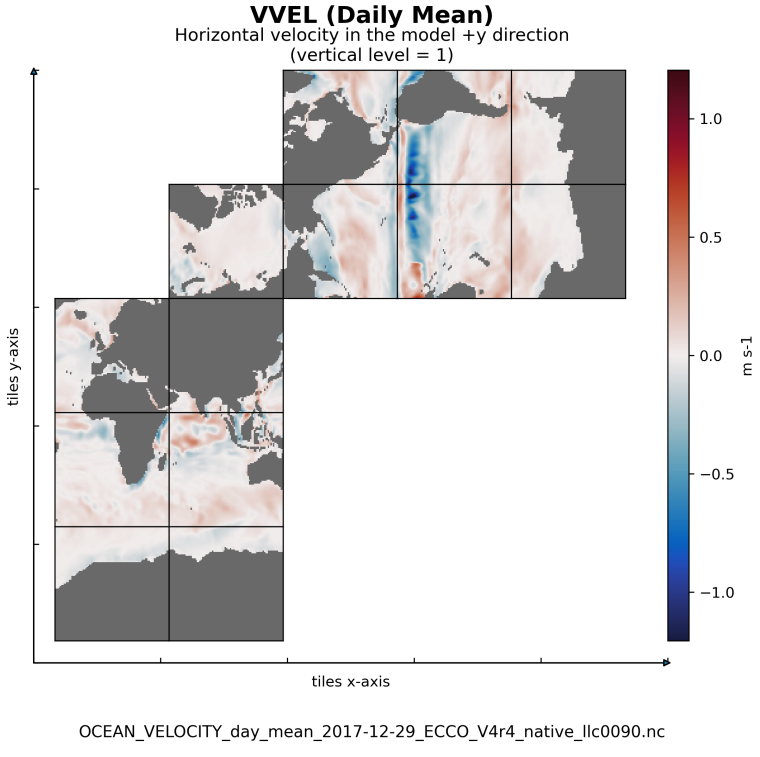


Figure 94: Dataset: OCEAN_VELOCITY, Variable: VVEL

11.16.4 Native Variable: WVEL

Table 11.90: Attributes description of the variable 'WVEL' from OCEAN_VELOCITY's dataset.

Storage Type	Variable Name	Description	Unit
float32	WVEL	Vertical velocity	m s-1

Description of the variable in Common Data language (CDL)

```
float32 WVEL(time, k_l, tile, j, i)
    WVEL: _FillValue = 9.96921e+36
    WVEL: coordinates = Zl YC time XC
    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: valid_max = 0.0016380994347855449
    WVEL: valid_min = -0.0023150660563260317
```

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.

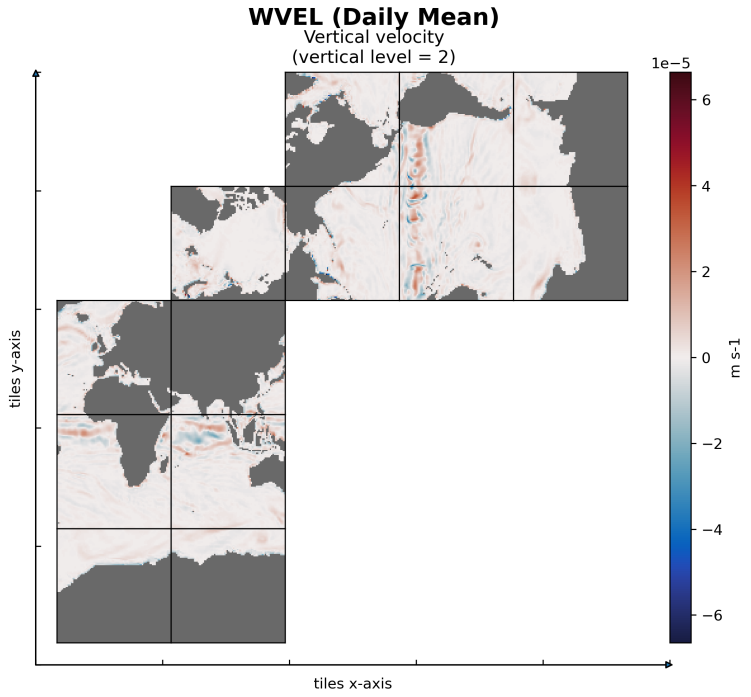


Figure 95: Dataset: OCEAN_VELOCITY, Variable: WVEL

11.17 Native dataset of SEA_ICE_CONC_THICKNESS

11.17.1 Overview

This dataset provides 2D fields of sea-ice and snow concentration, thickness, and pressure loading on the lat-lon-cap 90 (llc90) native model grid from the ECCO Version 4 Release 4 (V4r4) ocean and sea-ice state estimate. The dataset is provided on daily-average and monthly-average time resolution. Snapshot data of sea-ice and snow concentration, thickness, and pressure are also provided.

Table 11.91: Coordinates and Variables in the dataset SEA_ICE_CONC_THICKNESS

Coordinates	Description of data coordinates	Unit
i	Grid index in x for variables at tracer and 'v' locations	–none–
i_g	Grid index in x for variables at 'u' and 'g' locations	–none–
j	Grid index in y for variables at tracer and 'u' locations	–none–
j_g	Grid index in y for variables at 'v' and 'g' locations	–none–
tile	Lat-lon-cap tile index	–none–
time	Center time of averaging period	–none–
XC	Longitude of tracer grid cell center	degrees_east
YC	Latitude of tracer grid cell center	degrees_north
XG	Longitude of 'southwest' corner of tracer grid cell	degrees_east
YG	Latitude of 'southwest' corner of tracer grid cell	degrees_north
time_bnds	Time bounds of averaging period	–none–
XC_bnds	Longitudes of tracer grid cell corners	–none–
YC_bnds	Latitudes of tracer grid cell corners	–none–
Variables	**Description of data variables**	**Unit**
SIarea	Sea-ice concentration	1
SIheff	Area-averaged sea-ice thickness	m
SIhsnow	Area-averaged snow thickness	m
sIceLoad	Average sea-ice and snow mass per unit area	kg m-2

11.17.2 Native Variable: SIarea

Table 11.92: Attributes description of the variable 'SIarea' from SEA_ICE_CONC_THICKNESS's dataset.

Storage Type	Variable Name	Description	Unit
float32	SIarea	Sea-ice concentration	1

Description of the variable in Common Data language (CDL)

```
float32 SIarea(time, tile, j, i)
    SIarea:  _FillValue = 9.96921e+36
    SIarea:  coordinates = time YC XC
    SIarea:  coverage_content_type = modelResult
    SIarea:  long_name = Sea-ice concentration
    SIarea:  standard_name = sea ice area fraction
    SIarea:  units = 1
    SIarea:  valid_max = 0.9700000286102295
    SIarea:  valid_min = 0.0
```

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

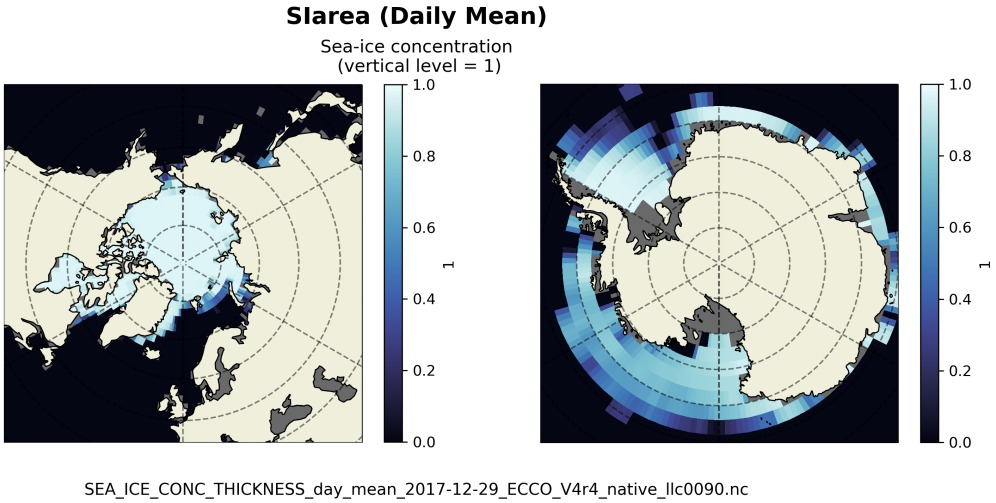


Figure 96: Dataset: SEA_ICE_CONC_THICKNESS, Variable: SIarea

11.17.3 Native Variable: SIheff

Table 11.93: Attributes description of the variable 'SIheff' from SEA_ICE_CONC_THICKNESS's dataset.

Storage Type	Variable Name	Description	Unit
float32	SIheff	Area-averaged sea-ice thickness	m

Description of the variable in Common Data language (CDL)

```
float32 SIheff(time, tile, j, i)
    SIheff:  _FillValue = 9.96921e+36
    SIheff:  coordinates = time YC XC
    SIheff:  coverage_content_type = modelResult
    SIheff:  long_name = Area-averaged sea-ice thickness
    SIheff:  standard_name = sea ice thickness
    SIheff:  units = m
    SIheff:  valid_max = 9.000518798828125
    SIheff:  valid_min = 0.0
```

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

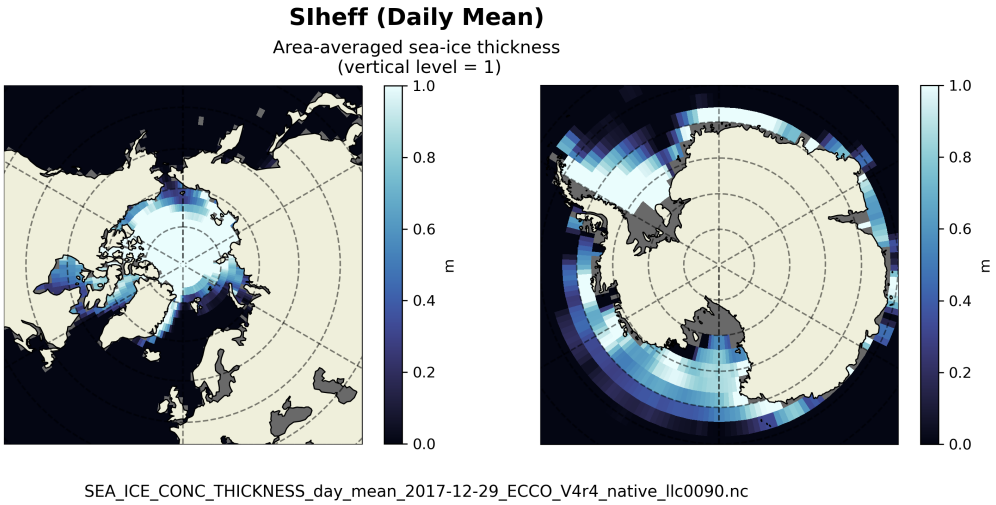


Figure 97: Dataset: SEA_ICE_CONC_THICKNESS, Variable: SIheff

11.17.4 Native Variable: SIhsnow

Table 11.94: Attributes description of the variable 'SIhsnow' from SEA_ICE_CONC_THICKNESS's dataset.

Storage Type	Variable Name	Description	Unit
float32	SIhsnow	Area-averaged snow thickness	m

Description of the variable in Common Data language (CDL)

```
float32 SIhsnow(time, tile, j, i)
    SIhsnow:  _FillValue = 9.96921e+36
    SIhsnow:  coordinates = time YC XC
    SIhsnow:  coverage_content_type = modelResult
    SIhsnow:  long_name = Area-averaged snow thickness
    SIhsnow:  standard_name = surface snow thickness
    SIhsnow:  units = m
    SIhsnow:  valid_max = 2.7013046741485596
    SIhsnow:  valid_min = -0.0004725505714304745
```

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

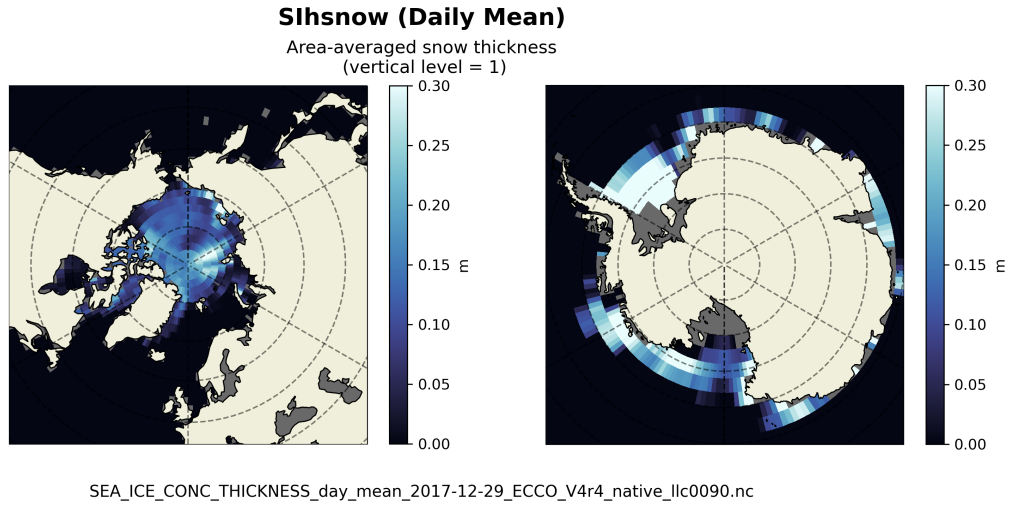


Figure 98: Dataset: SEA_ICE_CONC_THICKNESS, Variable: SIhsnow

11.17.5 Native Variable: sIceLoad

Table 11.95: Attributes description of the variable 'sIceLoad' from SEA_ICE_CONC_THICKNESS's dataset.

Storage Type	Variable Name	Description	Unit
float32	sIceLoad	Average sea-ice and snow mass per unit area	kg m-2

Description of the variable in Common Data language (CDL)

```
float32 sIceLoad(time, tile, j, i)
    sIceLoad:  _FillValue = 9.96921e+36
    sIceLoad:  coordinates = time YC XC
    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:  valid_max = 8729.935546875
    sIceLoad:  valid_min = -0.0015558383893221617
```

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.

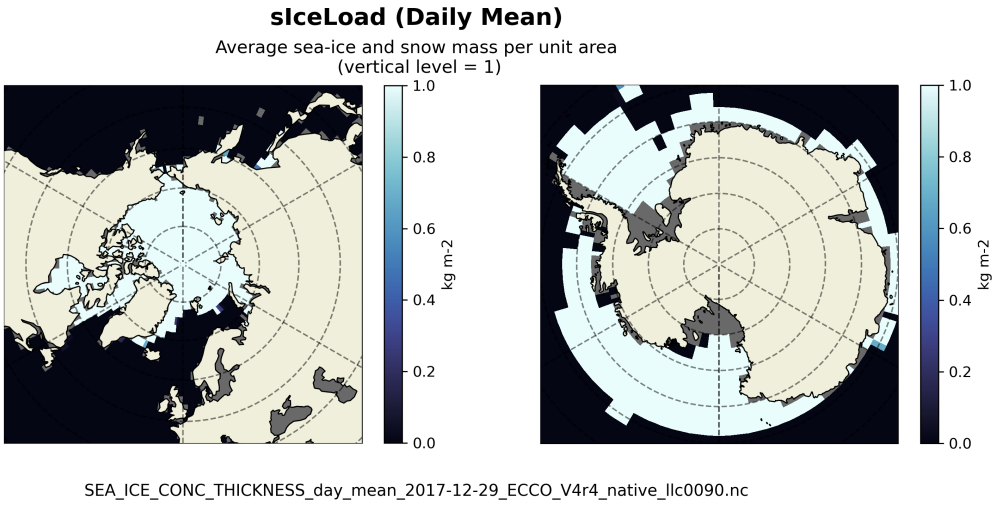


Figure 99: Dataset: SEA_ICE_CONC_THICKNESS, Variable: sIceLoad

11.18 Native dataset of SEA_ICE_HORIZ_VOLUME_FLUX

11.18.1 Overview

This dataset provides 2D fields of sea-ice and snow horizontal volume fluxes on the lat-lon-cap 90 (llc90) native model grid from the ECCO Version 4 Release 4 (V4r4) ocean and sea-ice state estimate. The dataset is provided on daily-average and monthly-average time resolution.

Table 11.96: Coordinates and Variables in the dataset SEA_ICE_HORIZ_VOLUME_FLUX

Coordinates	Description of data coordinates	Unit
i	Grid index in x for variables at tracer and 'v' locations	–none–
i_g	Grid index in x for variables at 'u' and 'g' locations	–none–
j	Grid index in y for variables at tracer and 'u' locations	–none–
j_g	Grid index in y for variables at 'v' and 'g' locations	–none–
tile	Lat-lon-cap tile index	–none–
time	Center time of averaging period	–none–
XC	Longitude of tracer grid cell center	degrees_east
YC	Latitude of tracer grid cell center	degrees_north
XG	Longitude of 'southwest' corner of tracer grid cell	degrees_east
YG	Latitude of 'southwest' corner of tracer grid cell	degrees_north
time_bnds	Time bounds of averaging period	–none–
XC_bnds	Longitudes of tracer grid cell corners	–none–
YC_bnds	Latitudes of tracer grid cell corners	–none–
Variables	**Description of data variables**	**Unit**
ADVxHEFF	Lateral advective flux of sea-ice thickness in the model +x direction	m3 s-1
ADVyHEFF	Lateral advective flux of sea-ice thickness in the model +y direction	m3 s-1
ADVxSNOW	Lateral advective flux of snow thickness in the model +x direction	m3 s-1
ADVySNOW	Lateral advective flux of snow thickness in the model +y direction	m3 s-1
DFxESNOW	Lateral diffusive flux of snow thickness in the model +x direction	m3 s-1
DFyEHEFF	Lateral diffusive flux of sea-ice thickness in the model +y direction.	m3 s-1
DFxEHEFF	Lateral diffusive flux of sea-ice thickness in the model +x direction.	m3 s-1
DFyESNOW	Lateral diffusive flux of snow thickness in the model +y direction	m3 s-1

11.18.2 Native Variable: ADVxHEFF

Table 11.97: Attributes description of the variable 'ADVxHEFF' from SEA_ICE_HORIZ_VOLUME_FLUX's dataset.

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

Description of the variable in Common Data language (CDL)

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

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.

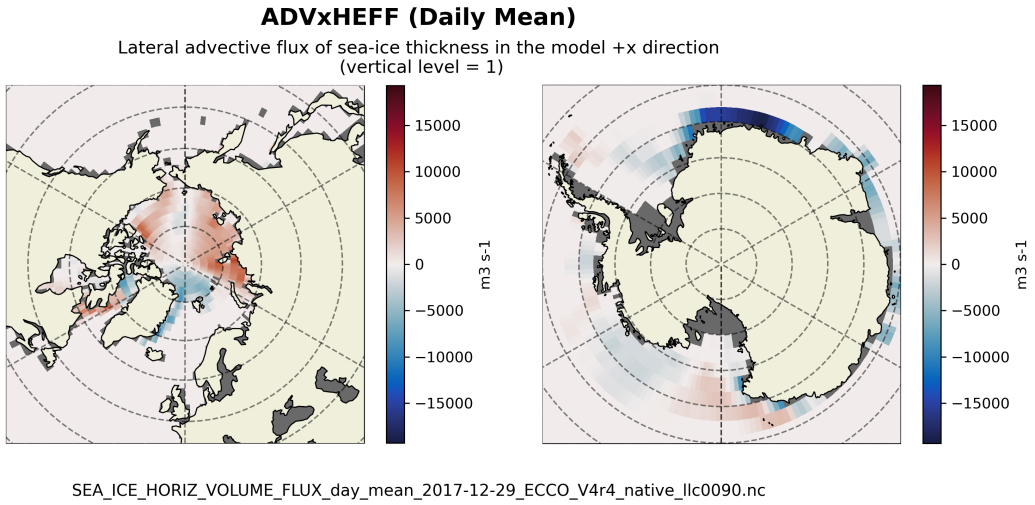


Figure 100: Dataset: SEA_ICE_HORIZ_VOLUME_FLUX, Variable: ADVxHEFF

11.18.3 Native Variable: ADVxSNOW

Table 11.98: Attributes description of the variable 'ADVxSNOW' from SEA_ICE_HORIZ_VOLUME_FLUX's dataset.

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

Description of the variable in Common Data language (CDL)

```
float32 ADVxSNOW(time, tile, j, i_g)
    ADVxSNOW: _FillValue = 9.96921e+36
    ADVxSNOW: coordinates = time
    ADVxSNOW: coverage_content_type = modelResult
    ADVxSNOW: direction = >0 increases mean snow thickness (HSNOW)
    ADVxSNOW: long_name = Lateral advective flux of snow thickness in the model +x direction
    ADVxSNOW: mate = ADVySNOW
    ADVxSNOW: units = m3 s-1
    ADVxSNOW: valid_max = 20385.103515625
    ADVxSNOW: valid_min = -38343.0234375
```

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.

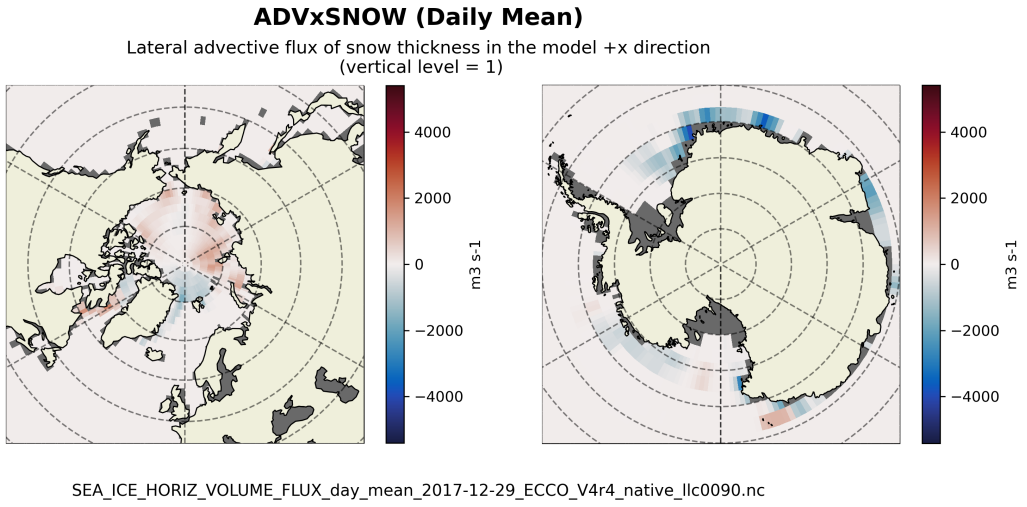


Figure 101: Dataset: SEA_ICE_HORIZ_VOLUME_FLUX, Variable: ADVxSNOW

11.18.4 Native Variable: ADVyHEFF

Table 11.99: Attributes description of the variable 'ADVyHEFF' from SEA_ICE_HORIZ_VOLUME_FLUX's dataset.

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

Description of the variable in Common Data language (CDL)

```
float32 ADVyHEFF(time, tile, j_g, i)
   ADVyHEFF: _FillValue = 9.96921e+36
   ADVyHEFF: coordinates = time
   ADVyHEFF: coverage_content_type = modelResult
   ADVyHEFF: direction = >0 increases mean sea-ice thickness (HEFF)
   ADVyHEFF: long_name = Lateral advective flux of sea-ice thickness in the model +y direction
   ADVyHEFF: mate = ADVxHEFF
   ADVyHEFF: units = m3 s-1
   ADVyHEFF: valid_max = 115755.4375
   ADVyHEFF: valid_min = -95350.6328125
```

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.

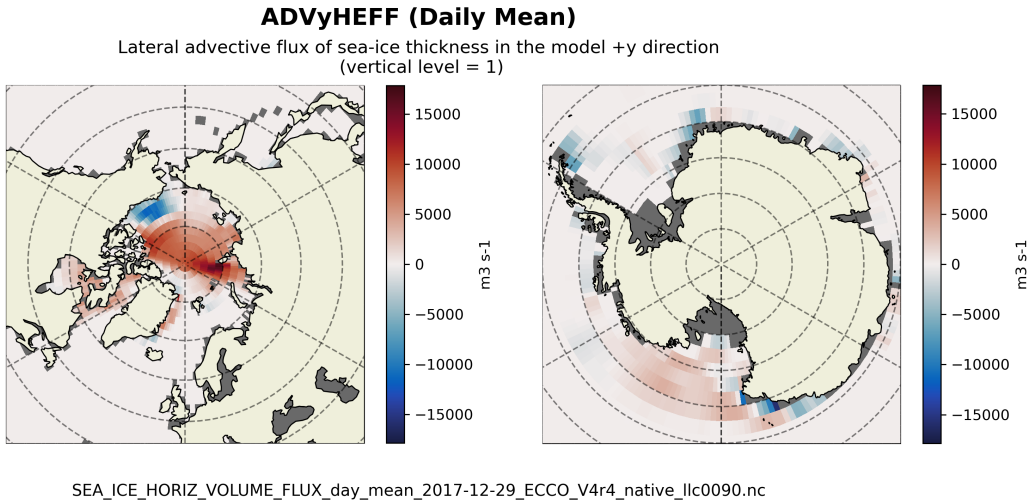


Figure 102: Dataset: SEA_ICE_HORIZ_VOLUME_FLUX, Variable: ADVyHEFF

11.18.5 Native Variable: ADVySNOW

Table 11.100: Attributes description of the variable 'ADVySNOW' from SEA_ICE_HORIZ_VOLUME_FLUX's dataset.

Storage Type	Variable Name	Description	Unit
float32	ADVySNOW	Lateral advective flux of snow thickness in the model +y direction	m3 s-1

Description of the variable in Common Data language (CDL)

```
float32 ADVySNOW(time, tile, j_g, i)
    ADVySNOW: _FillValue = 9.96921e+36
    ADVySNOW: coordinates = time
    ADVySNOW: coverage_content_type = modelResult
    ADVySNOW: direction = >0 increases mean snow thickness (HSNOW)
    ADVySNOW: long_name = Lateral advective flux of snow thickness in the model +y direction
    ADVySNOW: mate = ADVxSNOW
    ADVySNOW: units = m3 s-1
    ADVySNOW: valid_max = 27252.87890625
    ADVySNOW: valid_min = -30630.552734375
```

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.

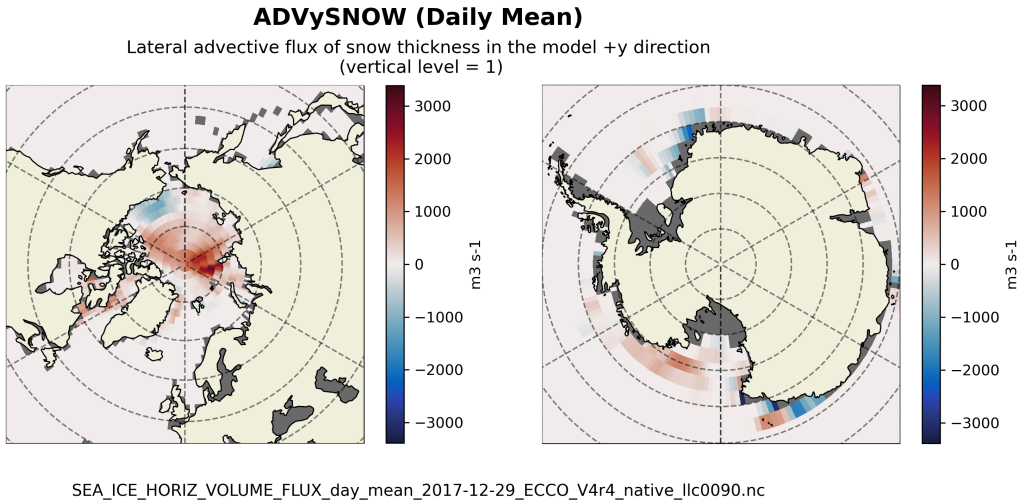


Figure 103: Dataset: SEA_ICE_HORIZ_VOLUME_FLUX, Variable: ADVySNOW

11.18.6 Native Variable: DFxEHEFF

Table 11.101: Attributes description of the variable 'DFxEHEFF' from SEA_ICE_HORIZ_VOLUME_FLUX's dataset.

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

Description of the variable in Common Data language (CDL)

```
float32 DFxEHEFF(time, tile, j, i_g)
    DFxEHEFF: _FillValue = 9.96921e+36
    DFxEHEFF: coordinates = time
    DFxEHEFF: coverage_content_type = modelResult
    DFxEHEFF: direction = >0 increases mean sea-ice thickness (HEFF)
    DFxEHEFF: long_name = Lateral diffusive flux of sea-ice thickness in the model +x direction.
    DFxEHEFF: mate = DFyEHEFF
    DFxEHEFF: units = m3 s-1
    DFxEHEFF: valid_max = 2379.271240234375
    DFxEHEFF: valid_min = -1444.172607421875
```

Comments

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.

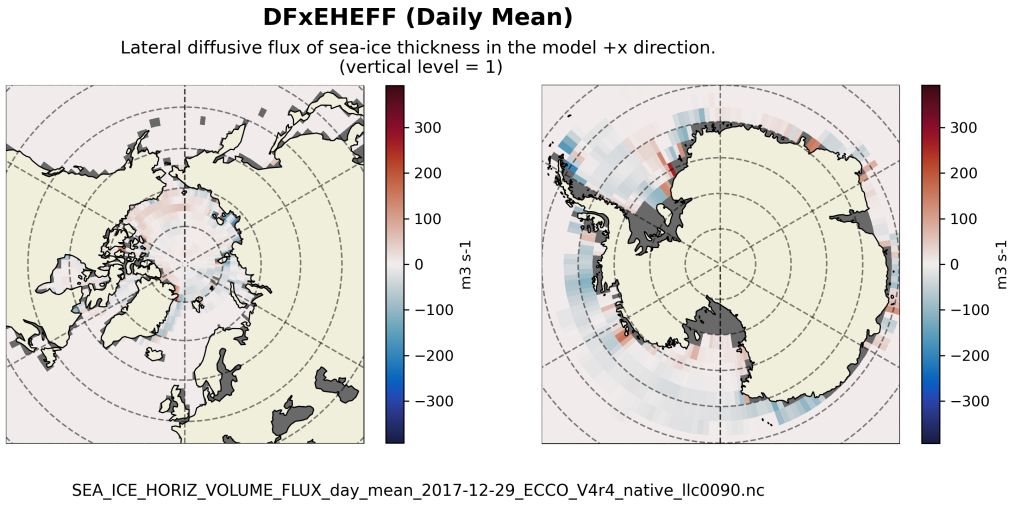


Figure 104: Dataset: SEA_ICE_HORIZ_VOLUME_FLUX, Variable: DFxEHEFF

11.18.7 Native Variable: DFxESNOW

Table 11.102: Attributes description of the variable 'DFxESNOW' from SEA_ICE_HORIZ_VOLUME_FLUX's dataset.

Storage Type	Variable Name	Description	Unit
float32	DFxESNOW	Lateral diffusive flux of snow thickness in the model +x direction	m3 s-1

Description of the variable in Common Data language (CDL)

```
float32 DFxESNOW(time, tile, j, i_g)
    DFxESNOW: _FillValue = 9.96921e+36
    DFxESNOW: coordinates = time
    DFxESNOW: coverage_content_type = modelResult
    DFxESNOW: direction = >0 increases mean snow thickness (HSNOW)
    DFxESNOW: long_name = Lateral diffusive flux of snow thickness in the model +x direction
    DFxESNOW: mate = DFyESNOW
    DFxESNOW: units = m3 s-1
    DFxESNOW: valid_max = 440.94427490234375
    DFxESNOW: valid_min = -448.1134948730469
```

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.

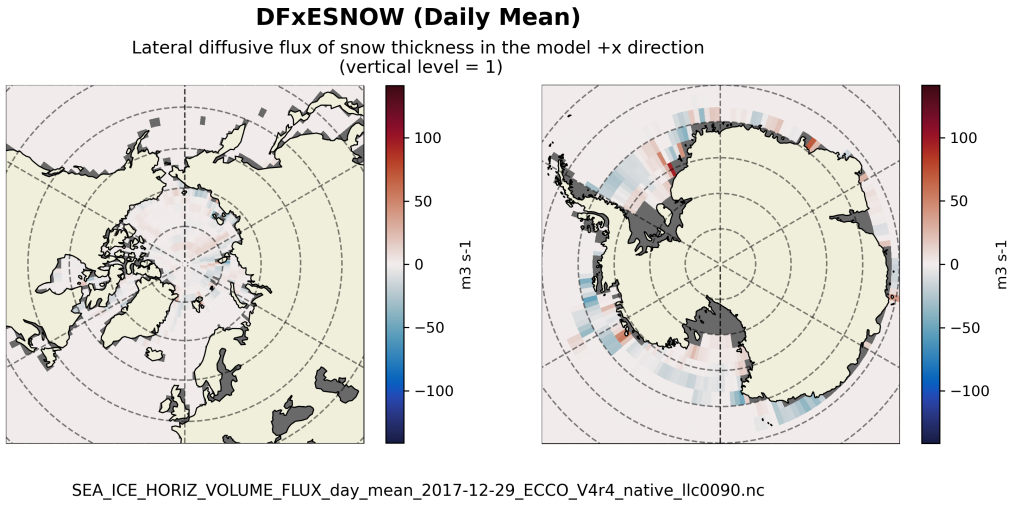


Figure 105: Dataset: SEA_ICE_HORIZ_VOLUME_FLUX, Variable: DFxESNOW

11.18.8 Native Variable: DFyEHEFF

Table 11.103: Attributes description of the variable 'DFyEHEFF' from SEA_ICE_HORIZ_VOLUME_FLUX's dataset.

Storage Type	Variable Name	Description	Unit
float32	DFyEHEFF	Lateral diffusive flux of sea-ice thickness in the model +y direction.	m3 s-1

Description of the variable in Common Data language (CDL)

```
float32 DFyEHEFF(time, tile, j_g, i)
   DFyEHEFF: _FillValue = 9.96921e+36
   DFyEHEFF: coordinates = time
   DFyEHEFF: coverage_content_type = modelResult
   DFyEHEFF: direction = >0 increases mean sea-ice thickness (HEFF)
   DFyEHEFF: long_name = Lateral diffusive flux of sea-ice thickness in the model +y direction.
   DFyEHEFF: mate = DFxEHEFF
   DFyEHEFF: units = m3 s-1
   DFyEHEFF: valid_max = 1614.6512451171875
   DFyEHEFF: valid_min = -3078.810791015625
```

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.

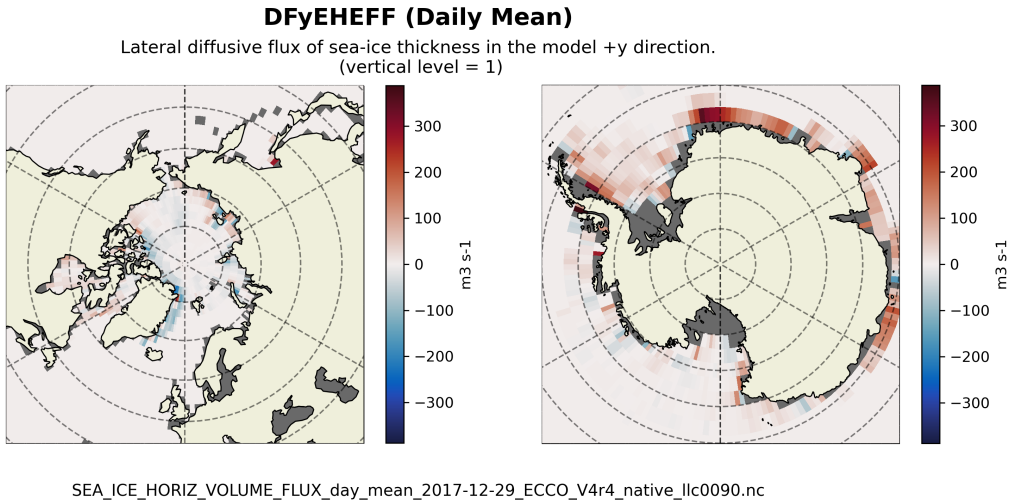


Figure 106: Dataset: SEA_ICE_HORIZ_VOLUME_FLUX, Variable: DFyEHEFF

11.18.9 Native Variable: DFyESNOW

Table 11.104: Attributes description of the variable 'DFyESNOW' from SEA_ICE_HORIZ_VOLUME_FLUX's dataset.

Storage Type	Variable Name	Description	Unit
float32	DFyESNOW	Lateral diffusive flux of snow thickness in the model +y direction	m3 s-1

Description of the variable in Common Data language (CDL)

```
float32 DFyESNOW(time, tile, j_g, i)
   DFyESNOW: _FillValue = 9.96921e+36
   DFyESNOW: coordinates = time
   DFyESNOW: coverage_content_type = modelResult
   DFyESNOW: direction = >0 increases mean snow thickness (HSNOW)
   DFyESNOW: long_name = Lateral diffusive flux of snow thickness in the model +y direction
   DFyESNOW: mate = DFxESNOW
   DFyESNOW: units = m3 s-1
   DFyESNOW: valid_max = 411.7032470703125
   DFyESNOW: valid_min = -662.0200805664062
```

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.

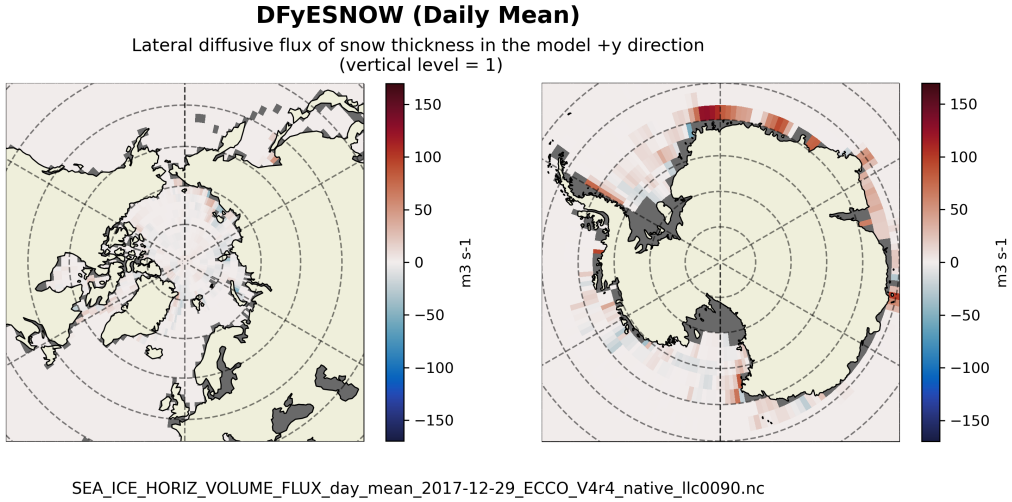


Figure 107: Dataset: SEA_ICE_HORIZ_VOLUME_FLUX, Variable: DFyESNOW

11.19 Native dataset of SEA_ICE_SALT_PLUME_FLUX

11.19.1 Overview

This dataset provides 2D fields of sea-ice salt plume fluxes on the lat-lon-cap 90 (llc90) native model grid from the ECCO Version 4 Release 4 (V4r4) ocean and sea-ice state estimate. The dataset is provided on daily-average and monthly-average time resolution. oceSPflx is salt mass flux per unit area (g m-2 s-1), not salinity flux.

Table 11.105: Coordinates and Variables in the dataset SEA_ICE_SALT_PLUME_FLUX

Coordinates	Description of data coordinates	Unit
i	Grid index in x for variables at tracer and 'v' locations	–none–
i_g	Grid index in x for variables at 'u' and 'g' locations	–none–
j	Grid index in y for variables at tracer and 'u' locations	–none–
j_g	Grid index in y for variables at 'v' and 'g' locations	–none–
tile	Lat-lon-cap tile index	–none–
time	Center time of averaging period	–none–
XC	Longitude of tracer grid cell center	degrees_east
YC	Latitude of tracer grid cell center	degrees_north
XG	Longitude of 'southwest' corner of tracer grid cell	degrees_east
YG	Latitude of 'southwest' corner of tracer grid cell	degrees_north
time_bnds	Time bounds of averaging period	–none–
XC_bnds	Longitudes of tracer grid cell corners	–none–
YC_bnds	Latitudes of tracer grid cell corners	–none–
Variables	**Description of data variables**	**Unit**
oceSPflx	Net salt flux into the ocean due to brine rejection	g m-2 s-1
oceSPDep	Salt plume depth	m

11.19.2 Native Variable: oceSPDep

Table 11.106: Attributes description of the variable 'oceSPDep' from SEA_ICE_SALT_PLUME_FLUX's dataset.

Storage Type	Variable Name	Description	Unit
float32	oceSPDep	Salt plume depth	m

Description of the variable in Common Data language (CDL)

```
float32 oceSPDep(time, tile, j, i)
    oceSPDep:  _FillValue = 9.96921e+36
    oceSPDep:  coordinates = time YC XC
    oceSPDep:  coverage_content_type = modelResult
    oceSPDep:  long_name = Salt plume depth
    oceSPDep:  units = m
    oceSPDep:  valid_max = 5530.31494140625
    oceSPDep:  valid_min = 5.500708103179932
```

Comments

Depth of parameterized salt plumes formed due to brine rejection during sea-ice formation.

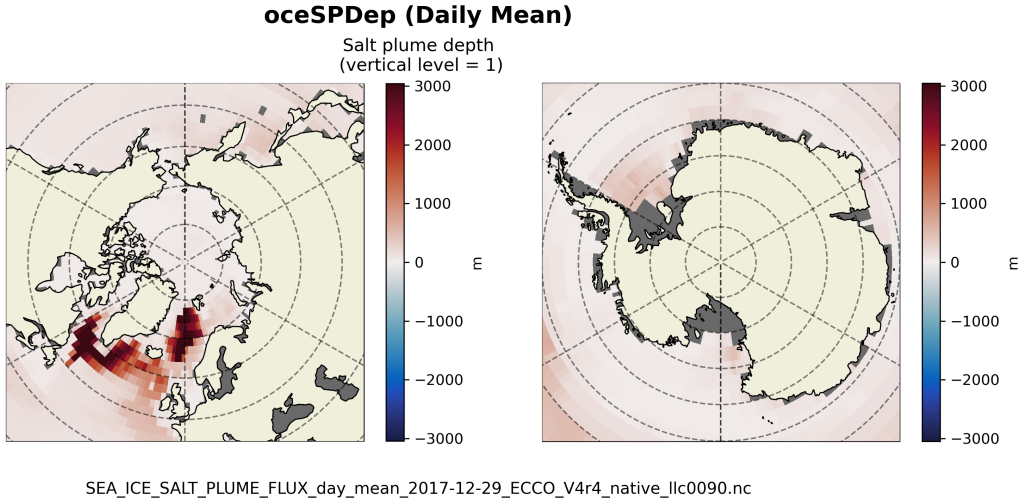


Figure 108: Dataset: SEA_ICE_SALT_PLUME_FLUX, Variable: oceSPDep

11.19.3 Native Variable: oceSPflx

Table 11.107: Attributes description of the variable 'oceSPflx' from SEA_ICE_SALT_PLUME_FLUX's dataset.

Storage Type	Variable Name	Description	Unit
float32	oceSPflx	Net salt flux into the ocean due to brine rejection	g m-2 s-1

Description of the variable in Common Data language (CDL)

```
float32 oceSPflx(time, tile, j, i)
    oceSPflx:  _FillValue = 9.96921e+36
    oceSPflx:  coordinates = time YC XC
    oceSPflx:  coverage_content_type = modelResult
    oceSPflx:  direction = >0 increases salinity (SALT)
    oceSPflx:  long_name = Net salt flux into the ocean due to brine rejection
    oceSPflx:  units = g m-2 s-1
    oceSPflx:  valid_max = 0.058169759809970856
    oceSPflx:  valid_min = 0.0
```

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.

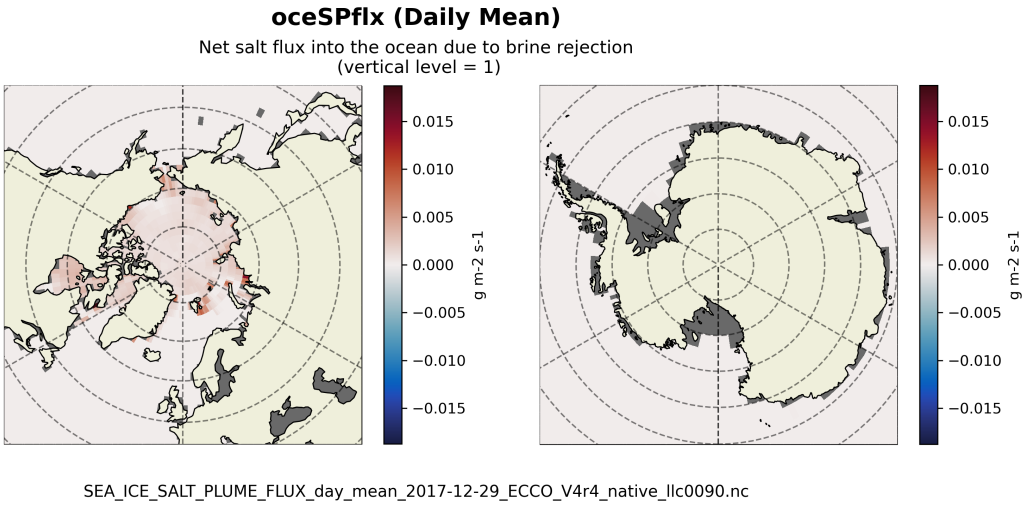


Figure 109: Dataset: SEA_ICE_SALT_PLUME_FLUX, Variable: oceSPflx

11.20 Native dataset of SEA_ICE_VELOCITY

11.20.1 Overview

This dataset provides 2D fields of sea-ice velocity on the lat-lon-cap 90 (llc90) native model grid from the ECCO Version 4 Release 4 (V4r4) ocean and sea-ice state estimate. The dataset is provided on daily-average and monthly-average time resolution. Snapshot data of sea-ice velocity are also provided.

Table 11.108: Coordinates and Variables in the dataset SEA_ICE_VELOCITY

Coordinates	Description of data coordinates	Unit
i	Grid index in x for variables at tracer and 'v' locations	–none–
i_g	Grid index in x for variables at 'u' and 'g' locations	–none–
j	Grid index in y for variables at tracer and 'u' locations	–none–
j_g	Grid index in y for variables at 'v' and 'g' locations	–none–
tile	Lat-lon-cap tile index	–none–
time	Center time of averaging period	–none–
XC	Longitude of tracer grid cell center	degrees_east
YC	Latitude of tracer grid cell center	degrees_north
XG	Longitude of 'southwest' corner of tracer grid cell	degrees_east
YG	Latitude of 'southwest' corner of tracer grid cell	degrees_north
time_bnds	Time bounds of averaging period	–none–
XC_bnds	Longitudes of tracer grid cell corners	–none–
YC_bnds	Latitudes of tracer grid cell corners	–none–
Variables	**Description of data variables**	**Unit**
SIuice	Sea-ice velocity in the model +x direction	m s-1
SIvice	Sea-ice velocity in the model +y direction	m s-1

11.20.2 Native Variable: SIuice

Table 11.109: Attributes description of the variable 'SIuice' from SEA_ICE_VELOCITY's dataset.

Storage Type	Variable Name	Description	Unit
float32	SIuice	Sea-ice velocity in the model +x direction	m s-1

Description of the variable in Common Data language (CDL)

```
float32 SIuice(time, tile, j, i_g)
    SIuice:  _FillValue = 9.96921e+36
    SIuice:  coordinates = time
    SIuice:  coverage_content_type = modelResult
    SIuice:  long_name = Sea-ice velocity in the model +x direction
    SIuice:  mate = SIvice
    SIuice:  standard_name = sea ice x velocity
    SIuice:  units = m s-1
    SIuice:  valid_max = 0.4000000059604645
    SIuice:  valid_min = -0.4000000059604645
```

Comments

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.

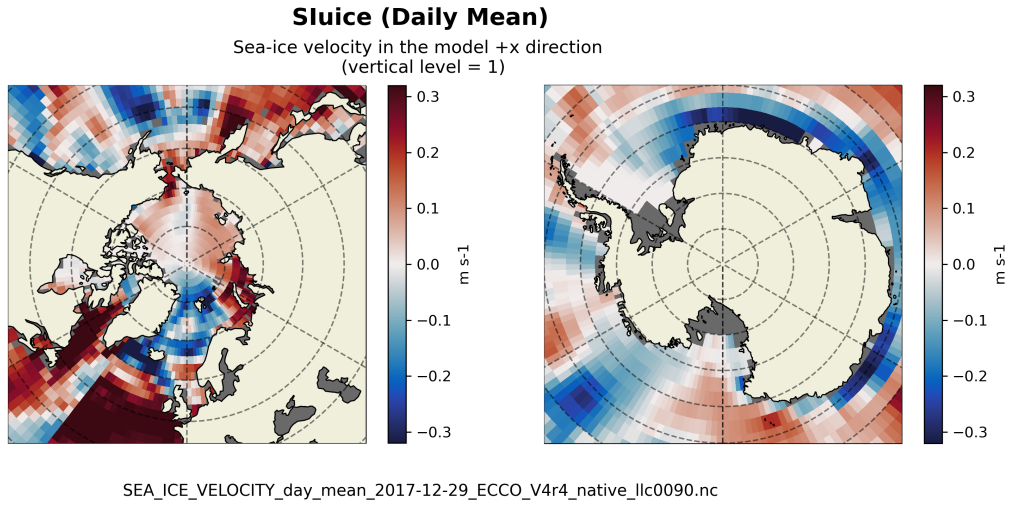


Figure 110: Dataset: SEA_ICE_VELOCITY, Variable: SIuice

11.20.3 Native Variable: SIvice

Table 11.110: Attributes description of the variable 'SIvice' from SEA_ICE_VELOCITY's dataset.

Storage Type	Variable Name	Description	Unit
float32	SIvice	Sea-ice velocity in the model +y direction	m s-1

Description of the variable in Common Data language (CDL)

```
float32 SIvice(time, tile, j_g, i)
    SIvice:  _FillValue = 9.96921e+36
    SIvice:  coordinates = time
    SIvice:  coverage_content_type = modelResult
    SIvice:  long_name = Sea-ice velocity in the model +y direction
    SIvice:  mate = SIuice
    SIvice:  standard_name = sea ice y velocity
    SIvice:  units = m s-1
    SIvice:  valid_max = 0.4000000059604645
    SIvice:  valid_min = -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.

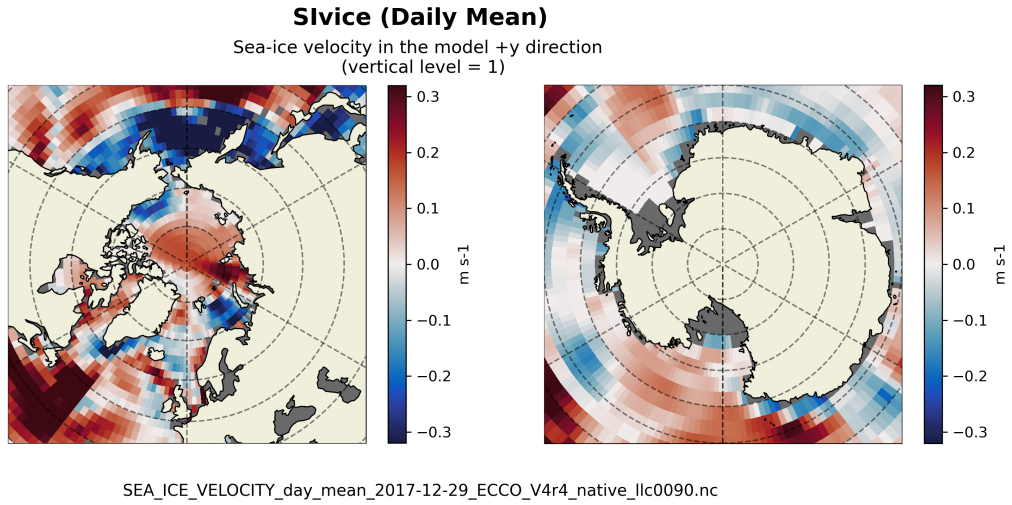


Figure 111: Dataset: SEA_ICE_VELOCITY, Variable: SIvice

11.21 Native dataset of SEA_SURFACE_HEIGHT

11.21.1 Overview

This dataset provides 2D fields of dynamic sea surface height and model sea level anomaly on the lat-lon-cap 90 (llc90) native model grid from the ECCO Version 4 Release 4 (V4r4) ocean and sea-ice state estimate. The dataset is provided on daily-average and monthly-average time resolution. Snapshot data of dynamic sea surface height and model sea level anomaly are also provided. SSH (dynamic sea surface height) = SSHNOIBC (dynamic sea surface without the inverse barometer correction) - SSHIBC (inverse barometer correction). The inverted barometer correction accounts for variations in sea surface height due to atmospheric pressure variations. Note: ETAN is model sea level anomaly and should not be compared with satellite altimetery products, see SSH and ETAN for more details.

Table 11.111: Coordinates and Variables in the dataset SEA_SURFACE_HEIGHT

Coordinates	Description of data coordinates	Unit
i	Grid index in x for variables at tracer and 'v' locations	–none–
i_g	Grid index in x for variables at 'u' and 'g' locations	–none–
j	Grid index in y for variables at tracer and 'u' locations	–none–
j_g	Grid index in y for variables at 'v' and 'g' locations	–none–
tile	Lat-lon-cap tile index	–none–
time	Center time of averaging period	–none–
XC	Longitude of tracer grid cell center	degrees_east
YC	Latitude of tracer grid cell center	degrees_north
XG	Longitude of 'southwest' corner of tracer grid cell	degrees_east
YG	Latitude of 'southwest' corner of tracer grid cell	degrees_north
time_bnds	Time bounds of averaging period	–none–
XC_bnds	Longitudes of tracer grid cell corners	–none–
YC_bnds	Latitudes of tracer grid cell corners	–none–
Variables	**Description of data variables**	**Unit**
SSH	Dynamic sea surface height anomaly	m
SSHIBC	The inverted barometer (ib) correction to sea surface height due to atmospheric pressure loading	m
SSHNOIBC	Sea surface height anomaly without the inverted barometer (ib) correction	m
ETAN	Model sea level anomaly	m

11.21.2 Native Variable: ETAN

Table 11.112: Attributes description of the variable 'ETAN' from SEA_SURFACE_HEIGHT's dataset.

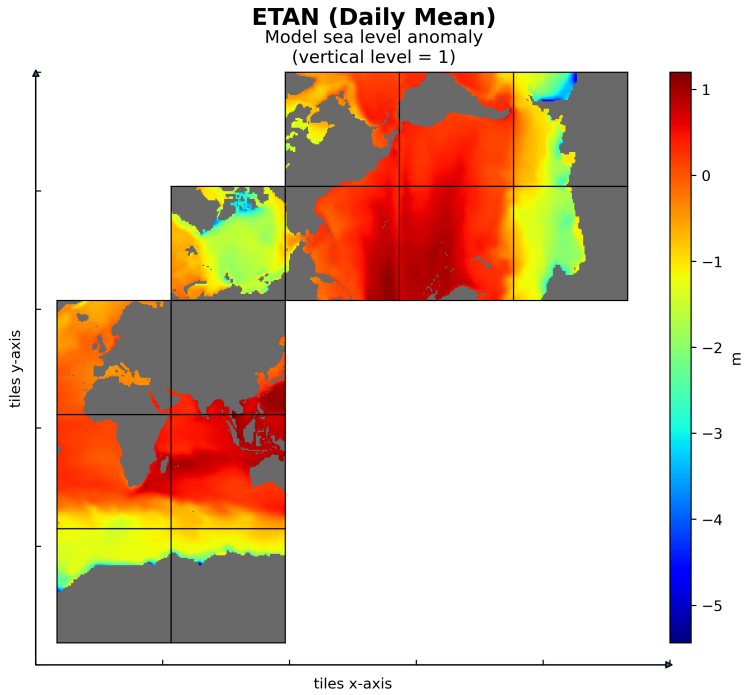
Storage Type	Variable Name	Description	Unit
float32	ETAN	Model sea level anomaly	m

Description of the variable in Common Data language (CDL)

```
float32 ETAN(time, tile, j, i)
    ETAN: _FillValue = 9.96921e+36
    ETAN: coordinates = YC time XC
    ETAN: coverage_content_type = modelResult
    ETAN: long_name = Model sea level anomaly
    ETAN: units = m
    ETAN: valid_max = 2.1783087253570557
    ETAN: valid_min = -9.067964553833008
```

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.



SEA_SURFACE_HEIGHT_day_mean_2017-12-29_ECCO_V4r4_native_llc0090.nc

Figure 112: Dataset: SEA_SURFACE_HEIGHT, Variable: ETAN

11.21.3 Native Variable: SSH

Table 11.113: Attributes description of the variable 'SSH' from SEA_SURFACE_HEIGHT's dataset.

Storage Type	Variable Name	Description	Unit
float32	SSH	Dynamic sea surface height anomaly	m

Description of the variable in Common Data language (CDL)

```
float32 SSH(time, tile, j, i)
    SSH: _FillValue = 9.96921e+36
    SSH: coordinates = YC time XC
    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: valid_max = 2.2875382900238037
    SSH: valid_min = -2.4861555099487305
```

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.

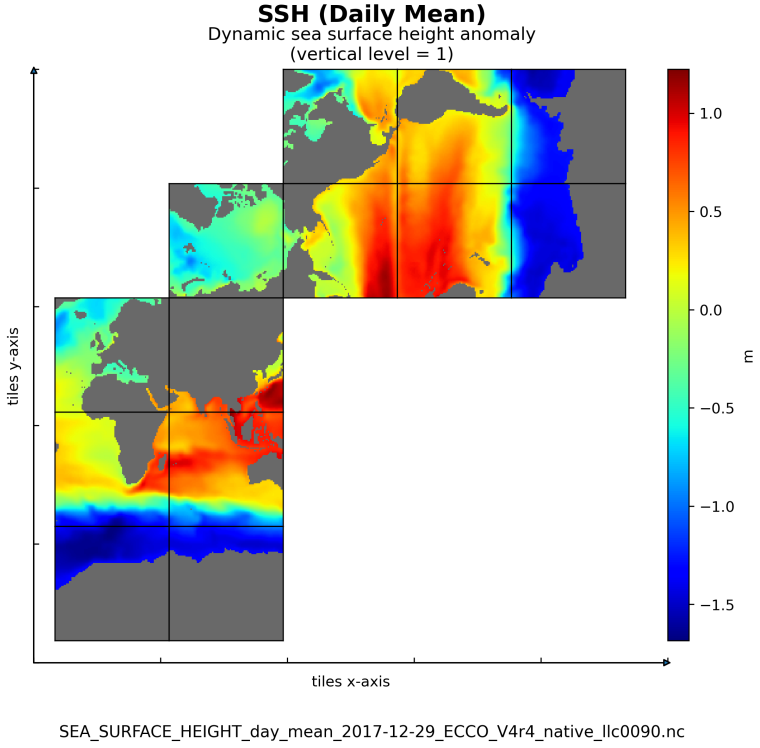


Figure 113: Dataset: SEA_SURFACE_HEIGHT, Variable: SSH

11.21.4 Native Variable: SSHIBC

Table 11.114: Attributes description of the variable 'SSHIBC' from SEA_SURFACE_HEIGHT's dataset.

Storage Type	Variable Name	Description	Unit
float32	SSHIBC	The inverted barometer (ib) correction to sea surface height due to atmospheric pressure loading	m

Description of the variable in Common Data language (CDL)

```
float32 SSHIBC(time, tile, j, i)
    SSHIBC: _FillValue = 9.96921e+36
    SSHIBC: coordinates = YC time XC
    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: valid_max = 0.9044463634490967
    SSHIBC: valid_min = -0.5228679180145264
```

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.

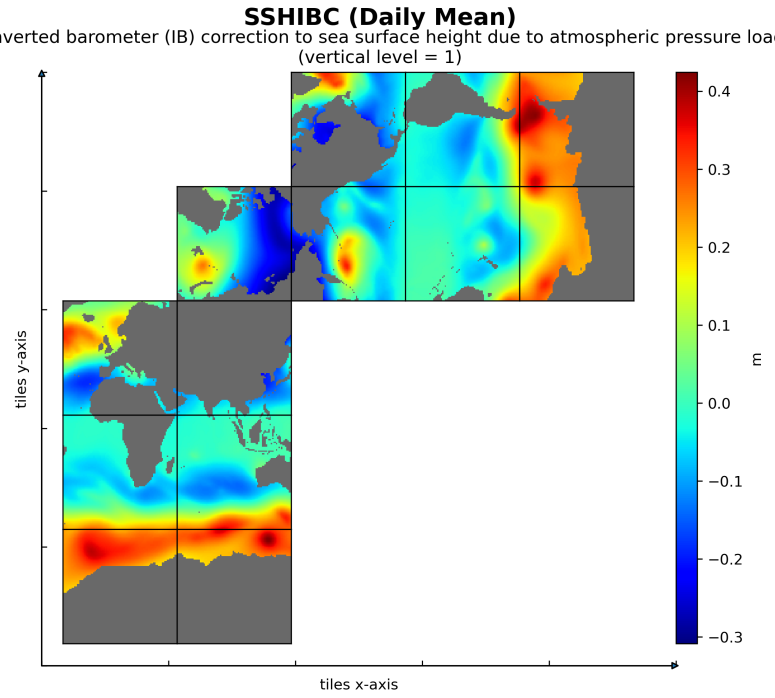


Figure 114: Dataset: SEA_SURFACE_HEIGHT, Variable: SSHIBC

11.21.5 Native Variable: SSHNOIBC

Table 11.115: Attributes description of the variable 'SSHNOIBC' from SEA_SURFACE_HEIGHT's dataset.

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

Description of the variable in Common Data language (CDL)

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

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.

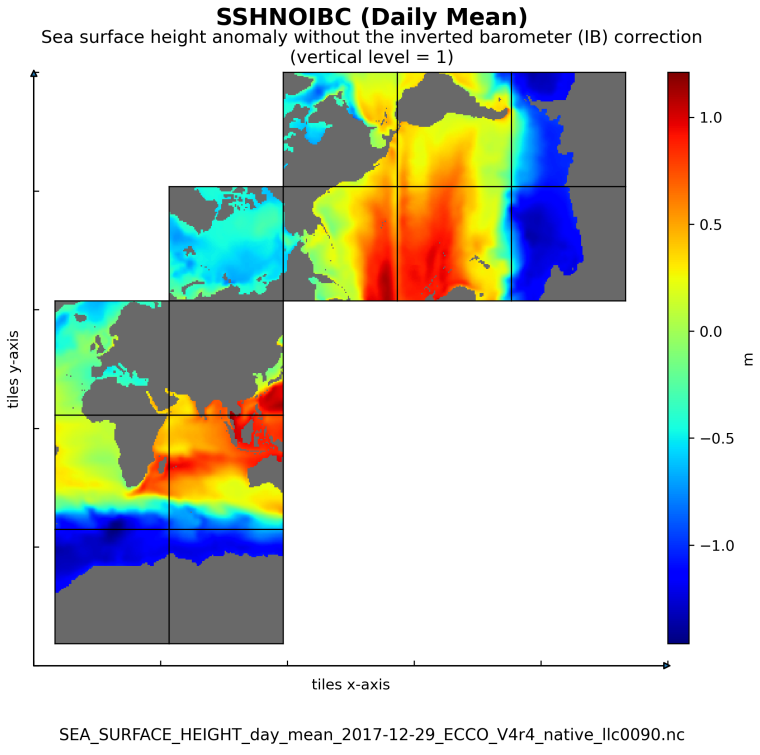


Figure 115: Dataset: SEA_SURFACE_HEIGHT, Variable: SSHNOIBC

12 Lat-Lon Coordinates and Grid Geometry

12.1 Latlon dataset of GRID_GEOMETRY_ECCO

12.1.1 Overview

This dataset provides geometric parameters for the regular 0.5-degree lat-lon grid from the ECCO Version 4 Release 4 (V4r4) ocean and sea-ice state estimate. Parameters include areas and lengths of grid cell sides, horizontal and vertical coordinates of grid cell centers and corners, and global domain geometry including bathymetry and land/ocean masks.

Table 12.1: Coordinates and Variables in the dataset GRID_GEOMETRY_ECCO

Coordinates	Description of data coordinates	Unit
Z	Depth of grid cell center	m
latitude	Latitude at grid cell center	degrees_north
longitude	Longitude at grid cell center	degrees_east
latitude_bnds	Latitudes of grid cell edges	–none–
longitude_bnds	Longitudes of grid cell edges	–none–
Z_bnds	Depths of grid cell upper and lower interfaces	–none–
Variables	**Description of data variables**	**Unit**
hFacC	Vertical open fraction of grid cell	1
Depth	Model seafloor depth below ocean surface at rest	m
area	Area of lat-lon grid cell	m2
drF	Distance between the upper and lower interfaces of the model grid cell	m
maskC	Wet/dry boolean mask for grid cell	–none–

12.1.2 Latlon Variable: Depth

Table 12.2: Attributes description of the variable 'Depth' from GRID_GEOMETRY_ECCO's dataset.

Storage Type	Variable Name	Description	Unit
float64	Depth	Model seafloor depth below ocean surface at rest	m

Description of the variable in Common Data language (CDL)

```
float64 Depth(latitude, longitude)
    Depth:  _FillValue = 9.969209968386869e+36
    Depth:  coverage_content_type = modelResult
    Depth:  long_name = model seafloor depth below ocean surface at rest
    Depth:  standard_name = sea floor depth below geoid
    Depth:  units = m
```

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 model seafloor depth differs from the seafloor depth provided by the input bathymetry file. also, this lat-lon gridded depth field is spatially-averaged from the depth field on the lat-lon-cap (llc90) model native grid.

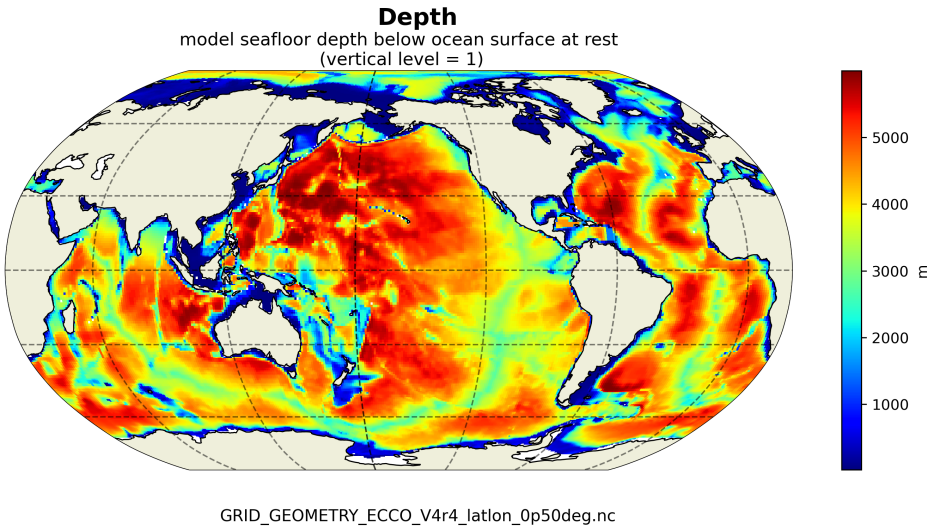


Figure 116: Dataset: GRID_GEOMETRY_ECCO, Variable: Depth

12.1.3 Latlon Variable: area

Table 12.3: Attributes description of the variable 'area' from GRID_GEOMETRY_ECCO's dataset.

Storage Type	Variable Name	Description	Unit
float64	area	Area of lat-lon grid cell	m2

Description of the variable in Common Data language (CDL)

```
float64 area(latitude, longitude)
    area:  _FillValue = 9.969209968386869e+36
    area:  coverage_content_type = modelResult
    area:  long_name =    area of lat-lon grid cell
    area:  standard_name = cell    area
    area:  units = m2
```

Comments

N/a

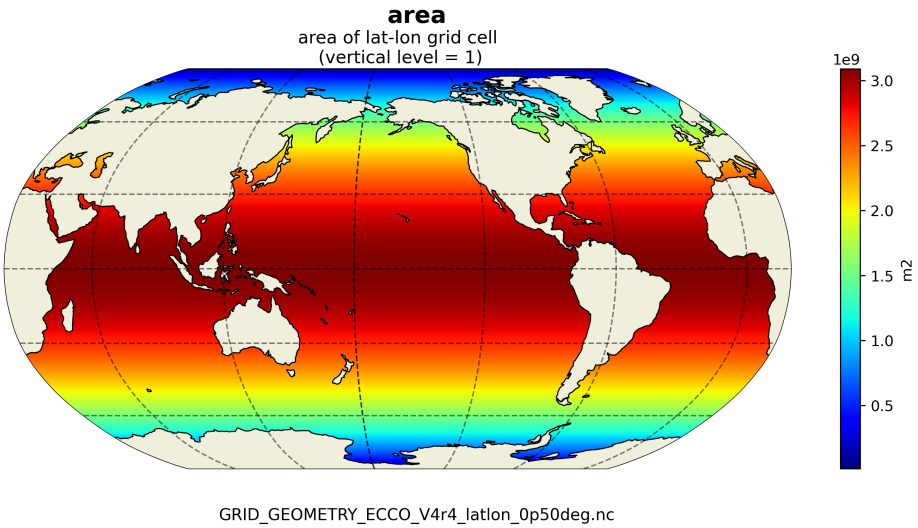


Figure 117: Dataset: GRID_GEOMETRY_ECCO, Variable: area

12.1.4 Latlon Variable: drF

Table 12.4: Attributes description of the variable 'drF' from GRID_GEOMETRY_ECCO's dataset.

Storage Type	Variable Name	Description	Unit
float32	drF	Distance between the upper and lower interfaces of the model grid cell	m

Description of the variable in Common Data language (CDL)

```
float32 drF(Z)
   drF: _FillValue = 9.96921e+36
   drF: coverage_content_type = modelResult
   drF: long_name = distance between the upper and lower interfaces of the model grid cell
   drF: standard_name = cell thickness
   drF: units = m
```

Comments

Nominal grid cell thickness.

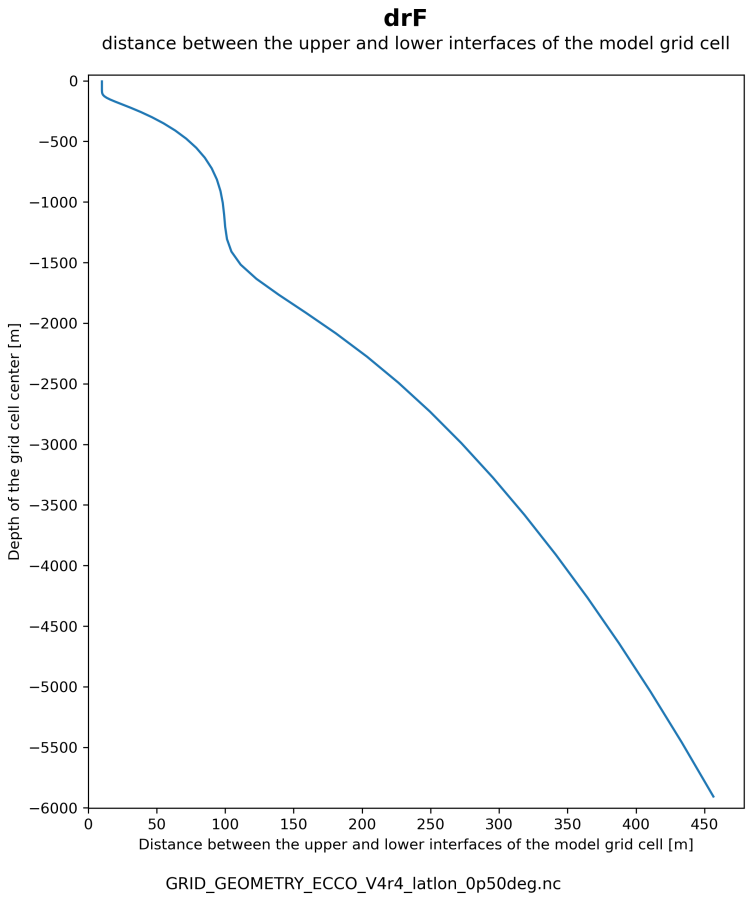


Figure 118: Dataset: GRID_GEOMETRY_ECCO, Variable: drF

12.1.5 Latlon Variable: hFacC

Table 12.5: Attributes description of the variable 'hFacC' from GRID_GEOMETRY_ECCO's dataset.

Storage Type	Variable Name	Description	Unit
float64	hFacC	Vertical open fraction of grid cell	1

Description of the variable in Common Data language (CDL)

```
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.

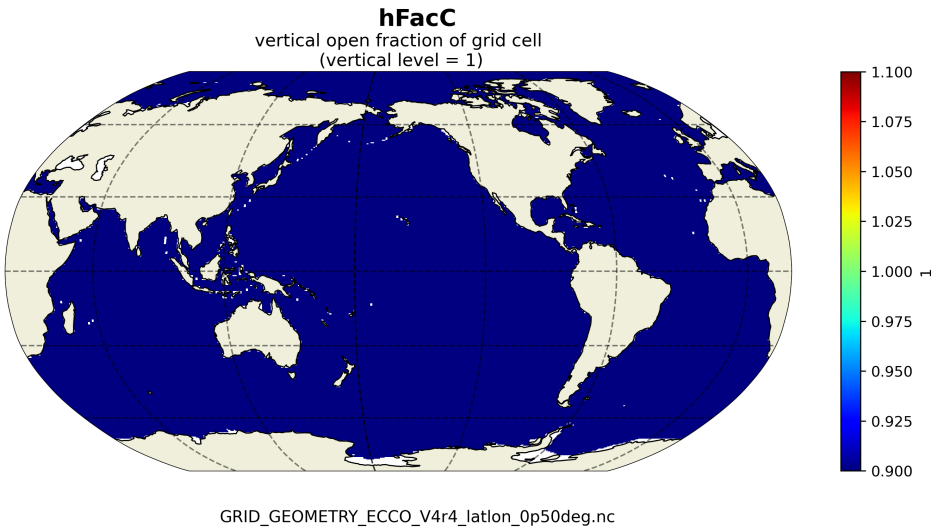


Figure 119: Dataset: GRID_GEOMETRY_ECCO, Variable: hFacC

12.1.6 Latlon Variable: maskC

Table 12.6: Attributes description of the variable 'maskC' from GRID_GEOMETRY_ECCO's dataset.

Storage Type	Variable Name	Description	Unit
bool	maskC	Wet/dry boolean mask for grid cell	N/A

Description of the variable in Common Data language (CDL)

```
bool maskC(Z, latitude, longitude)
   maskC: _FillValue = 1
   maskC: coverage_content_type = modelResult
   maskC: long_name = wet/dry boolean mask for grid cell
```

Comments

True for grid cells with nonzero open vertical fraction (hfacc > 0), otherwise false.

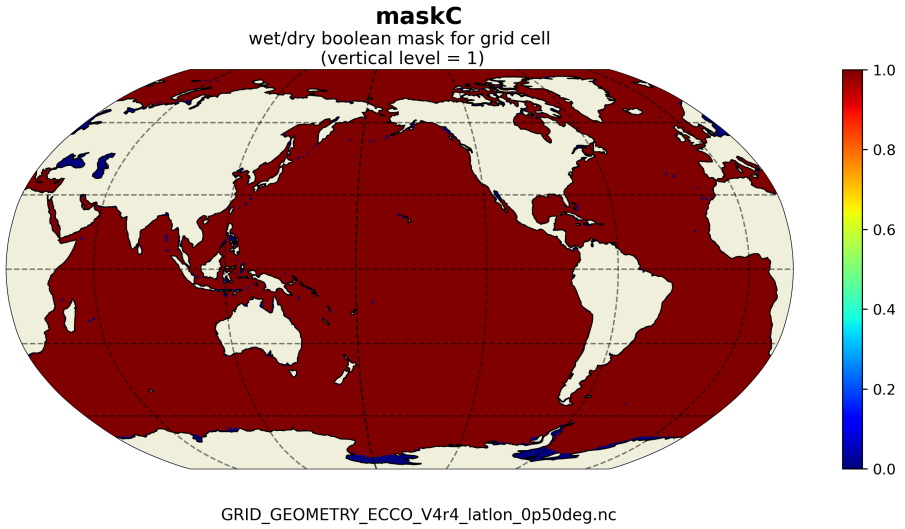


Figure 120: Dataset: GRID_GEOMETRY_ECCO, Variable: maskC

13 Latlon Dataset Groupings

13.1 Latlon dataset of ATM_SURFACE_TEMP_HUM_WIND_PRES

13.1.1 Overview

This dataset provides 2D fields of atmosphere surface temperature, humidity, wind, and pressure interpolated to a regular 0.5-degree grid from the ECCO Version 4 Release 4 (V4r4) ocean and sea-ice state estimate. The dataset is provided on daily-average and monthly-average time resolution.

Table 13.1: Coordinates and Variables in the dataset ATM_SURFACE_TEMP_HUM_WIND_PRES

Coordinates	Description of data coordinates	Unit
time	Center time of averaging period	–none–
latitude	Latitude at grid cell center	degrees_north
longitude	Longitude at grid cell center	degrees_east
time_bnds	Time bounds of averaging period	–none–
latitude_bnds	Latitude bounds grid cells	–none–
longitude_bnds	Longitude bounds grid cells	–none–
Variables	**Description of data variables**	**Unit**
EXFatemp	Atmosphere surface (2 m) air temperature	degree_K
EXFaqh	Atmosphere surface (2 m) specific humidity	kg kg-1
EXFewind	Zonal (east-west) wind speed	m s-1
EXFnwind	Meridional (north-south) wind speed	m s-1
EXFwspee	Wind speed	m s-1
EXFpress	Atmosphere surface pressure	N m-2

13.1.2 Latlon Variable: EXFaqh

Table 13.2: Attributes description of the variable 'EXFaqh' from ATM_SURFACE_TEMP_HUM_WIND_PRES's dataset.

Storage Type	Variable Name	Description	Unit
float32	EXFaqh	Atmosphere surface (2 m) specific humidity	kg kg-1

Description of the variable in Common Data language (CDL)

```
float32 EXFaqh(time, latitude, longitude)
   EXFaqh:  _FillValue = 9.96921e+36
   EXFaqh:  coordinates = time
   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:  valid_max = 0.03014513850212097
   EXFaqh:  valid_min = -0.0014020215021446347
```

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.

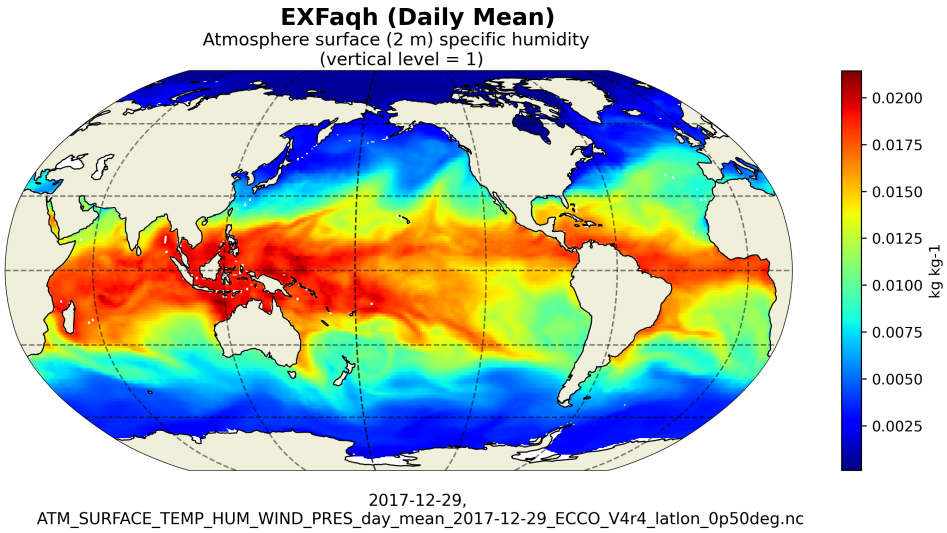


Figure 121: Dataset: ATM_SURFACE_TEMP_HUM_WIND_PRES, Variable: EXFaqh

13.1.3 Latlon Variable: EXFatemp

Table 13.3: Attributes description of the variable 'EXFatemp' from ATM_SURFACE_TEMP_HUM_WIND_PRES's dataset.

Storage Type	Variable Name	Description	Unit
float32	EXFatemp	Atmosphere surface (2 m) air temperature	degree_K

Description of the variable in Common Data language (CDL)

```
float32 EXFatemp(time, latitude, longitude)
   EXFatemp:  _FillValue = 9.96921e+36
   EXFatemp:  coordinates = time
   EXFatemp:  coverage_content_type = modelResult
   EXFatemp:  long_name = Atmosphere surface (2 m) air temperature
   EXFatemp:  standard_name = air temperature
   EXFatemp:  units = degree K
   EXFatemp:  valid_max = 312.8451232910156
   EXFatemp:  valid_min = 195.37054443359375
```

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.

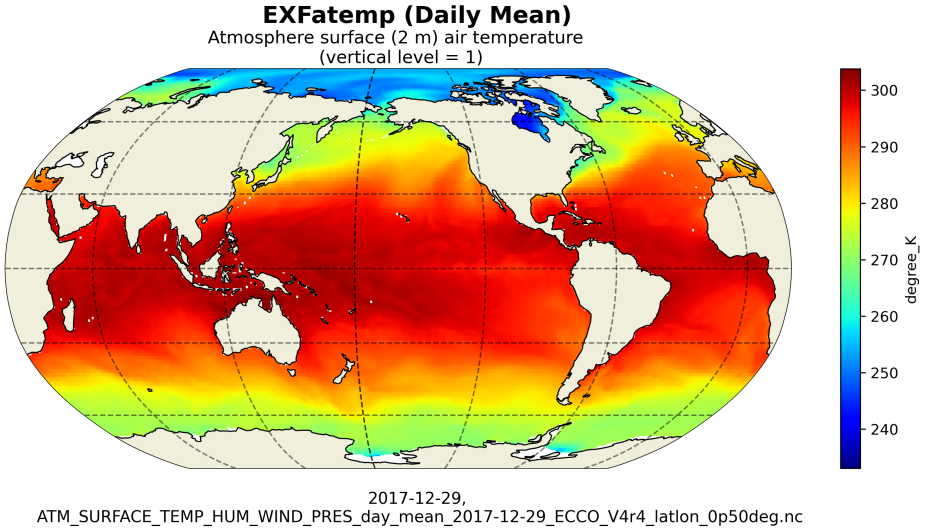


Figure 122: Dataset: ATM_SURFACE_TEMP_HUM_WIND_PRES, Variable: EXFatemp

13.1.4 Latlon Variable: EXFewind

Table 13.4: Attributes description of the variable 'EXFewind' from ATM_SURFACE_TEMP_HUM_WIND_PRES's dataset.

Storage Type	Variable Name	Description	Unit
float32	EXFewind	Zonal (east-west) wind speed	m s-1

Description of the variable in Common Data language (CDL)

```
float32 EXFewind(time, latitude, longitude)
    EXFewind:  _FillValue = 9.96921e+36
    EXFewind:  coordinates = time
    EXFewind:  coverage_content_type = modelResult
    EXFewind:  long_name = Zonal (east-west) wind speed
    EXFewind:  standard_name = eastward wind
    EXFewind:  units = m s-1
    EXFewind:  valid_max = 39.48556900024414
    EXFewind:  valid_min = -33.524742126464844
```

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.

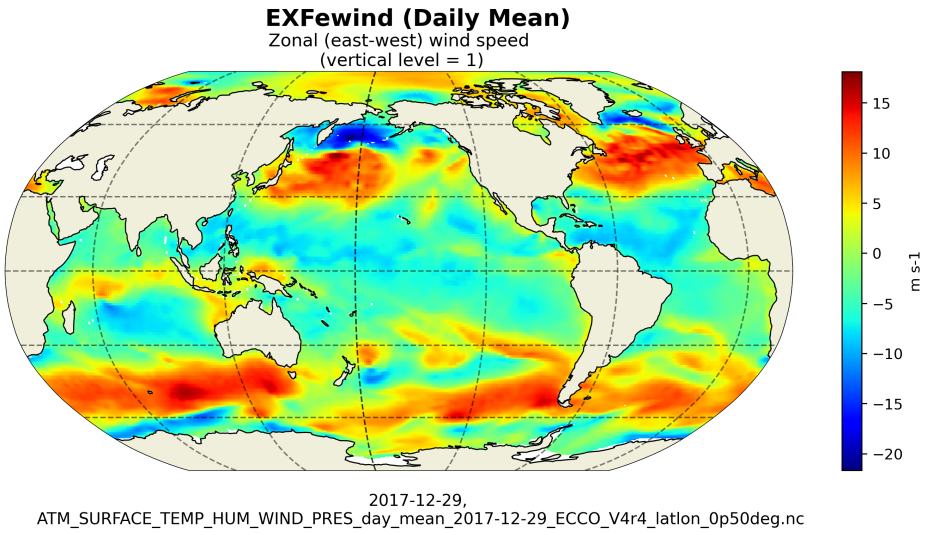


Figure 123: Dataset: ATM_SURFACE_TEMP_HUM_WIND_PRES, Variable: EXFewind

13.1.5 Latlon Variable: EXFnwind

Table 13.5: Attributes description of the variable 'EXFnwind' from ATM_SURFACE_TEMP_HUM_WIND_PRES's dataset.

Storage Type	Variable Name	Description	Unit
float32	EXFnwind	Meridional (north-south) wind speed	m s-1

Description of the variable in Common Data language (CDL)

```
float32 EXFnwind(time, latitude, longitude)
    EXFnwind:  _FillValue = 9.96921e+36
    EXFnwind:  coordinates = time
    EXFnwind:  coverage_content_type = modelResult
    EXFnwind:  long_name = Meridional (north-south) wind speed
    EXFnwind:  standard_name = northward wind
    EXFnwind:  units = m s-1
    EXFnwind:  valid_max = 33.95014190673828
    EXFnwind:  valid_min = -30.042686462402344
```

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.

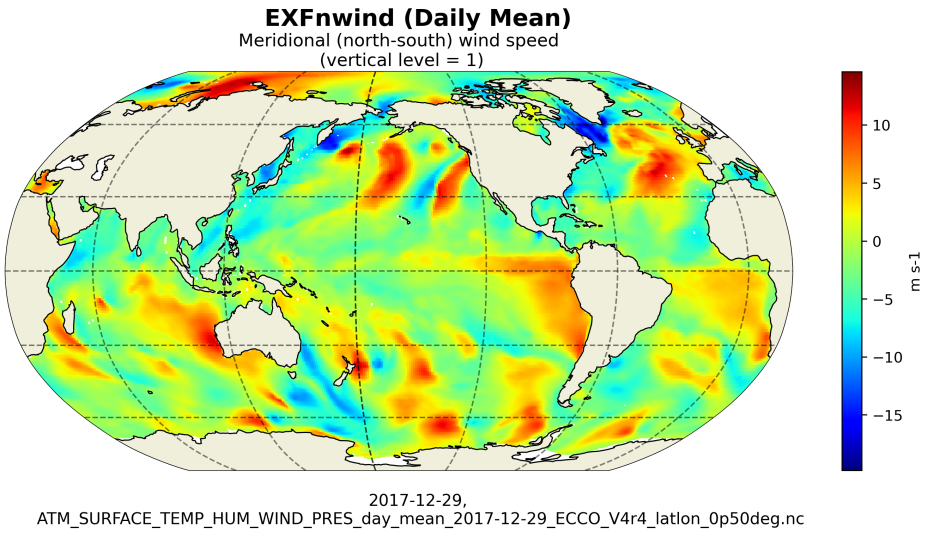


Figure 124: Dataset: ATM_SURFACE_TEMP_HUM_WIND_PRES, Variable: EXFnwind

13.1.6 Latlon Variable: EXFpress

Table 13.6: Attributes description of the variable 'EXFpress' from ATM_SURFACE_TEMP_HUM_WIND_PRES's dataset.

Storage Type	Variable Name	Description	Unit
float32	EXFpress	Atmosphere surface pressure	N m-2

Description of the variable in Common Data language (CDL)

```
float32 EXFpress(time, latitude, longitude)
   EXFpress:  _FillValue = 9.96921e+36
   EXFpress:  coordinates = time
   EXFpress:  coverage_content_type = modelResult
   EXFpress:  long_name = Atmosphere surface pressure
   EXFpress:  standard_name = surface air pressure
   EXFpress:  units = N m-2
   EXFpress:  valid_max = 106314.7734375
   EXFpress:  valid_min = 92090.3125
```

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.

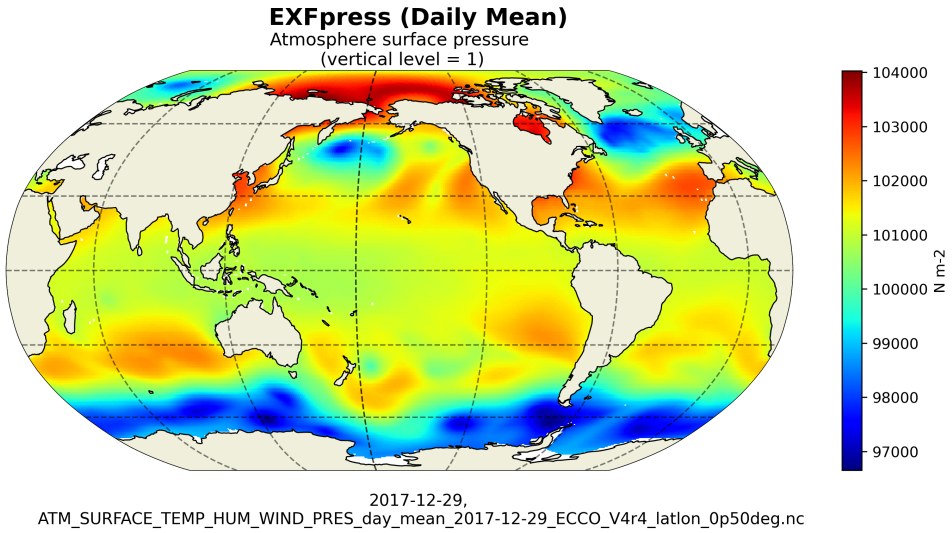


Figure 125: Dataset: ATM_SURFACE_TEMP_HUM_WIND_PRES, Variable: EXFpress

13.1.7 Latlon Variable: EXFwspee

Table 13.7: Attributes description of the variable 'EXFwspee' from ATM_SURFACE_TEMP_HUM_WIND_PRES's dataset.

Storage Type	Variable Name	Description	Unit
float32	EXFwspee	Wind speed	m s-1

Description of the variable in Common Data language (CDL)

```
float32 EXFwspee(time, latitude, longitude)
   EXFwspee:  _FillValue = 9.96921e+36
   EXFwspee:  coordinates = time
   EXFwspee:  coverage_content_type = modelResult
   EXFwspee:  long_name = Wind speed
   EXFwspee:  standard_name = wind speed
   EXFwspee:  units = m s-1
   EXFwspee:  valid_max = 45.87086486816406
   EXFwspee:  valid_min = 0.27271032333374023
```

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.

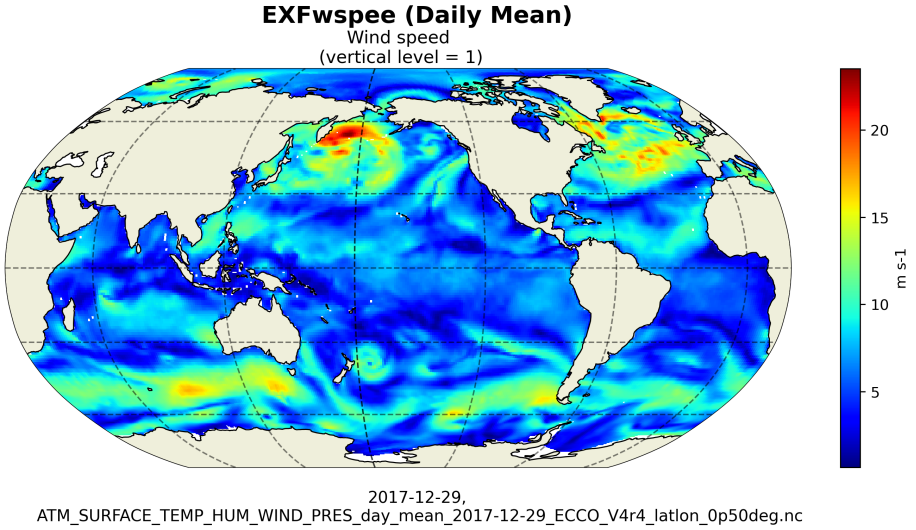


Figure 126: Dataset: ATM_SURFACE_TEMP_HUM_WIND_PRES, Variable: EXFwspee

13.2 Latlon dataset of OCEAN_AND_ICE_SURFACE_FW_FLUX

13.2.1 Overview

This dataset provides 2D fields of ocean and sea-ice surface freshwater fluxes interpolated to a regular 0.5-degree grid from the ECCO Version 4 Release 4 (V4r4) ocean and sea-ice state estimate. The dataset is provided on daily-average and monthly-average time resolution.

Table 13.8: Coordinates and Variables in the dataset OCEAN_AND_ICE_SURFACE_FW_FLUX

Coordinates	Description of data coordinates	Unit
time	Center time of averaging period	–none–
latitude	Latitude at grid cell center	degrees_north
longitude	Longitude at grid cell center	degrees_east
time_bnds	Time bounds of averaging period	–none–
latitude_bnds	Latitude bounds grid cells	–none–
longitude_bnds	Longitude bounds grid cells	–none–
Variables	**Description of data variables**	**Unit**
EXFpreci	Precipitation rate	m s-1
EXFevap	Open ocean evaporation rate	m s-1
EXFroff	River runoff	m s-1
SIsnPrcp	Snow precipitation on sea-ice	kg m-2 s-1
EXFempmr	Open ocean net surface freshwater flux from precipitation, evaporation, and runoff	m s-1
oceFWflx	Net freshwater flux into the ocean	kg m-2 s-1
SIatmFW	Net freshwater flux into the open ocean, sea-ice, and snow	kg m-2 s-1
SFLUX	Rate of change of total ocean salinity per m2 accounting for mass fluxes.	g m-2 s-1
SIacSubl	Freshwater flux to the atmosphere due to sublimation-deposition of snow or ice	kg m-2 s-1
SIrsSubl	Residual sublimation freshwater flux	kg m-2 s-1
SIfwThru	Precipitation through sea-ice	kg m-2 s-1

13.2.2 Latlon Variable: EXFempmr

Table 13.9: Attributes description of the variable 'EXFempmr' from OCEAN_AND_ICE_SURFACE_FW_FLUX's dataset.

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

Description of the variable in Common Data language (CDL)

```
float32 EXFempmr(time, latitude, longitude)
   EXFempmr:  _FillValue = 9.96921e+36
   EXFempmr:  coordinates = time
   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:  valid_max = 5.400421514423215e-07
   EXFempmr:  valid_min = -8.299433829961345e-06
```

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.

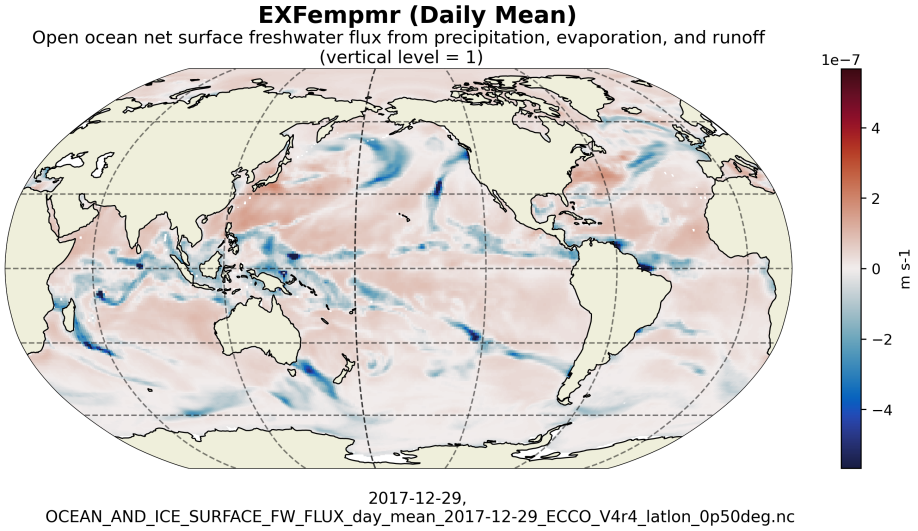


Figure 127: Dataset: OCEAN_AND_ICE_SURFACE_FW_FLUX, Variable: EXFempmr

13.2.3 Latlon Variable: EXFevap

Table 13.10: Attributes description of the variable 'EXFevap' from OCEAN_AND_ICE_SURFACE_FW_FLUX's dataset.

Storage Type	Variable Name	Description	Unit
float32	EXFevap	Open ocean evaporation rate	m s-1

Description of the variable in Common Data language (CDL)

```
float32 EXFevap(time, latitude, longitude)
   EXFevap:  _FillValue = 9.96921e+36
   EXFevap:  coordinates = time
   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:  valid_max = 7.090054623404285e-07
   EXFevap:  valid_min = -1.0958113705328287e-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.

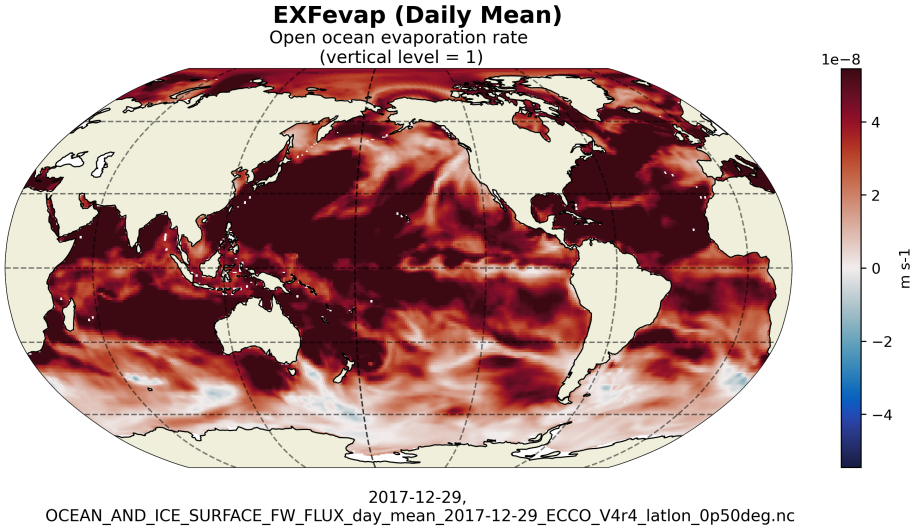


Figure 128: Dataset: OCEAN_AND_ICE_SURFACE_FW_FLUX, Variable: EXFevap

13.2.4 Latlon Variable: EXFpreci

Table 13.11: Attributes description of the variable 'EXFpreci' from OCEAN_AND_ICE_SURFACE_FW_FLUX's dataset.

Storage Type	Variable Name	Description	Unit
float32	EXFpreci	Precipitation rate	m s-1

Description of the variable in Common Data language (CDL)

```
float32 EXFpreci(time, latitude, longitude)
   EXFpreci:  _FillValue = 9.96921e+36
   EXFpreci:  coordinates = time
   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:  valid_max = 8.317776519106701e-06
   EXFpreci:  valid_min = -1.4860395936011628e-07
```

Comments

Precipitation rate. note: sum of era-interim precipitation and the control adjustment from ocean state estimation.

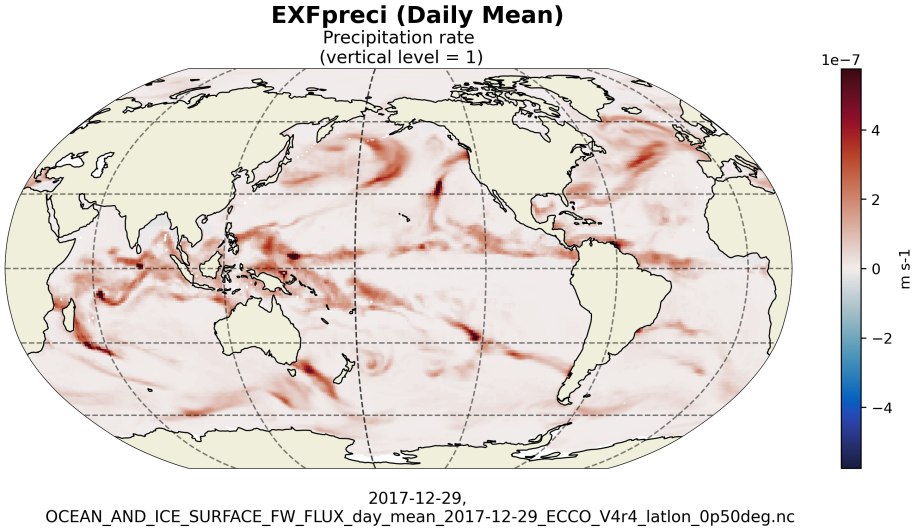


Figure 129: Dataset: OCEAN_AND_ICE_SURFACE_FW_FLUX, Variable: EXFpreci

13.2.5 Latlon Variable: EXFroff

Table 13.12: Attributes description of the variable 'EXFroff' from OCEAN_AND_ICE_SURFACE_FW_FLUX's dataset.

Storage Type	Variable Name	Description	Unit
float32	EXFroff	River runoff	m s-1

Description of the variable in Common Data language (CDL)

```
float32 EXFroff(time, latitude, longitude)
   EXFroff:  _FillValue = 9.96921e+36
   EXFroff:  coordinates = time
   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:  valid_max = 4.185612397122895e-06
   EXFroff:  valid_min = 0.0
```

Comments

River runoff freshwater flux. note: not adjusted by the optimization.

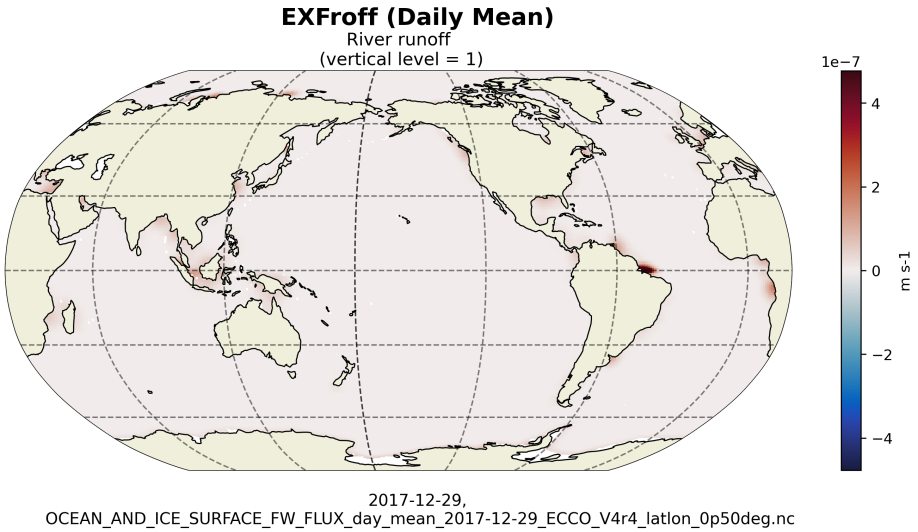


Figure 130: Dataset: OCEAN_AND_ICE_SURFACE_FW_FLUX, Variable: EXFroff

13.2.6 Latlon Variable: SFLUX

Table 13.13: Attributes description of the variable 'SFLUX' from OCEAN_AND_ICE_SURFACE_FW_FLUX's dataset.

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

Description of the variable in Common Data language (CDL)

```
float32 SFLUX(time, latitude, longitude)
   SFLUX: _FillValue = 9.96921e+36
   SFLUX: coordinates = time
   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: valid_max = 0.010570422746241093
   SFLUX: valid_min = -0.06244903802871704
```

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).

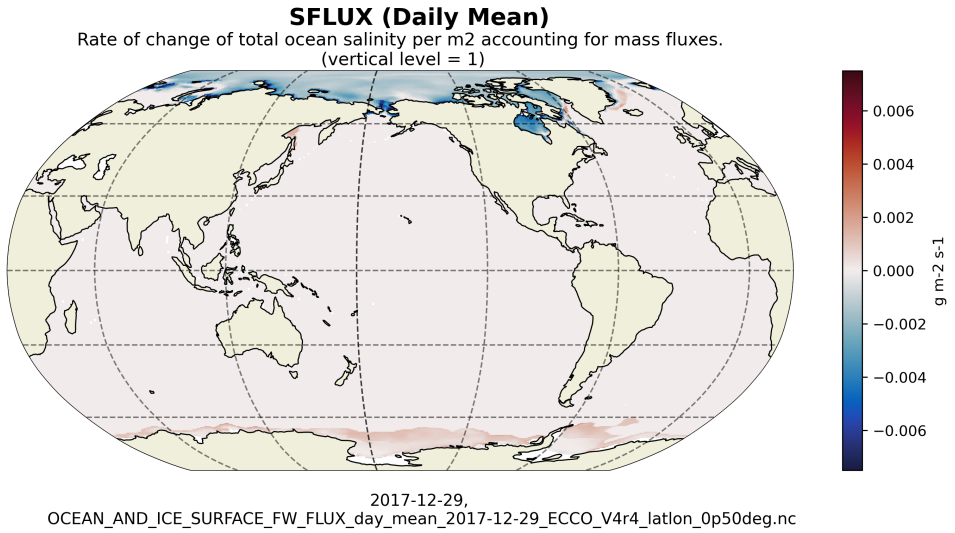


Figure 131: Dataset: OCEAN_AND_ICE_SURFACE_FW_FLUX, Variable: SFLUX

13.2.7 Latlon Variable: SIacSubl

Table 13.14: Attributes description of the variable 'SIacSubl' from OCEAN_AND_ICE_SURFACE_FW_FLUX's dataset.

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

Description of the variable in Common Data language (CDL)

```
float32 SIacSubl(time, latitude, longitude)
   SIacSubl:  _FillValue = 9.96921e+36
   SIacSubl:  coordinates = time
   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:  valid_max = 7.735946564935148e-05
   SIacSubl:  valid_min = 0.0
```

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

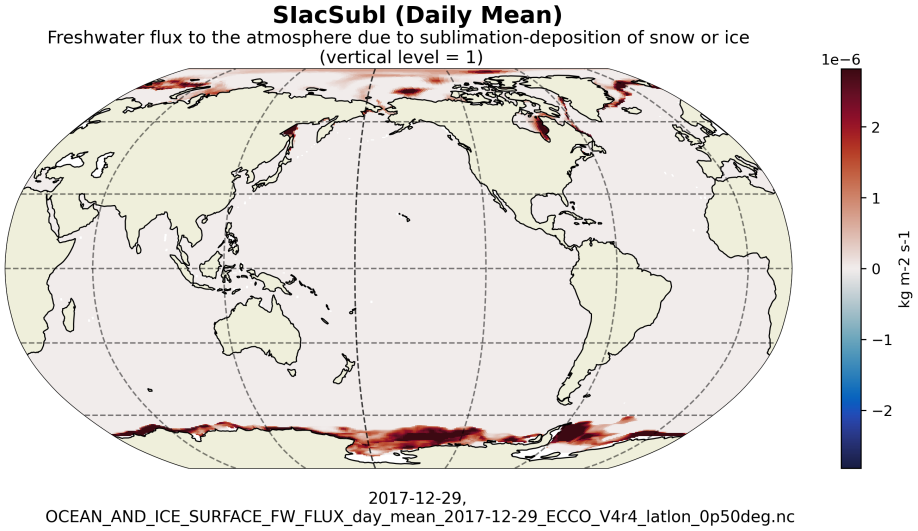


Figure 132: Dataset: OCEAN_AND_ICE_SURFACE_FW_FLUX, Variable: SIacSubl

13.2.8 Latlon Variable: SIatmFW

Table 13.15: Attributes description of the variable 'SIatmFW' from OCEAN_AND_ICE_SURFACE_FW_FLUX's dataset.

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

Description of the variable in Common Data language (CDL)

```
float32 SIatmFW(time, latitude, longitude)
   SIatmFW: _FillValue = 9.96921e+36
   SIatmFW: coordinates = time
   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: valid_max = 0.008299433626234531
   SIatmFW: valid_min = -0.00043017856660299003
```

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.

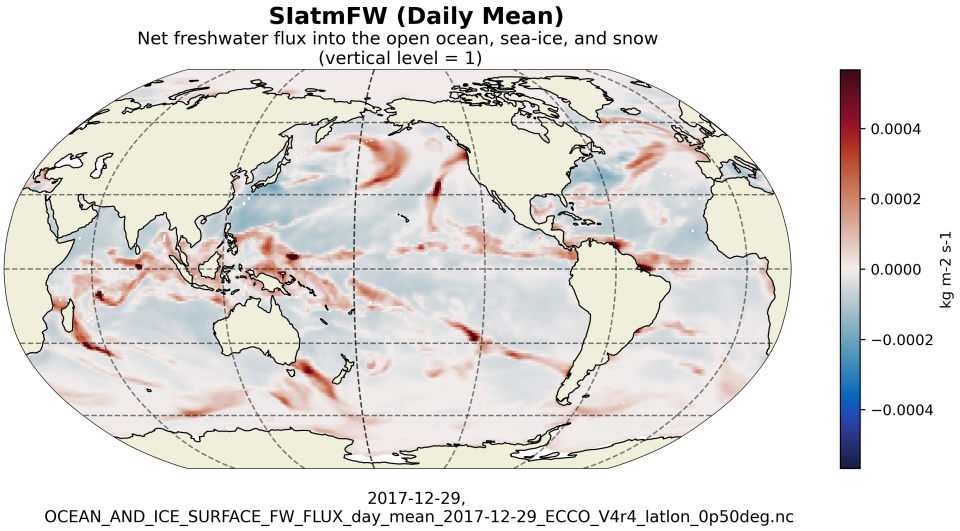


Figure 133: Dataset: OCEAN_AND_ICE_SURFACE_FW_FLUX, Variable: SIatmFW

13.2.9 Latlon Variable: SIfwThru

Table 13.16: Attributes description of the variable 'SIfwThru' from OCEAN_AND_ICE_SURFACE_FW_FLUX's dataset.

Storage Type	Variable Name	Description	Unit
float32	SIfwThru	Precipitation through sea-ice	kg m-2 s-1

Description of the variable in Common Data language (CDL)

```
float32 SIfwThru(time, latitude, longitude)
   SIfwThru:  _FillValue = 9.96921e+36
   SIfwThru:  coordinates = time
   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:  valid_max = 0.0010632629273459315
   SIfwThru:  valid_min = -1.695218452368863e-05
```

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.

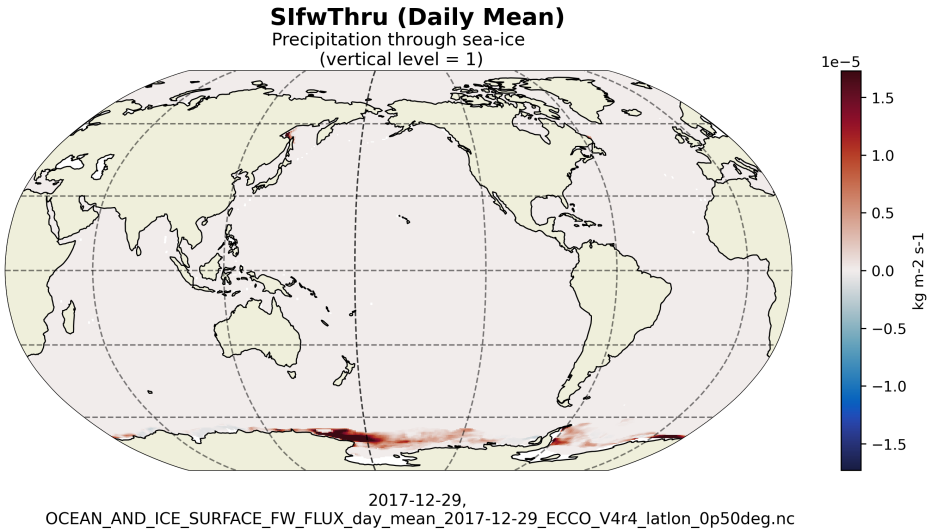


Figure 134: Dataset: OCEAN_AND_ICE_SURFACE_FW_FLUX, Variable: SIfwThru

13.2.10 Latlon Variable: SIrsSubl

Table 13.17: Attributes description of the variable 'SIrsSubl' from OCEAN_AND_ICE_SURFACE_FW_FLUX's dataset.

Storage Type	Variable Name	Description	Unit
float32	SIrsSubl	Residual sublimation freshwater flux	kg m-2 s-1

Description of the variable in Common Data language (CDL)

```
float32 SIrsSubl(time, latitude, longitude)
   SIrsSubl:  _FillValue = 9.96921e+36
   SIrsSubl:  coordinates = time
   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:  valid_max = 8.640533451398369e-06
   SIrsSubl:  valid_min = -0.0001067528864950873
```

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.

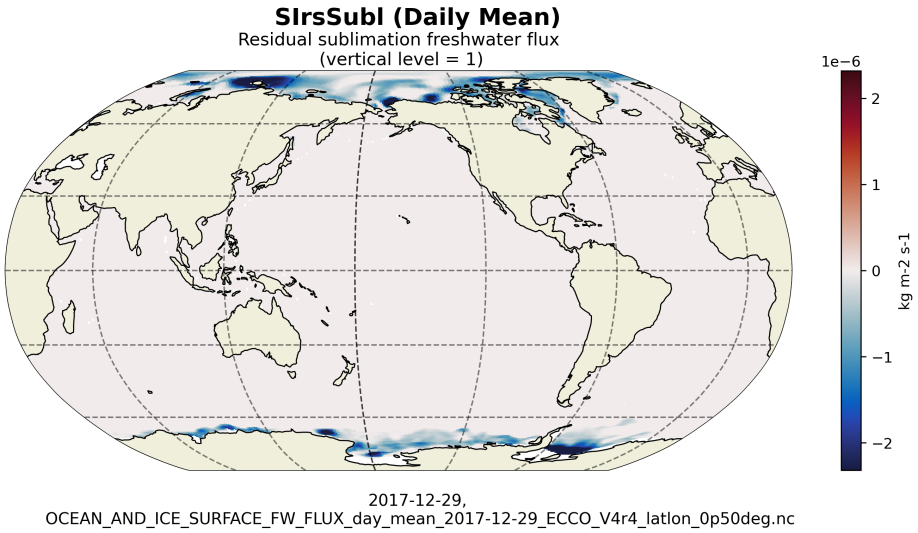


Figure 135: Dataset: OCEAN_AND_ICE_SURFACE_FW_FLUX, Variable: SIrsSubl

13.2.11 Latlon Variable: SIsnPrcp

Table 13.18: Attributes description of the variable 'SIsnPrcp' from OCEAN_AND_ICE_SURFACE_FW_FLUX's dataset.

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

Description of the variable in Common Data language (CDL)

```
float32 SIsnPrcp(time, latitude, longitude)
   SIsnPrcp:  _FillValue = 9.96921e+36
   SIsnPrcp:  coordinates = time
   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:  valid_max = 0.0009354020585305989
   SIsnPrcp:  valid_min = -4.334669574745931e-05
```

Comments

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

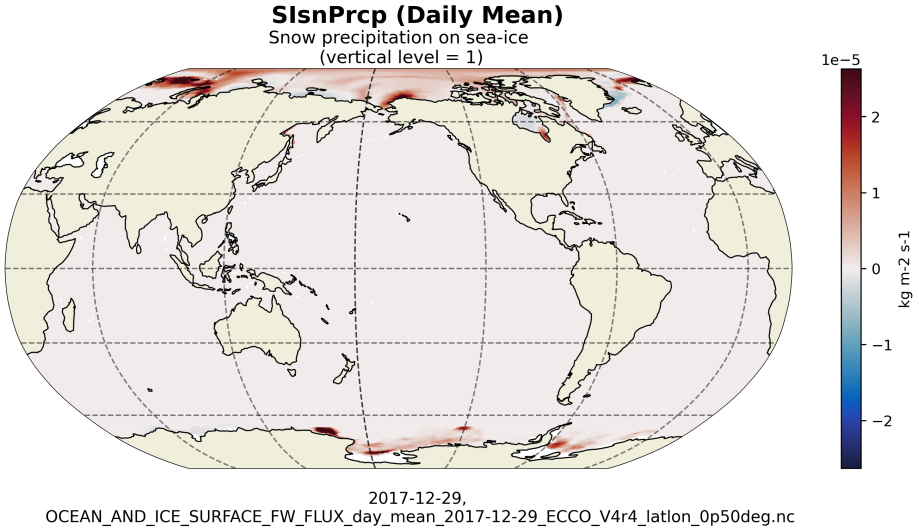


Figure 136: Dataset: OCEAN_AND_ICE_SURFACE_FW_FLUX, Variable: SIsnPrcp

13.2.12 Latlon Variable: oceFWflx

Table 13.19: Attributes description of the variable 'oceFWflx' from OCEAN_AND_ICE_SURFACE_FW_FLUX's dataset.

Storage Type	Variable Name	Description	Unit
float32	oceFWflx	Net freshwater flux into the ocean	kg m-2 s-1

Description of the variable in Common Data language (CDL)

```
float32 oceFWflx(time, latitude, longitude)
    oceFWflx:  _FillValue = 9.96921e+36
    oceFWflx:  coordinates = time
    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:  valid_max = 0.008299433626234531
    oceFWflx:  valid_min = -0.0033125500194728374
```

Comments

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.

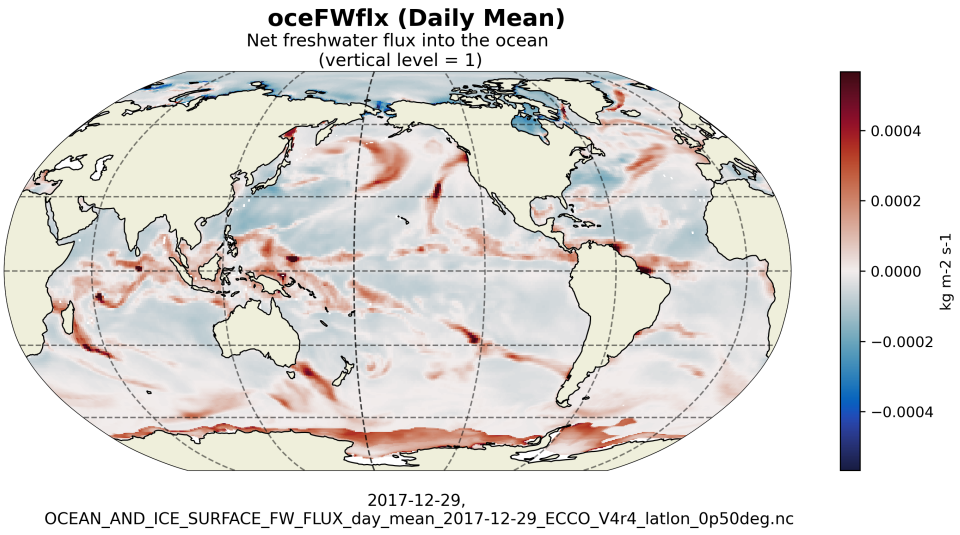


Figure 137: Dataset: OCEAN_AND_ICE_SURFACE_FW_FLUX, Variable: oceFWflx

13.3 Latlon dataset of OCEAN_AND_ICE_SURFACE_HEAT_FLUX

13.3.1 Overview

This dataset provides 2D fields of ocean and sea-ice surface heat fluxes interpolated to a regular 0.5-degree grid from the ECCO Version 4 Release 4 (V4r4) ocean and sea-ice state estimate. The dataset is provided on daily-average and monthly-average time resolution.

Table 13.20: Coordinates and Variables in the dataset OCEAN_AND_ICE_SURFACE_HEAT_FLUX

Coordinates	Description of data coordinates	Unit
time	Center time of averaging period	–none–
latitude	Latitude at grid cell center	degrees_north
longitude	Longitude at grid cell center	degrees_east
time_bnds	Time bounds of averaging period	–none–
latitude_bnds	Latitude bounds grid cells	–none–
longitude_bnds	Longitude bounds grid cells	–none–
Variables	**Description of data variables**	**Unit**
EXFhl	Open ocean air-sea latent heat flux	W m-2
EXFhs	Open ocean air-sea sensible heat flux	W m-2
EXFlwdn	Downward longwave radiative flux	W m-2
EXFswdn	Downwelling shortwave radiative flux	W m-2
EXFqnet	Open ocean net air-sea heat flux	W m-2
oceQnet	Net heat flux into the ocean surface	W m-2
SIatmQnt	Net upward heat flux to the atmosphere	W m-2
TFLUX	Rate of change of ocean heat content per m2 accounting for mass fluxes.	W m-2
EXFswnet	Open ocean net shortwave radiative flux	W m-2
EXFlwnet	Net open ocean longwave radiative flux	W m-2
oceQsw	Net shortwave radiative flux across the ocean surface	W m-2
SIaaflux	Conservative ocean and sea-ice advective heat flux adjustment	W m-2

13.3.2 Latlon Variable: EXFhl

Table 13.21: Attributes description of the variable 'EXFhl' from OCEAN_AND_ICE_SURFACE_HEAT_FLUX's dataset.

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

Description of the variable in Common Data language (CDL)

```
float32 EXFhl(time, latitude, longitude)
    EXFhl:  _FillValue = 9.96921e+36
    EXFhl:  coordinates = time
    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:  valid_max = 273.9528503417969
    EXFhl:  valid_min = -1772.513671875
```

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.

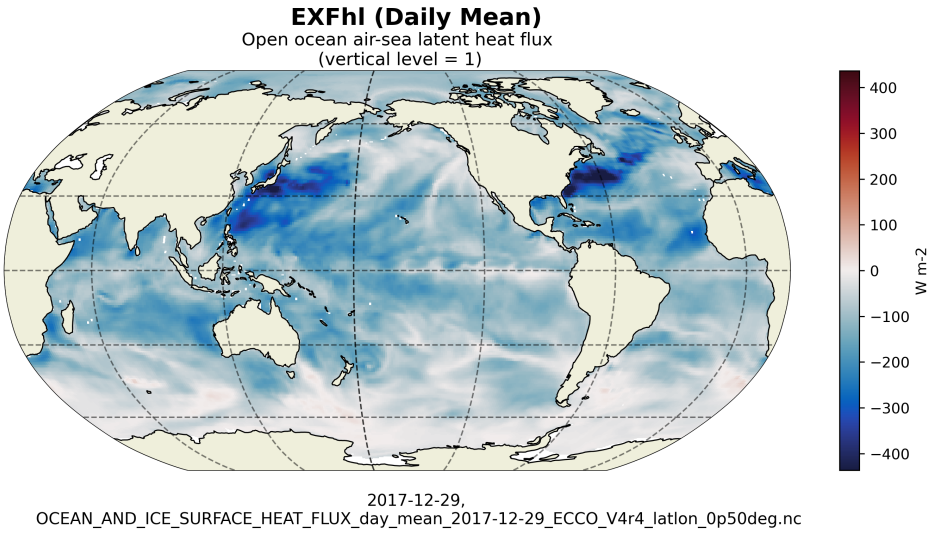


Figure 138: Dataset: OCEAN_AND_ICE_SURFACE_HEAT_FLUX, Variable: EXFhl

13.3.3 Latlon Variable: EXFhs

Table 13.22: Attributes description of the variable 'EXFhs' from OCEAN_AND_ICE_SURFACE_HEAT_FLUX's dataset.

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

Description of the variable in Common Data language (CDL)

```
float32 EXFhs(time, latitude, longitude)
    EXFhs:  _FillValue = 9.96921e+36
    EXFhs:  coordinates = time
    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:  valid_max = 357.0105895996094
    EXFhs:  valid_min = -2478.766357421875
```

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.

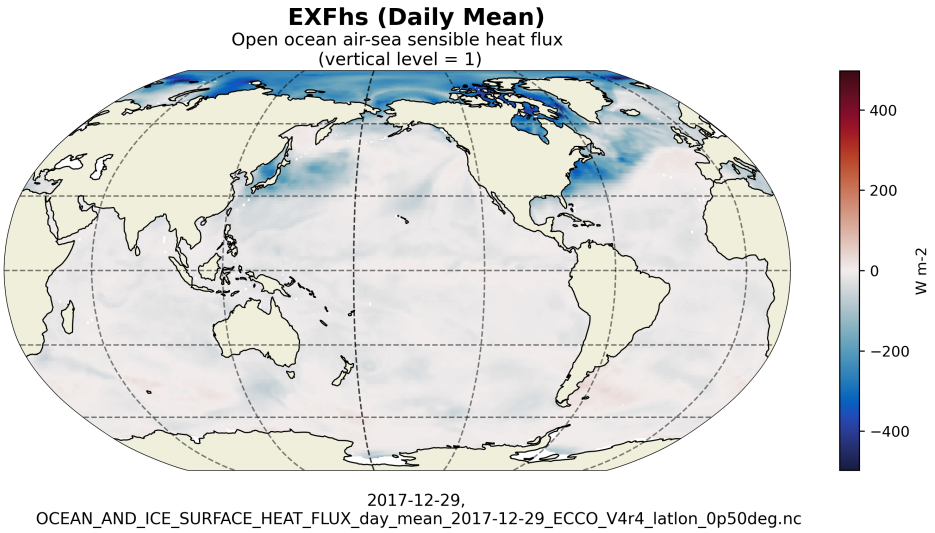


Figure 139: Dataset: OCEAN_AND_ICE_SURFACE_HEAT_FLUX, Variable: EXFhs

13.3.4 Latlon Variable: EXFlwdn

Table 13.23: Attributes description of the variable 'EXFlwdn' from OCEAN_AND_ICE_SURFACE_HEAT_FLUX's dataset.

Storage Type	Variable Name	Description	Unit
float32	EXFlwdn	Downward longwave radiative flux	W m-2

Description of the variable in Common Data language (CDL)

```
float32 EXFlwdn(time, latitude, longitude)
    EXFlwdn:  _FillValue = 9.96921e+36
    EXFlwdn:  coordinates = time
    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:  valid_max = 513.3919067382812
    EXFlwdn:  valid_min = 4.188045501708984
```

Comments

Downward longwave radiative flux. note: sum of era-interim downward longwave radiation and the control adjustment from ocean state estimation.

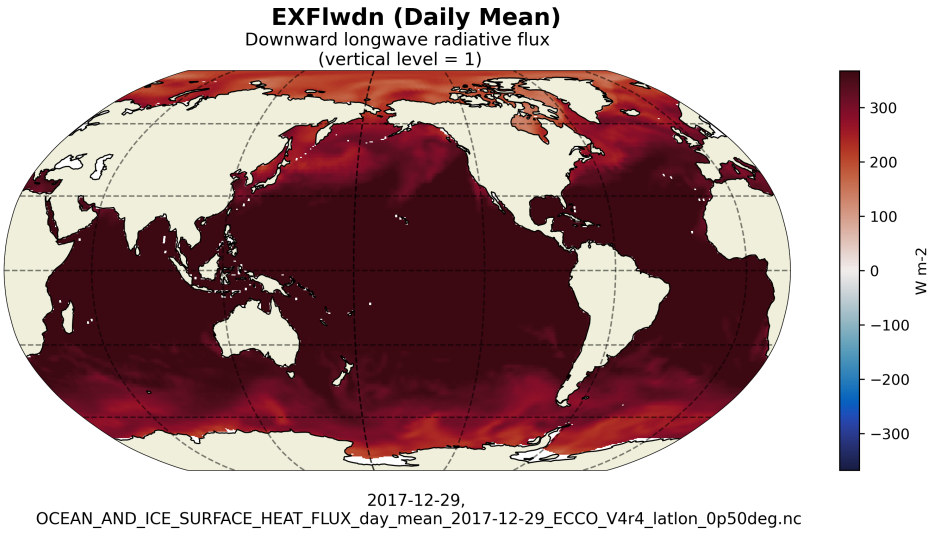


Figure 140: Dataset: OCEAN_AND_ICE_SURFACE_HEAT_FLUX, Variable: EXFlwdn

13.3.5 Latlon Variable: EXFlwnet

Table 13.24: Attributes description of the variable 'EXFlwnet' from OCEAN_AND_ICE_SURFACE_HEAT_FLUX's dataset.

Storage Type	Variable Name	Description	Unit
float32	EXFlwnet	Net open ocean longwave radiative flux	W m-2

Description of the variable in Common Data language (CDL)

```
float32 EXFlwnet(time, latitude, longitude)
   EXFlwnet:  _FillValue = 9.96921e+36
   EXFlwnet:  coordinates = time
   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:  valid_max = 293.4114990234375
   EXFlwnet:  valid_min = -144.3661346435547
```

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).

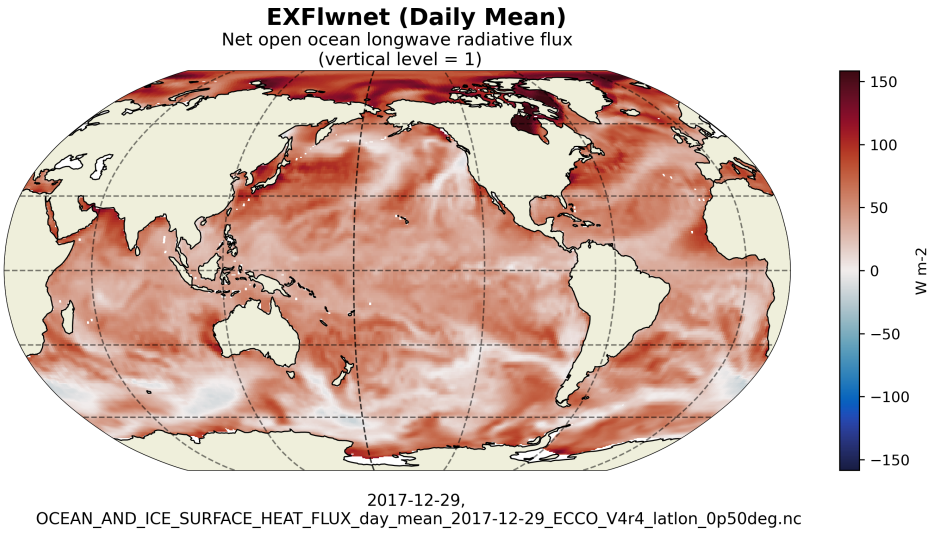


Figure 141: Dataset: OCEAN_AND_ICE_SURFACE_HEAT_FLUX, Variable: EXFlwnet

13.3.6 Latlon Variable: EXFqnet

Table 13.25: Attributes description of the variable 'EXFqnet' from OCEAN_AND_ICE_SURFACE_HEAT_FLUX's dataset.

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

Description of the variable in Common Data language (CDL)

```
float32 EXFqnet(time, latitude, longitude)
   EXFqnet:  _FillValue = 9.96921e+36
   EXFqnet:  coordinates = time
   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:  valid_max = 3408.977783203125
   EXFqnet:  valid_min = -687.8736572265625
```

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.

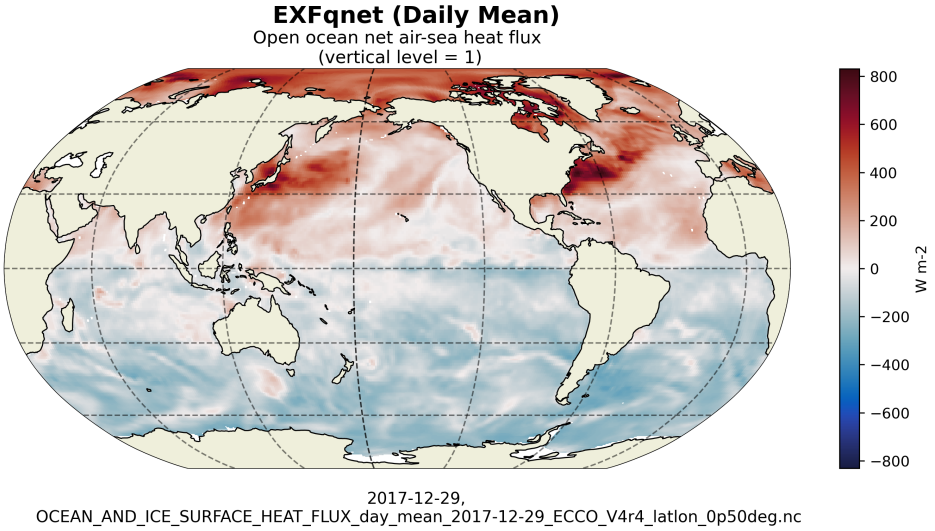


Figure 142: Dataset: OCEAN_AND_ICE_SURFACE_HEAT_FLUX, Variable: EXFqnet

13.3.7 Latlon Variable: EXFswdn

Table 13.26: Attributes description of the variable 'EXFswdn' from OCEAN_AND_ICE_SURFACE_HEAT_FLUX's dataset.

Storage Type	Variable Name	Description	Unit
float32	EXFswdn	Downwelling shortwave radiative flux	W m-2

Description of the variable in Common Data language (CDL)

```
float32 EXFswdn(time, latitude, longitude)
    EXFswdn:  _FillValue = 9.96921e+36
    EXFswdn:  coordinates = time
    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:  valid_max = 707.345947265625
    EXFswdn:  valid_min = -224.63368225097656
```

Comments

Downward shortwave radiative flux. note: sum of era-interim downward shortwave radiation and the control adjustment from ocean state estimation.

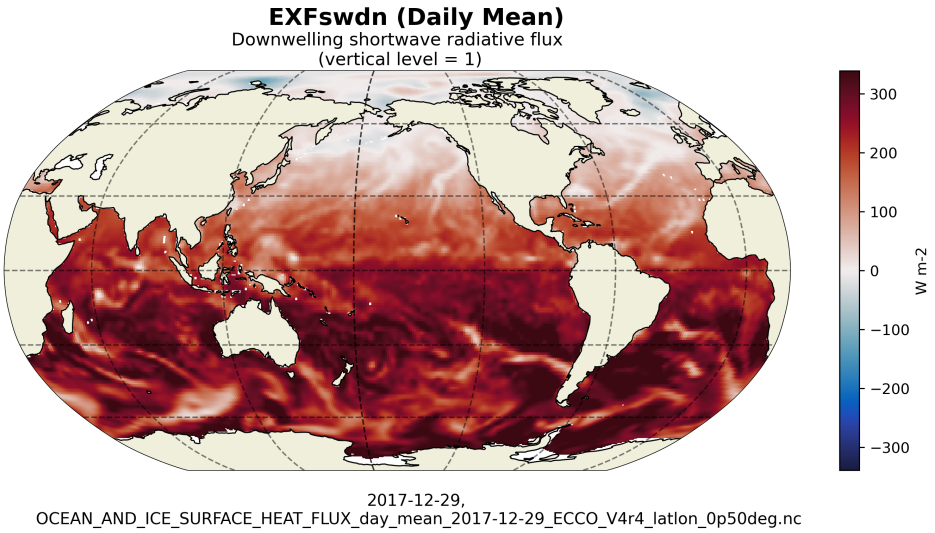


Figure 143: Dataset: OCEAN_AND_ICE_SURFACE_HEAT_FLUX, Variable: EXFswdn

13.3.8 Latlon Variable: EXFswnet

Table 13.27: Attributes description of the variable 'EXFswnet' from OCEAN_AND_ICE_SURFACE_HEAT_FLUX's dataset.

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

Description of the variable in Common Data language (CDL)

```
float32 EXFswnet(time, latitude, longitude)
    EXFswnet:  _FillValue = 9.96921e+36
    EXFswnet:  coordinates = time
    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:  valid_max = 193.89297485351562
    EXFswnet:  valid_min = -655.6171264648438
```

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.

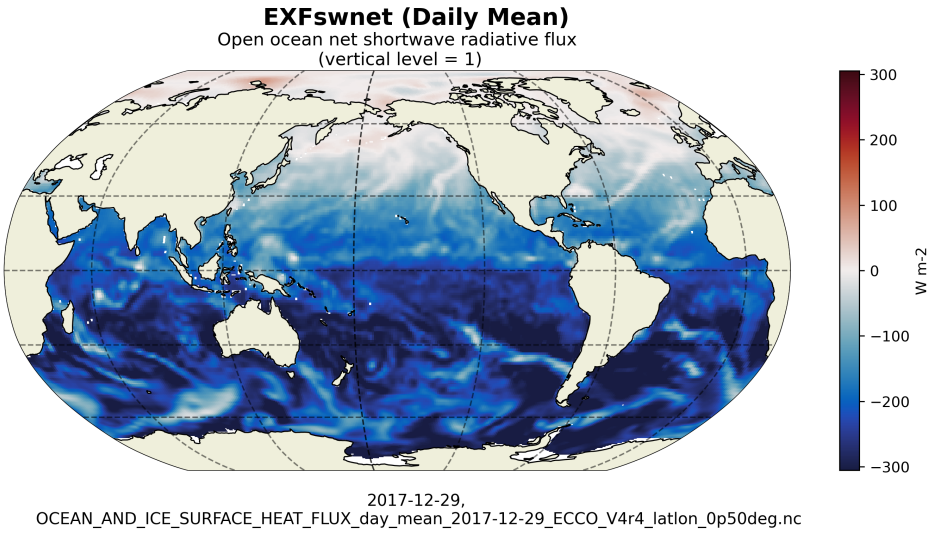


Figure 144: Dataset: OCEAN_AND_ICE_SURFACE_HEAT_FLUX, Variable: EXFswnet

13.3.9 Latlon Variable: SIaaflux

Table 13.28: Attributes description of the variable 'SIaaflux' from OCEAN_AND_ICE_SURFACE_HEAT_FLUX's dataset.

Storage Type	Variable Name	Description	Unit
float32	SIaaflux	Conservative ocean and sea-ice advective heat flux adjustment	W m-2

Description of the variable in Common Data language (CDL)

```
float32 SIaaflux(time, latitude, longitude)
   SIaaflux:  _FillValue = 9.96921e+36
   SIaaflux:  coordinates = time
   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:  valid_max = 50.35451889038086
   SIaaflux:  valid_min = -16.214622497558594
```

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.

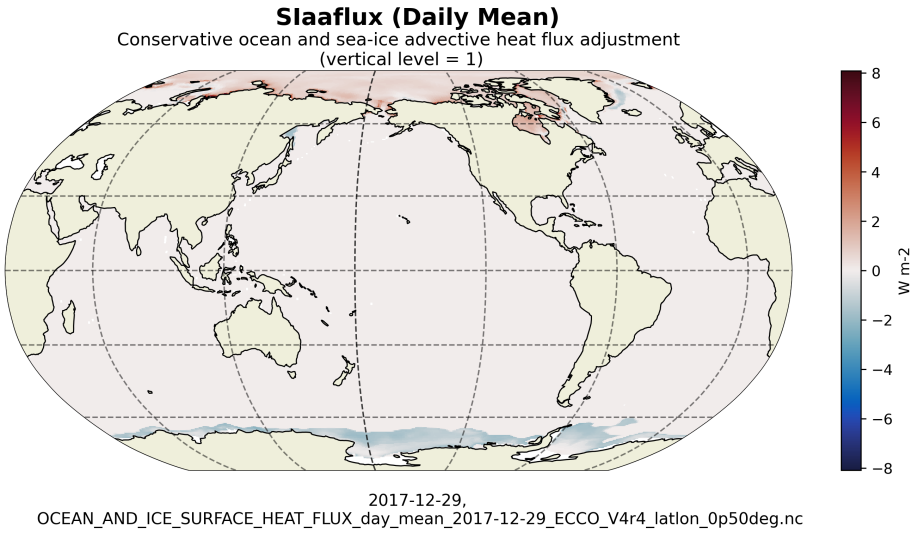


Figure 145: Dataset: OCEAN_AND_ICE_SURFACE_HEAT_FLUX, Variable: SIaaflux

13.3.10 Latlon Variable: SIatmQnt

Table 13.29: Attributes description of the variable 'SIatmQnt' from OCEAN_AND_ICE_SURFACE_HEAT_FLUX's dataset.

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

Description of the variable in Common Data language (CDL)

```
float32 SIatmQnt(time, latitude, longitude)
   SIatmQnt:  _FillValue = 9.96921e+36
   SIatmQnt:  coordinates = time
   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:  valid_max = 1704.7703857421875
   SIatmQnt:  valid_min = -756.0607299804688
```

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).

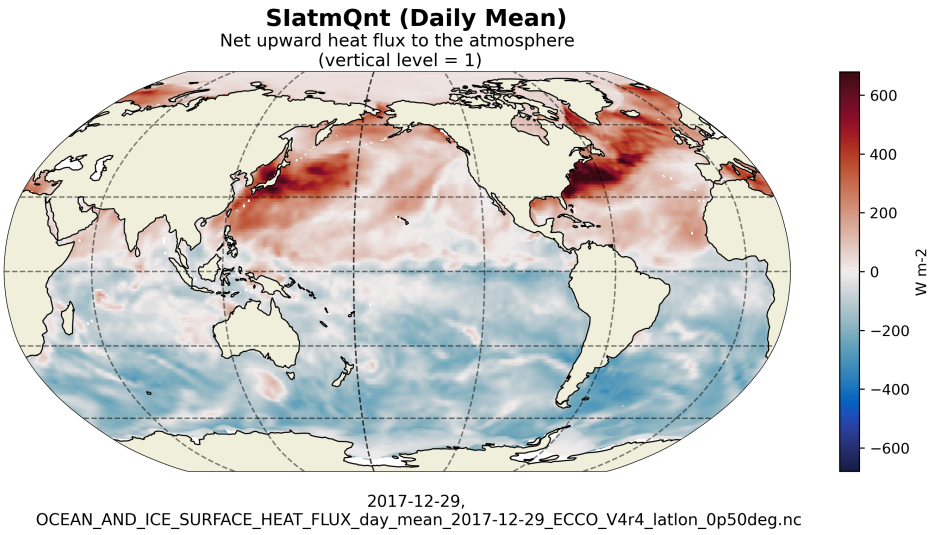


Figure 146: Dataset: OCEAN_AND_ICE_SURFACE_HEAT_FLUX, Variable: SIatmQnt

13.3.11 Latlon Variable: TFLUX

Table 13.30: Attributes description of the variable 'TFLUX' from OCEAN_AND_ICE_SURFACE_HEAT_FLUX's dataset.

Storage Type	Variable Name	Description	Unit
float32	TFLUX	Rate of change of ocean heat content per m2 accounting for mass fluxes.	W m-2

Description of the variable in Common Data language (CDL)

```
float32 TFLUX(time, latitude, longitude)
   TFLUX: _FillValue = 9.96921e+36
   TFLUX: coordinates = time
   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: valid_max = 870.3130493164062
   TFLUX: valid_min = -1713.51220703125
```

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).

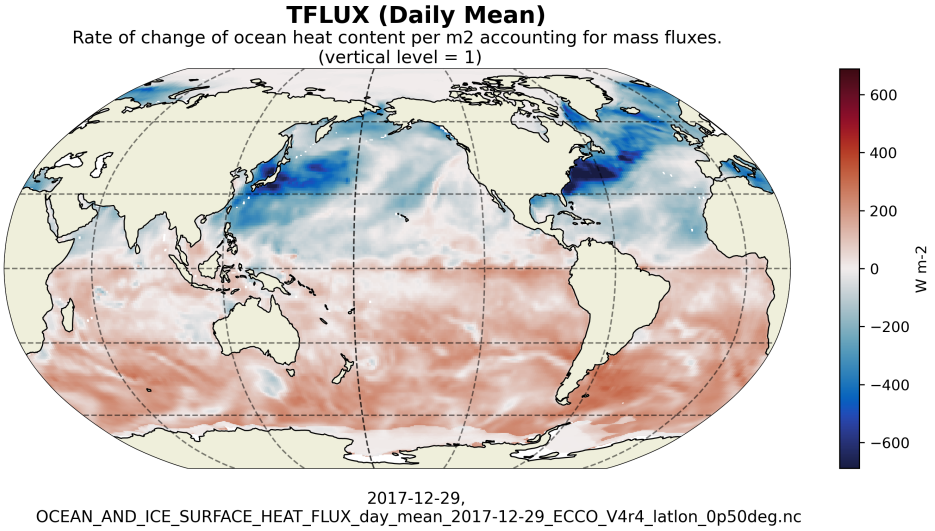


Figure 147: Dataset: OCEAN_AND_ICE_SURFACE_HEAT_FLUX, Variable: TFLUX

13.3.12 Latlon Variable: oceQnet

Table 13.31: Attributes description of the variable 'oceQnet' from OCEAN_AND_ICE_SURFACE_HEAT_FLUX's dataset.

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

Description of the variable in Common Data language (CDL)

```
float32 oceQnet(time, latitude, longitude)
    oceQnet:  _FillValue = 9.96921e+36
    oceQnet:  coordinates = time
    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:  valid_max = 675.3716430664062
    oceQnet:  valid_min = -1708.8460693359375
```

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.

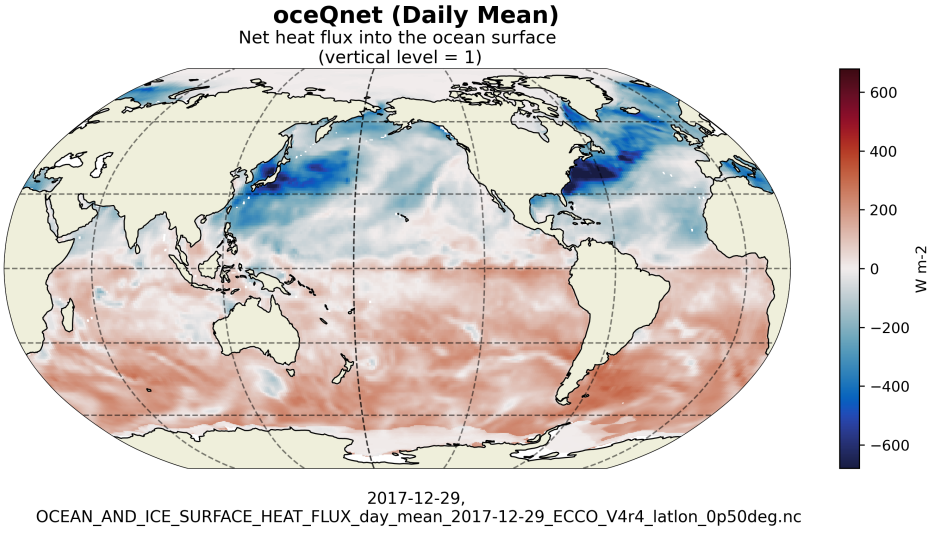


Figure 148: Dataset: OCEAN_AND_ICE_SURFACE_HEAT_FLUX, Variable: oceQnet

13.3.13 Latlon Variable: oceQsw

Table 13.32: Attributes description of the variable 'oceQsw' from OCEAN_AND_ICE_SURFACE_HEAT_FLUX's dataset.

Storage Type	Variable Name	Description	Unit
float32	oceQsw	Net shortwave radiative flux across the ocean surface	W m-2

Description of the variable in Common Data language (CDL)

```
float32 oceQsw(time, latitude, longitude)
   oceQsw:  _FillValue = 9.96921e+36
   oceQsw:  coordinates = time
   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:  valid_max = 655.6171264648438
   oceQsw:  valid_min = -134.39808654785156
```

Comments

Net shortwave radiative flux across the ocean surface. note: shortwave radiation penetrates below the surface grid cell.

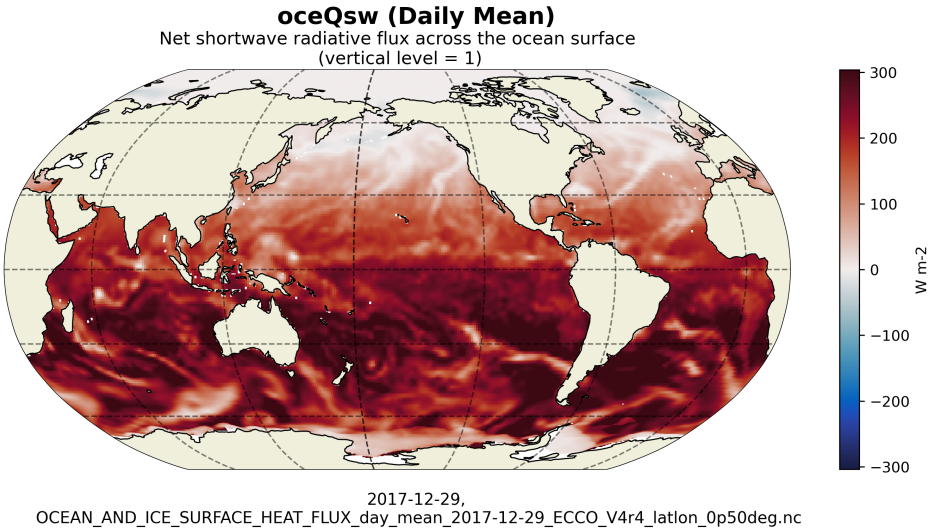


Figure 149: Dataset: OCEAN_AND_ICE_SURFACE_HEAT_FLUX, Variable: oceQsw

13.4 Latlon dataset of OCEAN_AND_ICE_SURFACE_STRESS

13.4.1 Overview

This dataset provides 2D fields of ocean and sea-ice surface stress interpolated to a regular 0.5-degree grid from the ECCO Version 4 Release 4 (V4r4) ocean and sea-ice state estimate. The dataset is provided on daily-average and monthly-average time resolution.

Table 13.33: Coordinates and Variables in the dataset OCEAN_AND_ICE_SURFACE_STRESS

Coordinates	Description of data coordinates	Unit
time	Center time of averaging period	–none–
latitude	Latitude at grid cell center	degrees_north
longitude	Longitude at grid cell center	degrees_east
time_bnds	Time bounds of averaging period	–none–
latitude_bnds	Latitude bounds grid cells	–none–
longitude_bnds	Longitude bounds grid cells	–none–
Variables	**Description of data variables**	**Unit**
EXFtaue	Zonal (east-west) wind stress	N m-2
EXFtaun	Meridional (north-south) wind stress	N m-2
oceTAUE	Zonal (east-west) ocean surface stress	N m-2
oceTAUN	Meridional (north-south) ocean surface stress	N m-2

13.4.2 Latlon Variable: EXFtaue

Table 13.34: Attributes description of the variable 'EXFtaue' from OCEAN_AND_ICE_SURFACE_STRESS's dataset.

Storage Type	Variable Name	Description	Unit
float32	EXFtaue	Zonal (east-west) wind stress	N m-2

Description of the variable in Common Data language (CDL)

```
float32 EXFtaue(time, latitude, longitude)
    EXFtaue:  _FillValue = 9.96921e+36
    EXFtaue:  coordinates = time
    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:  valid_max = 3.284827709197998
    EXFtaue:  valid_min = -3.1686902046203613
```

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.

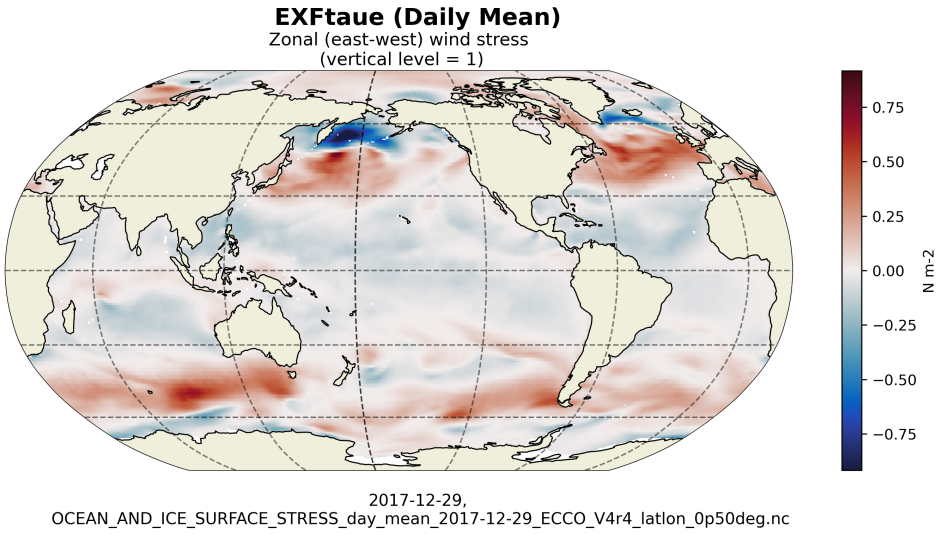


Figure 150: Dataset: OCEAN_AND_ICE_SURFACE_STRESS, Variable: EXFtaue

13.4.3 Latlon Variable: EXFtaun

Table 13.35: Attributes description of the variable 'EXFtaun' from OCEAN_AND_ICE_SURFACE_STRESS's dataset.

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

Description of the variable in Common Data language (CDL)

```
float32 EXFtaun(time, latitude, longitude)
   EXFtaun:  _FillValue = 9.96921e+36
   EXFtaun:  coordinates = time
   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:  valid_max = 6.878159523010254
   EXFtaun:  valid_min = -4.111213207244873
```

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.

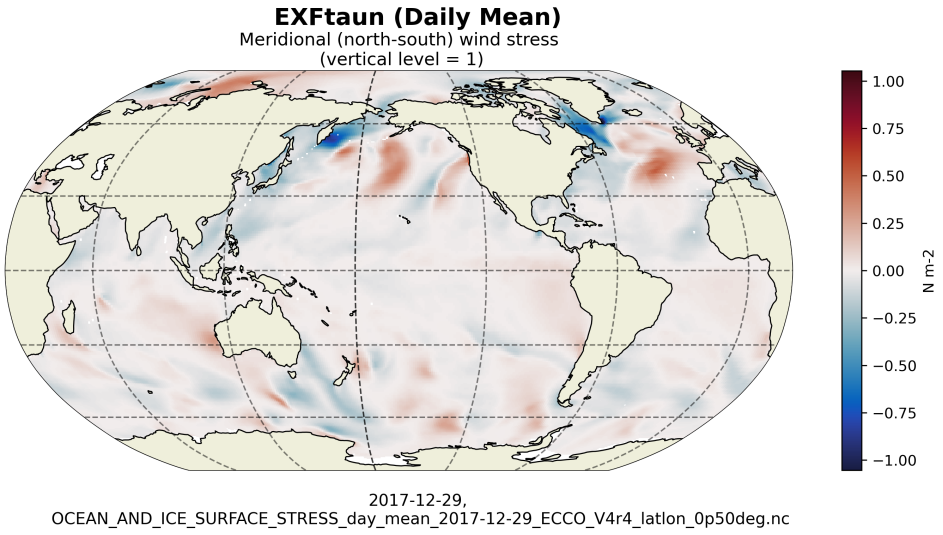


Figure 151: Dataset: OCEAN_AND_ICE_SURFACE_STRESS, Variable: EXFtaun

13.4.4 Latlon Variable: oceTAUE

Table 13.36: Attributes description of the variable 'oceTAUE' from OCEAN_AND_ICE_SURFACE_STRESS's dataset.

Storage Type	Variable Name	Description	Unit
float32	oceTAUE	Zonal (east-west) ocean surface stress	N m-2

Description of the variable in Common Data language (CDL)

```
float32 oceTAUE(time, latitude, longitude)
   oceTAUE: _FillValue = 9.96921e+36
   oceTAUE: coordinates = time
   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: valid_max = 2.000103712081909
   oceTAUE: valid_min = -2.058817148208618
```

Comments

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.

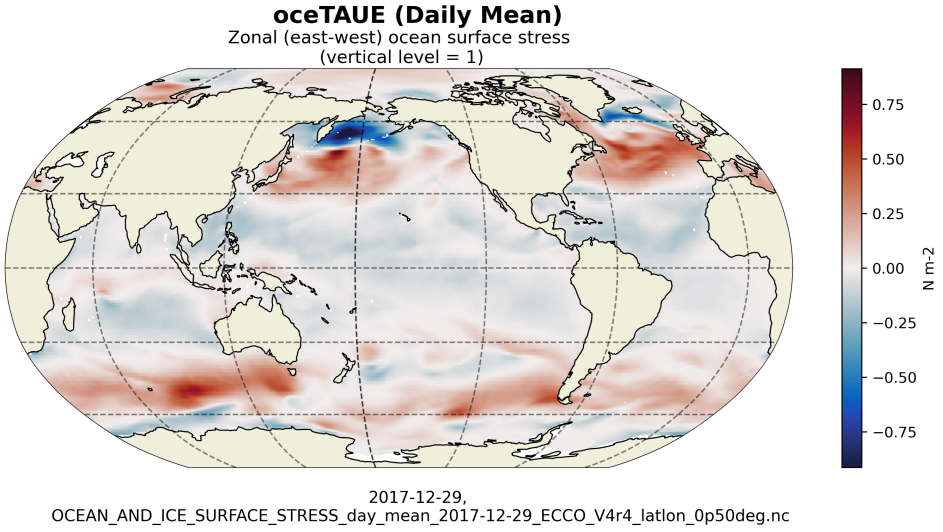


Figure 152: Dataset: OCEAN_AND_ICE_SURFACE_STRESS, Variable: oceTAUE

13.4.5 Latlon Variable: oceTAUN

Table 13.37: Attributes description of the variable 'oceTAUN' from OCEAN_AND_ICE_SURFACE_STRESS's dataset.

Storage Type	Variable Name	Description	Unit
float32	oceTAUN	Meridional (north-south) ocean surface stress	N m-2

Description of the variable in Common Data language (CDL)

```
float32 oceTAUN(time, latitude, longitude)
   oceTAUN: _FillValue = 9.96921e+36
   oceTAUN: coordinates = time
   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: valid_max = 2.019313097000122
   oceTAUN: valid_min = -2.4036266803741455
```

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.

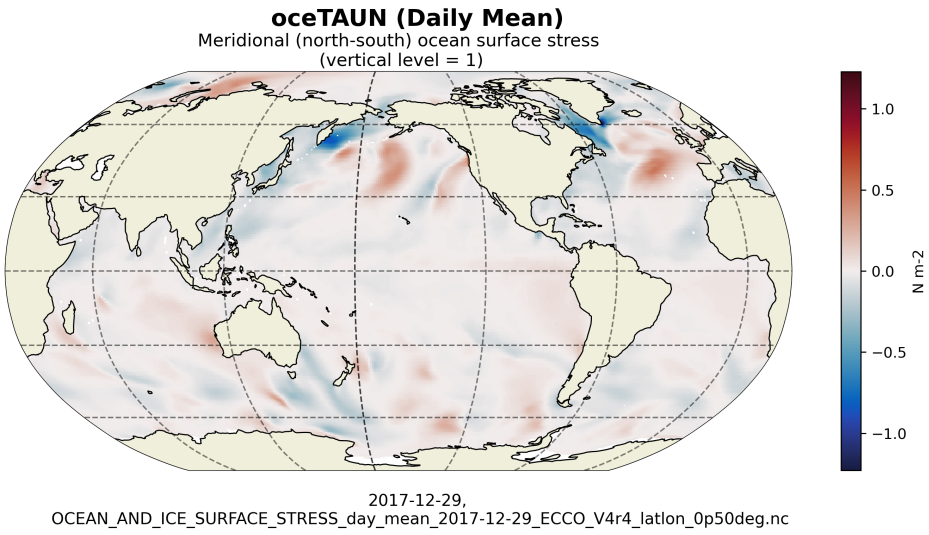


Figure 153: Dataset: OCEAN_AND_ICE_SURFACE_STRESS, Variable: oceTAUN

13.5 Latlon dataset of OCEAN_BOLUS_VELOCITY

13.5.1 Overview

This dataset provides 3D fields of Gent-McWilliams ocean bolus velocity interpolated to a regular 0.5-degree grid from the ECCO Version 4 Release 4 (V4r4) ocean and sea-ice state estimate. The dataset is provided on daily-average and monthly-average time resolution.

Table 13.38: Coordinates and Variables in the dataset OCEAN_BOLUS_VELOCITY

Coordinates	Description of data coordinates	Unit
time	Center time of averaging period	–none–
Z	Depth of grid cell center	m
latitude	Latitude at grid cell center	degrees_north
longitude	Longitude at grid cell center	degrees_east
time_bnds	Time bounds of averaging period	–none–
latitude_bnds	Latitude bounds grid cells	–none–
longitude_bnds	Longitude bounds grid cells	–none–
Z_bnds	Depths of grid cell upper and lower interfaces	–none–
Variables	**Description of data variables**	**Unit**
EVELSTAR	Gent-mcwilliams zonal (east-west) bolus velocity	m s-1
NVELSTAR	Gent-mcwilliams meridional (north-south) bolus velocity	m s-1
WVELSTAR	Gent-mcwilliams vertical bolus velocity	m s-1

13.5.2 Latlon Variable: EVELSTAR

Table 13.39: Attributes description of the variable 'EVELSTAR' from OCEAN_BOLUS_VELOCITY's dataset.

Storage Type	Variable Name	Description	Unit
float32	EVELSTAR	Gent-mcwilliams zonal (east-west) bolus velocity	m s-1

Description of the variable in Common Data language (CDL)

```
float32 EVELSTAR(time, Z, latitude, longitude)
   EVELSTAR: _FillValue = 9.96921e+36
   EVELSTAR: coordinates = time Z
   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: valid_max = 0.7810457944869995
   EVELSTAR: valid_min = -0.5832233428955078
```

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.

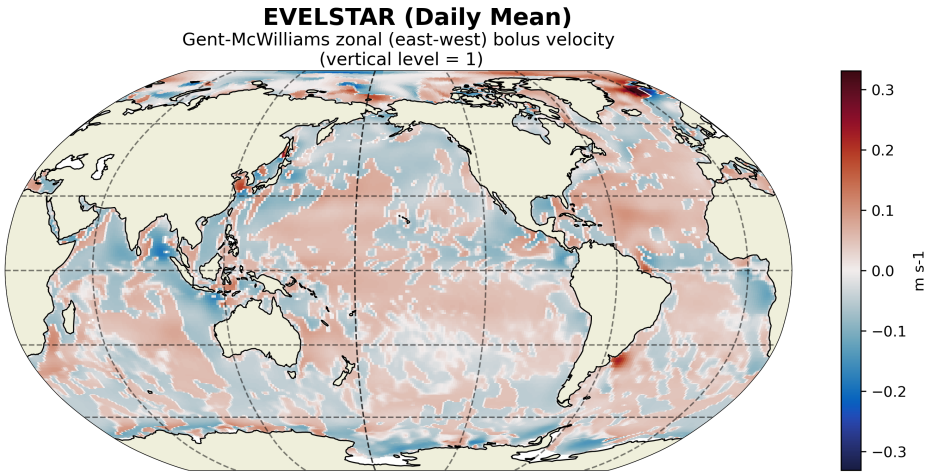


Figure 154: Dataset: OCEAN_BOLUS_VELOCITY, Variable: EVELSTAR

13.5.3 Latlon Variable: NVELSTAR

Table 13.40: Attributes description of the variable 'NVELSTAR' from OCEAN_BOLUS_VELOCITY's dataset.

Storage Type	Variable Name	Description	Unit
float32	NVELSTAR	Gent-mcwilliams meridional (north-south) bolus velocity	m s-1

Description of the variable in Common Data language (CDL)

```
float32 NVELSTAR(time, Z, latitude, longitude)
   NVELSTAR: _FillValue = 9.96921e+36
   NVELSTAR: coordinates = time Z
   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: valid_max = 0.6751338243484497
   NVELSTAR: valid_min = -0.6472858190536499
```

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

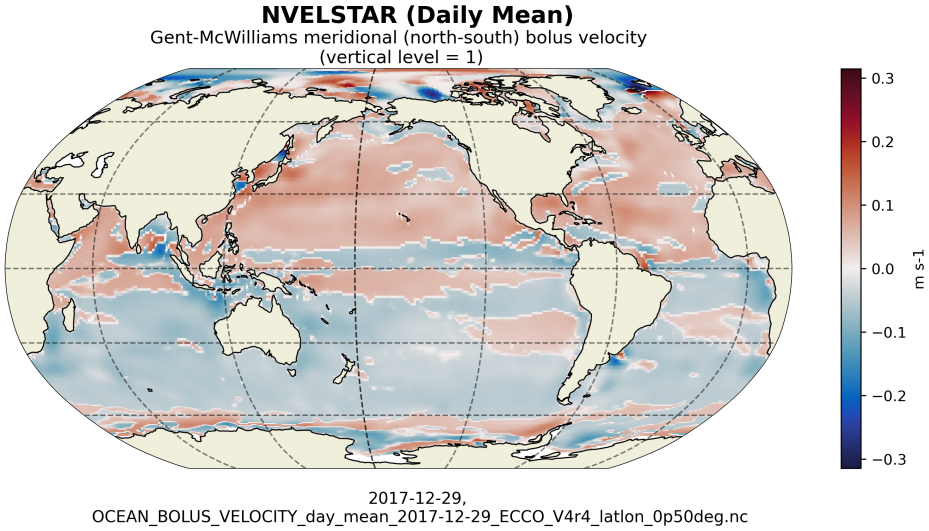


Figure 155: Dataset: OCEAN_BOLUS_VELOCITY, Variable: NVELSTAR

13.5.4 Latlon Variable: WVELSTAR

Table 13.41: Attributes description of the variable 'WVELSTAR' from OCEAN_BOLUS_VELOCITY's dataset.

Storage Type	Variable Name	Description	Unit
float32	WVELSTAR	Gent-mcwilliams vertical bolus velocity	m s-1

Description of the variable in Common Data language (CDL)

```
float32 WVELSTAR(time, Z, latitude, longitude)
   WVELSTAR: _FillValue = 9.96921e+36
   WVELSTAR: coordinates = time Z
   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: valid_max = 0.0004019034677185118
   WVELSTAR: valid_min = -0.00037936007720418274
```

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.

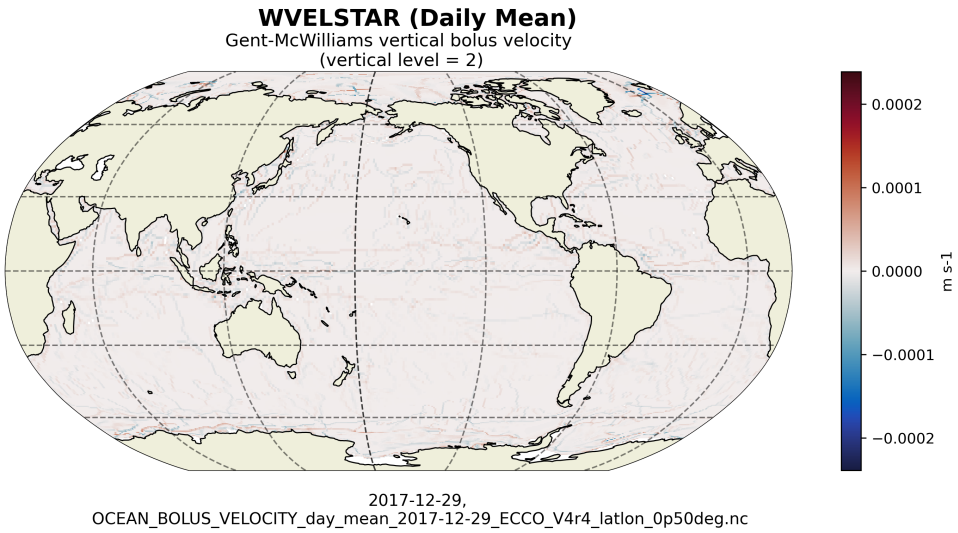


Figure 156: Dataset: OCEAN_BOLUS_VELOCITY, Variable: WVELSTAR

13.6 Latlon dataset of OCEAN_BOTTOM_PRESSURE

13.6.1 Overview

This dataset provides 2D fields of ocean bottom pressure interpolated to a regular 0.5-degree grid from the ECCO Version 4 Release 4 (V4r4) ocean and sea-ice state estimate. The dataset is provided on daily-average and monthly-average time resolution. Ocean bottom pressure given in equivalent water thickness excluding (OBP) and including (OBPGMAP) the contribution from global mean atmospheric pressure.

Table 13.42: Coordinates and Variables in the dataset OCEAN_BOTTOM_PRESSURE

Coordinates	Description of data coordinates	Unit
time	Center time of averaging period	–none–
latitude	Latitude at grid cell center	degrees_north
longitude	Longitude at grid cell center	degrees_east
time_bnds	Time bounds of averaging period	–none–
latitude_bnds	Latitude bounds grid cells	–none–
longitude_bnds	Longitude bounds grid cells	–none–
Variables	**Description of data variables**	**Unit**
OBP	Ocean bottom pressure given as equivalent water thickness	m
OBPGMAP	Ocean bottom pressure given as equivalent water thickness, includes global mean atmospheric pressure	m

13.6.2 Latlon Variable: OBP

Table 13.43: Attributes description of the variable 'OBP' from OCEAN_BOTTOM_PRESSURE's dataset.

Storage Type	Variable Name	Description	Unit
float32	OBP	Ocean bottom pressure given as equivalent water thickness	m

Description of the variable in Common Data language (CDL)

```
float32 OBP(time, latitude, longitude)
    OBP: _FillValue = 9.96921e+36
    OBP: coordinates = time
    OBP: coverage_content_type = modelResult
    OBP: long_name = Ocean bottom pressure given as equivalent water thickness
    OBP: units = m
    OBP: valid_max = 72.1243667602539
    OBP: valid_min = -2.544442892074585
```

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.

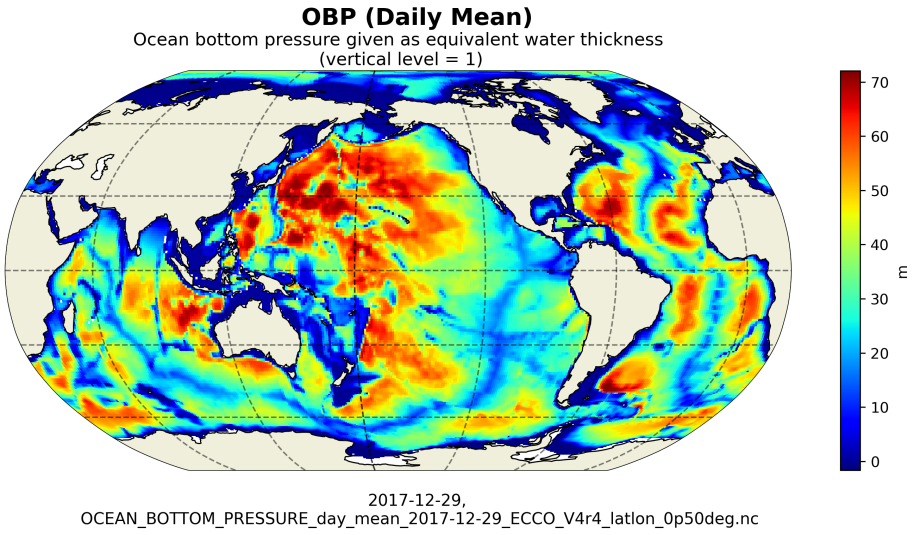


Figure 157: Dataset: OCEAN_BOTTOM_PRESSURE, Variable: OBP

13.6.3 Latlon Variable: OBPGMAP

Table 13.44: Attributes description of the variable 'OBPGMAP' from OCEAN_BOTTOM_PRESSURE's dataset.

Storage Type	Variable Name	Description	Unit
float32	OBPGMAP	Ocean bottom pressure given as equivalent water thickness, includes global mean atmospheric pressure	m

Description of the variable in Common Data language (CDL)

```
float32 OBPGMAP(time, latitude, longitude)
    OBPGMAP: _FillValue = 9.96921e+36
    OBPGMAP: coordinates = time
    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: valid_max = 82.14805603027344
    OBPGMAP: valid_min = 7.395928859710693
```

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.

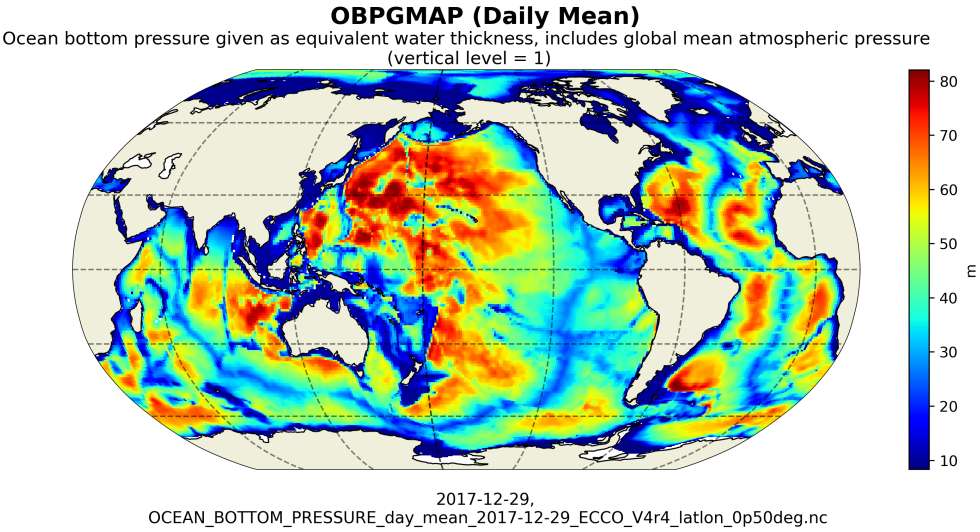


Figure 158: Dataset: OCEAN_BOTTOM_PRESSURE, Variable: OBPGMAP

13.7 Latlon dataset of OCEAN_DENS_STRAT_PRESS

13.7.1 Overview

This dataset provides 3D fields of ocean density, stratification, and hydrostatic pressure interpolated to a regular0.5-degree grid from the ECCO Version 4 Release 4 (V4r4) ocean and sea-ice state estimate. The dataset is provided on daily-average and monthly-average time resolution.

Table 13.45: Coordinates and Variables in the dataset OCEAN_DENS_STRAT_PRESS

Coordinates	Description of data coordinates	Unit
time	Center time of averaging period	–none–
Z	Depth of grid cell center	m
latitude	Latitude at grid cell center	degrees_north
longitude	Longitude at grid cell center	degrees_east
time_bnds	Time bounds of averaging period	–none–
latitude_bnds	Latitude bounds grid cells	–none–
longitude_bnds	Longitude bounds grid cells	–none–
Z_bnds	Depths of grid cell upper and lower interfaces	–none–
Variables	**Description of data variables**	**Unit**
RHOAnoma	In-situ seawater density anomaly	kg m-3
DRHODR	Density stratification	kg m-3 m-1
PHIHYD	Ocean hydrostatic pressure anomaly	m2 s-2

13.7.2 Latlon Variable: DRHODR

Table 13.46: Attributes description of the variable 'DRHODR' from OCEAN_DENS_STRAT_PRESS's dataset.

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

Description of the variable in Common Data language (CDL)

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

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 $p_0=-g ho_{0} z$.

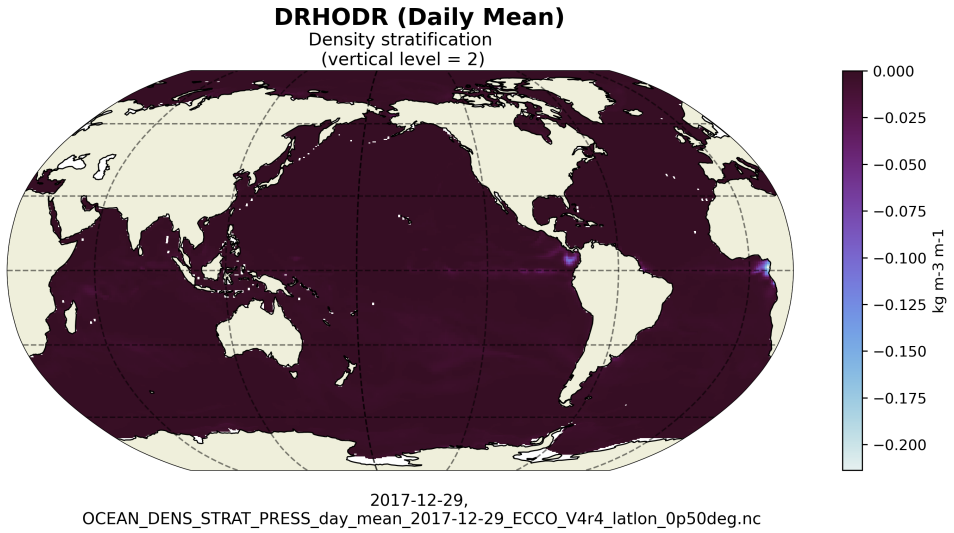


Figure 159: Dataset: OCEAN_DENS_STRAT_PRESS, Variable: DRHODR

13.7.3 Latlon Variable: PHIHYD

Table 13.47: Attributes description of the variable 'PHIHYD' from OCEAN_DENS_STRAT_PRESS's dataset.

Storage Type	Variable Name	Description	Unit
float32	PHIHYD	Ocean hydrostatic pressure anomaly	m2 s-2

Description of the variable in Common Data language (CDL)

```
float32 PHIHYD(time, Z, latitude, longitude)
   PHIHYD: _FillValue = 9.96921e+36
   PHIHYD: coordinates = time Z
   PHIHYD: coverage_content_type = modelResult
   PHIHYD: long_name = Ocean hydrostatic pressure anomaly
   PHIHYD: units = m2 s-2
   PHIHYD: valid_max = 783.9188232421875
   PHIHYD: valid_min = 74.71473693847656
```

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).

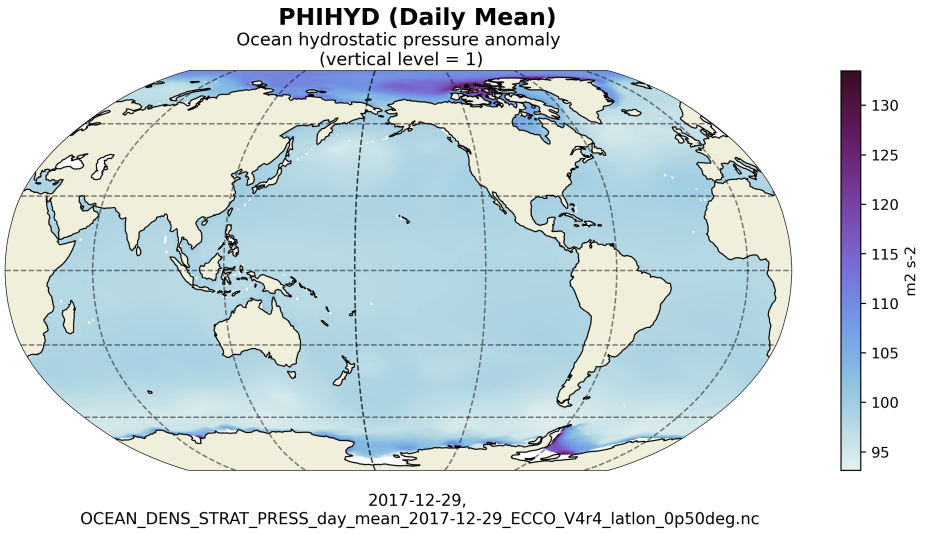


Figure 160: Dataset: OCEAN_DENS_STRAT_PRESS, Variable: PHIHYD

13.7.4 Latlon Variable: RHOAnoma

Table 13.48: Attributes description of the variable 'RHOAnoma' from OCEAN_DENS_STRAT_PRESS's dataset.

Storage Type	Variable Name	Description	Unit
float32	RHOAnoma	In-situ seawater density anomaly	kg m-3

Description of the variable in Common Data language (CDL)

```
float32 RHOAnoma(time, Z, latitude, longitude)
   RHOAnoma:  _FillValue = 9.96921e+36
   RHOAnoma:  coordinates = time Z
   RHOAnoma:  coverage_content_type = modelResult
   RHOAnoma:  long_name = In-situ seawater density anomaly
   RHOAnoma:  units = kg m-3
   RHOAnoma:  valid_max = 25.540647506713867
   RHOAnoma:  valid_min = -19.919862747192383
```

Comments

In-situ seawater density anomaly relative to the reference density, rhoconst. rhoconst = 1029 kg m-3

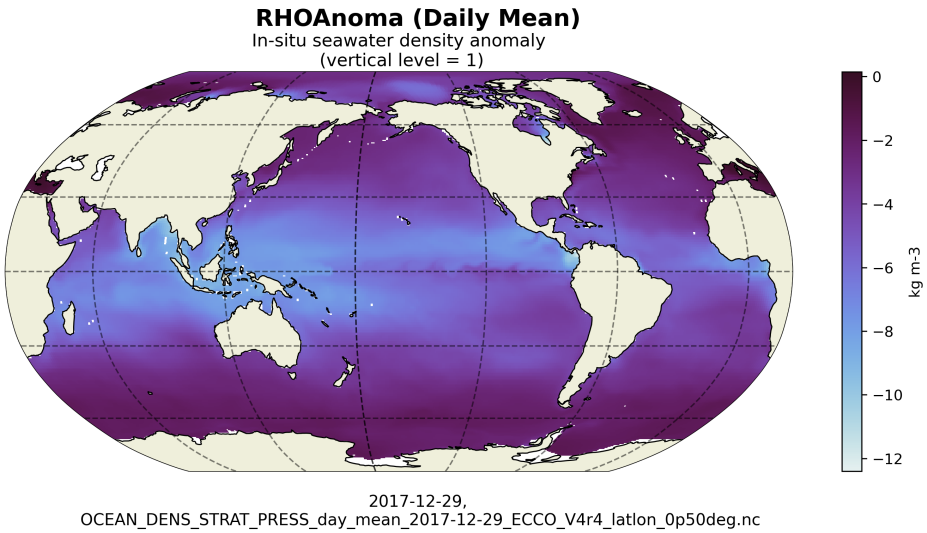


Figure 161: Dataset: OCEAN_DENS_STRAT_PRESS, Variable: RHOAnoma

13.8 Latlon dataset of OCEAN_MIXED_LAYER_DEPTH

13.8.1 Overview

This dataset provides 2D fileds of ocean mixed layer depth interpolated to a regular 0.5-degree grid from the ECCO Version 4 Release 4 (V4r4) ocean and sea-ice state estimate. The dataset is provided on daily-average and monthly-average time resolution.

Table 13.49: Coordinates and Variables in the dataset OCEAN_MIXED_LAYER_DEPTH

Coordinates	Description of data coordinates	Unit
time	Center time of averaging period	–none–
latitude	Latitude at grid cell center	degrees_north
longitude	Longitude at grid cell center	degrees_east
time_bnds	Time bounds of averaging period	–none–
latitude_bnds	Latitude bounds grid cells	–none–
longitude_bnds	Longitude bounds grid cells	–none–
Variables	**Description of data variables**	**Unit**
MXLDEPTH	Mixed-layer depth diagnosed using the temperature difference criterion of kara et al., 2000	m

13.8.2 Latlon Variable: MXLDEPTH

Table 13.50: Attributes description of the variable 'MXLDEPTH' from OCEAN_MIXED_LAYER_DEPTH's dataset.

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

Description of the variable in Common Data language (CDL)

```
float32 MXLDEPTH(time, latitude, longitude)
   MXLDEPTH: _FillValue = 9.96921e+36
   MXLDEPTH: coordinates = time
   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: valid_max = 5331.2001953125
   MXLDEPTH: valid_min = 5.000001430511475
```

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).

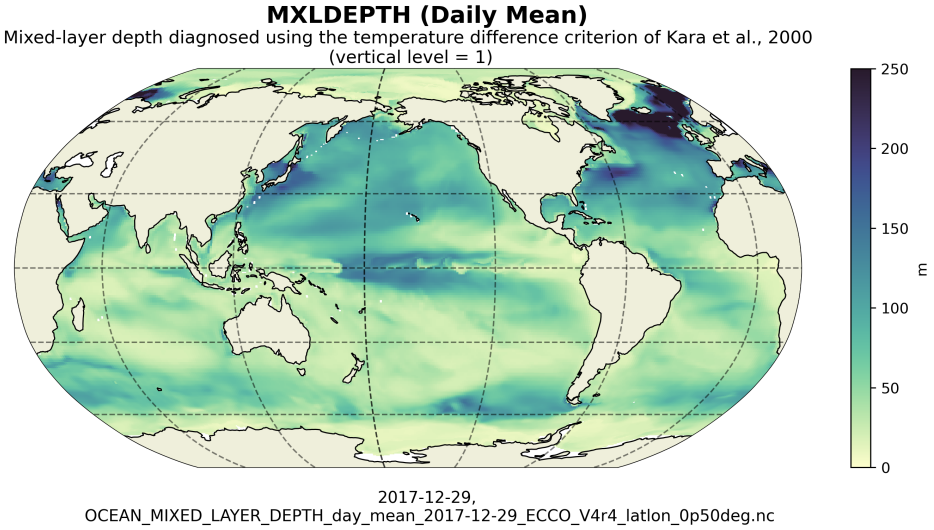


Figure 162: Dataset: OCEAN_MIXED_LAYER_DEPTH, Variable: MXLDEPTH

13.9 Latlon dataset of OCEAN_TEMPERATURE_SALINITY

13.9.1 Overview

This dataset provides 3D fields of ocean potential temperature and salinity interpolated to a regular 0.5-degree grid from the ECCO Version 4 Release 4 (V4r4) ocean and sea-ice state estimate. The dataset is provided on daily-average and monthly-average time resolution.

Table 13.51: Coordinates and Variables in the dataset OCEAN_TEMPERATURE_SALINITY

Coordinates	Description of data coordinates	Unit
time	Center time of averaging period	–none–
Z	Depth of grid cell center	m
latitude	Latitude at grid cell center	degrees_north
longitude	Longitude at grid cell center	degrees_east
time_bnds	Time bounds of averaging period	–none–
latitude_bnds	Latitude bounds grid cells	–none–
longitude_bnds	Longitude bounds grid cells	–none–
Z_bnds	Depths of grid cell upper and lower interfaces	–none–
Variables	**Description of data variables**	**Unit**
THETA	Potential temperature	degree_C
SALT	Salinity	1e-3

13.9.2 Latlon Variable: SALT

Table 13.52: Attributes description of the variable 'SALT' from OCEAN_TEMPERATURE_SALINITY's dataset.

Storage Type	Variable Name	Description	Unit
float32	SALT	Salinity	1e-3

Description of the variable in Common Data language (CDL)

```
float32 SALT(time, Z, latitude, longitude)
   SALT: _FillValue = 9.96921e+36
   SALT: coordinates = time Z
   SALT: coverage_content_type = modelResult
   SALT: long_name = Salinity
   SALT: standard_name = sea water salinity
   SALT: units = 1e-3
   SALT: valid_max = 41.321231842041016
   SALT: valid_min = 16.73577880859375
```

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

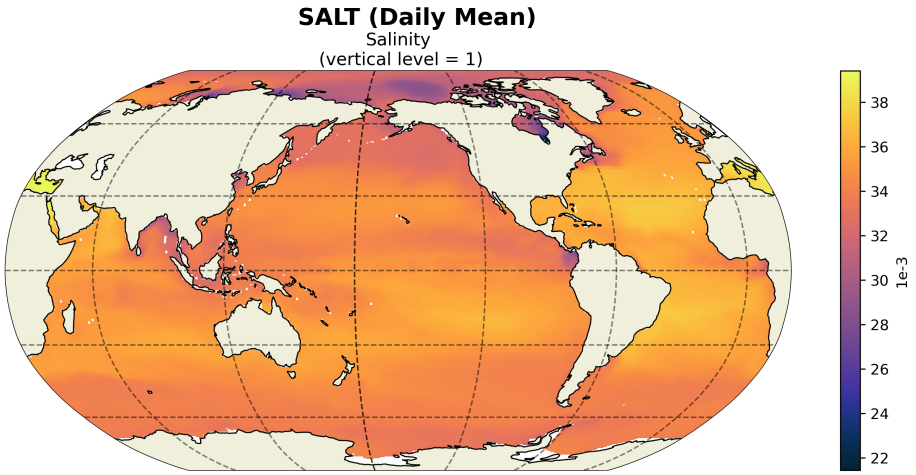


Figure 163: Dataset: OCEAN_TEMPERATURE_SALINITY, Variable: SALT

13.9.3 Latlon Variable: THETA

Table 13.53: Attributes description of the variable 'THETA' from OCEAN_TEMPERATURE_SALINITY's dataset.

Storage Type	Variable Name	Description	Unit
float32	THETA	Potential temperature	degree_C

Description of the variable in Common Data language (CDL)

```
float32 THETA(time, Z, latitude, longitude)
   THETA: _FillValue = 9.96921e+36
   THETA: coordinates = time Z
   THETA: coverage_content_type = modelResult
   THETA: long_name = Potential temperature
   THETA: standard_name = sea water potential temperature
   THETA: units = degree C
   THETA: valid_max = 36.425140380859375
   THETA: valid_min = -2.9179372787475586
```

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 $p_0=-g ho_{0} z$.

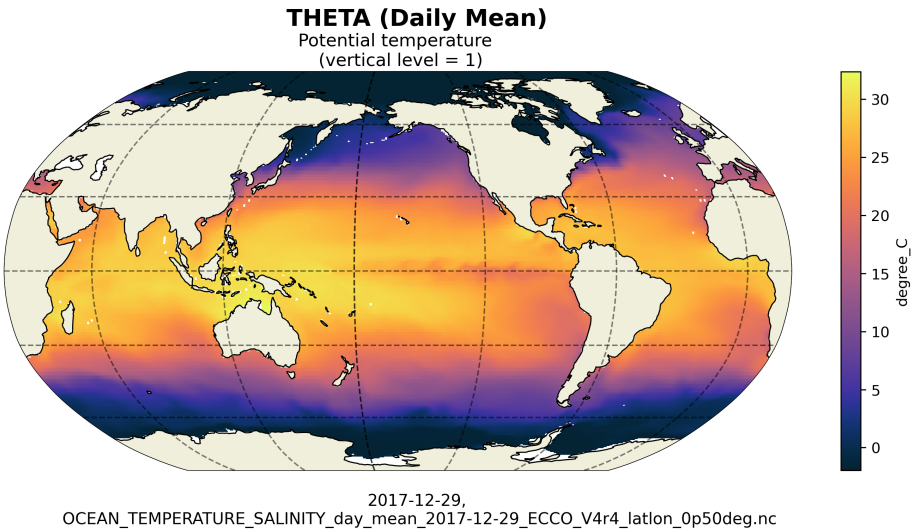


Figure 164: Dataset: OCEAN_TEMPERATURE_SALINITY, Variable: THETA

13.10 Latlon dataset of OCEAN_VELOCITY

13.10.1 Overview

This dataset provides 3D fields of ocean velocity interpolated to a regular 0.5-degree grid from the ECCO Version 4 Release 4 (V4r4) ocean and sea-ice state estimate. The dataset is provided on daily-average and monthly-average time resolution.

Table 13.54: Coordinates and Variables in the dataset OCEAN_VELOCITY

Coordinates	Description of data coordinates	Unit
time	Center time of averaging period	–none–
Z	Depth of grid cell center	m
latitude	Latitude at grid cell center	degrees_north
longitude	Longitude at grid cell center	degrees_east
time_bnds	Time bounds of averaging period	–none–
latitude_bnds	Latitude bounds grid cells	–none–
longitude_bnds	Longitude bounds grid cells	–none–
Z_bnds	Depths of grid cell upper and lower interfaces	–none–
Variables	**Description of data variables**	**Unit**
EVEL	Zonal (east-west) velocity	m s-1
NVEL	Meridional (north-south) velocity	m s-1
WVEL	Vertical velocity	m s-1

13.10.2 Latlon Variable: EVEL

Table 13.55: Attributes description of the variable 'EVEL' from OCEAN_VELOCITY's dataset.

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

Description of the variable in Common Data language (CDL)

```
float32 EVEL(time, Z, latitude, longitude)
   EVEL: _FillValue = 9.96921e+36
   EVEL: coordinates = Z time
   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: valid_max = 1.948591947555542
   EVEL: valid_min = -1.746832251548767
```

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.

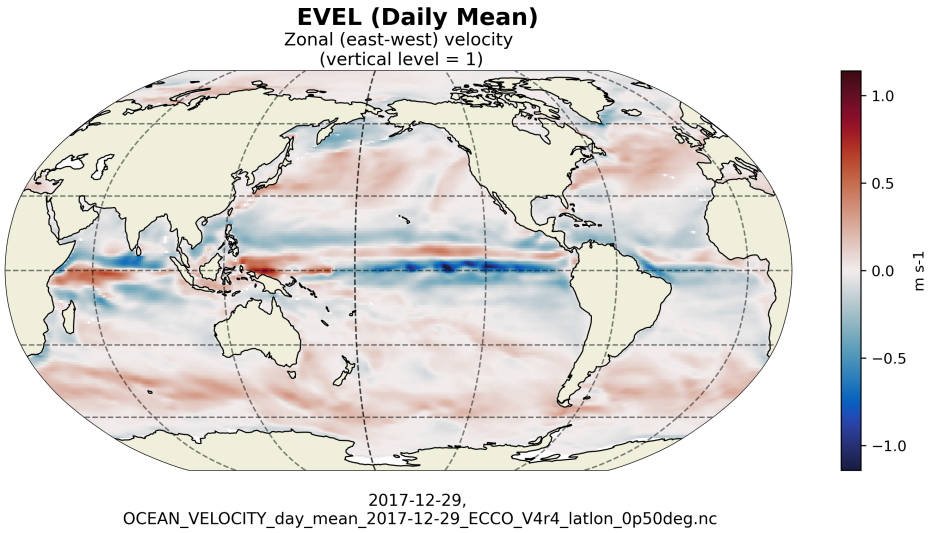


Figure 165: Dataset: OCEAN_VELOCITY, Variable: EVEL

13.10.3 Latlon Variable: NVEL

Table 13.56: Attributes description of the variable 'NVEL' from OCEAN_VELOCITY's dataset.

Storage Type	Variable Name	Description	Unit
float32	NVEL	Meridional (north-south) velocity	m s-1

Description of the variable in Common Data language (CDL)

```
float32 NVEL(time, Z, latitude, longitude)
   NVEL: _FillValue = 9.96921e+36
   NVEL: coordinates = Z time
   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: valid_max = 2.0500051975250244
   NVEL: valid_min = -1.2522369623184204
```

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.

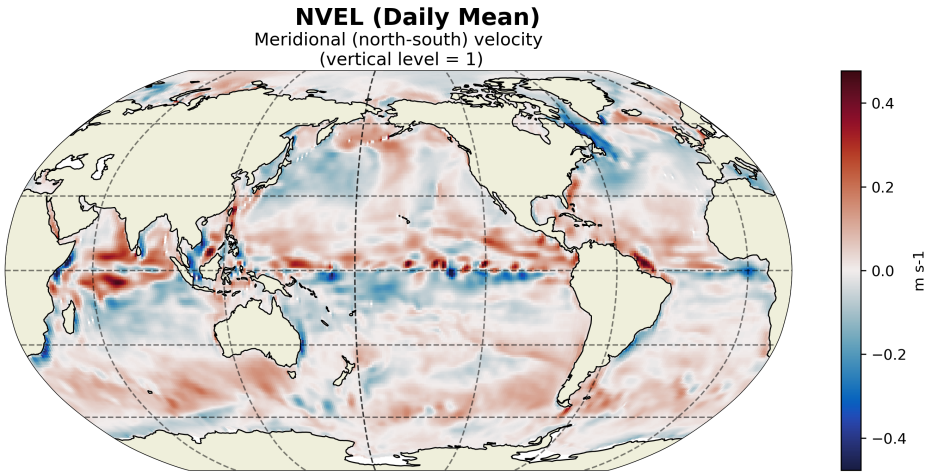


Figure 166: Dataset: OCEAN_VELOCITY, Variable: NVEL

13.10.4 Latlon Variable: WVEL

Table 13.57: Attributes description of the variable 'WVEL' from OCEAN_VELOCITY's dataset.

Storage Type	Variable Name	Description	Unit
float32	WVEL	Vertical velocity	m s-1

Description of the variable in Common Data language (CDL)

```
float32 WVEL(time, Z, latitude, longitude)
   WVEL: _FillValue = 9.96921e+36
   WVEL: coordinates = Z time
   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: valid_max = 0.0016380994347855449
   WVEL: valid_min = -0.0023150660563260317
```

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.

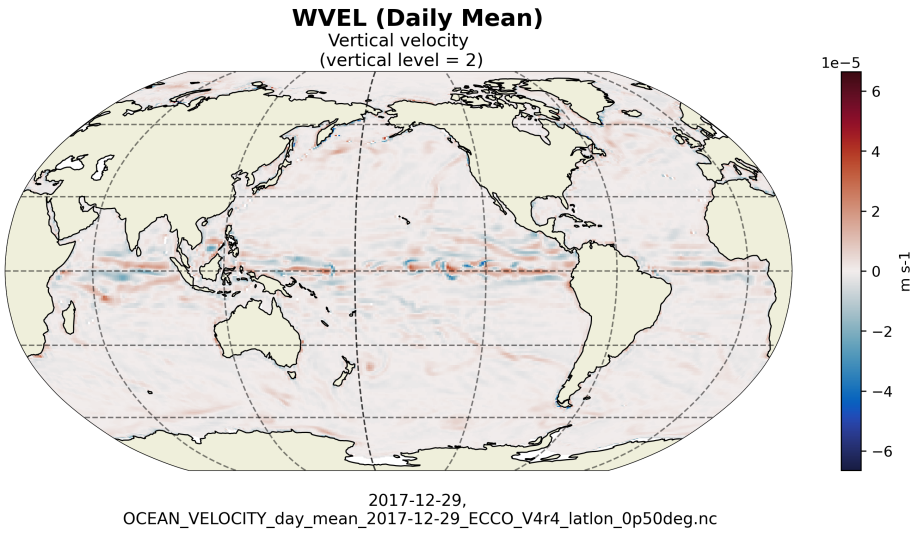


Figure 167: Dataset: OCEAN_VELOCITY, Variable: WVEL

13.11 Latlon dataset of SEA_ICE_CONC_THICKNESS

13.11.1 Overview

This dataset provides 2D fields of sea-ice and snow concentration and thickness interpolated to a regular 0.5-degree grid from the ECCO Version 4 Release 4 (V4r4) ocean and sea-ice state estimate. The dataset is provided on daily-average and monthly-average time resolution.

Table 13.58: Coordinates and Variables in the dataset SEA_ICE_CONC_THICKNESS

Coordinates	Description of data coordinates	Unit
time	Center time of averaging period	–none–
latitude	Latitude at grid cell center	degrees_north
longitude	Longitude at grid cell center	degrees_east
time_bnds	Time bounds of averaging period	–none–
latitude_bnds	Latitude bounds grid cells	–none–
longitude_bnds	Longitude bounds grid cells	–none–
Variables	**Description of data variables**	**Unit**
SIarea	Sea-ice concentration	1
SIheff	Area-averaged sea-ice thickness	m
SIhsnow	Area-averaged snow thickness	m
sIceLoad	Average sea-ice and snow mass per unit area	kg m-2

13.11.2 Latlon Variable: SIarea

Table 13.59: Attributes description of the variable 'SIarea' from SEA_ICE_CONC_THICKNESS's dataset.

Storage Type	Variable Name	Description	Unit
float32	SIarea	Sea-ice concentration	1

Description of the variable in Common Data language (CDL)

```
float32 SIarea(time, latitude, longitude)
    SIarea:  _FillValue = 9.96921e+36
    SIarea:  coordinates = time
    SIarea:  coverage_content_type = modelResult
    SIarea:  long_name = Sea-ice concentration
    SIarea:  standard_name = sea ice area fraction
    SIarea:  units = 1
    SIarea:  valid_max = 0.9700000286102295
    SIarea:  valid_min = 0.0
```

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

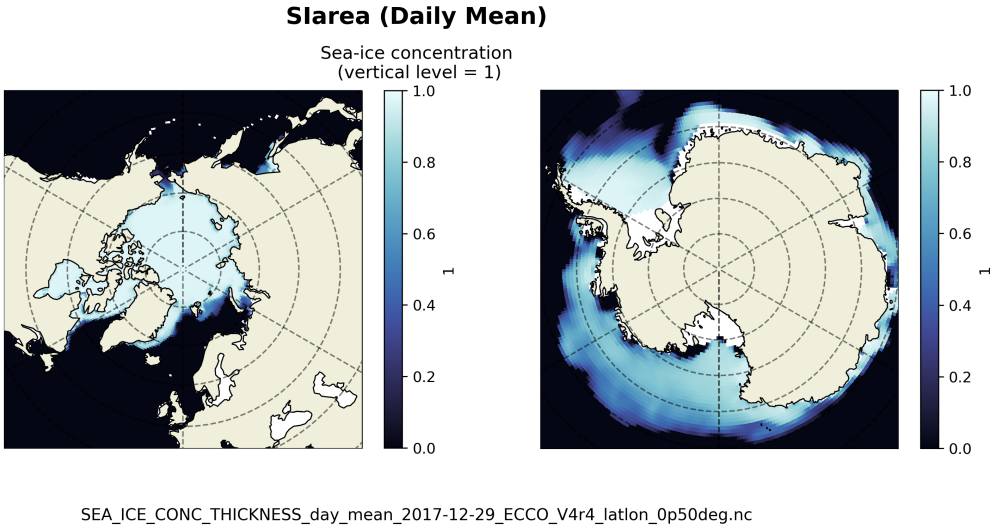


Figure 168: Dataset: SEA_ICE_CONC_THICKNESS, Variable: SIarea

13.11.3 Latlon Variable: SIheff

Table 13.60: Attributes description of the variable 'SIheff' from SEA_ICE_CONC_THICKNESS's dataset.

Storage Type	Variable Name	Description	Unit
float32	SIheff	Area-averaged sea-ice thickness	m

Description of the variable in Common Data language (CDL)

```
float32 SIheff(time, latitude, longitude)
   SIheff:  _FillValue = 9.96921e+36
   SIheff:  coordinates = time
   SIheff:  coverage_content_type = modelResult
   SIheff:  long_name = Area-averaged sea-ice thickness
   SIheff:  standard_name = sea ice thickness
   SIheff:  units = m
   SIheff:  valid_max = 9.000518798828125
   SIheff:  valid_min = 0.0
```

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

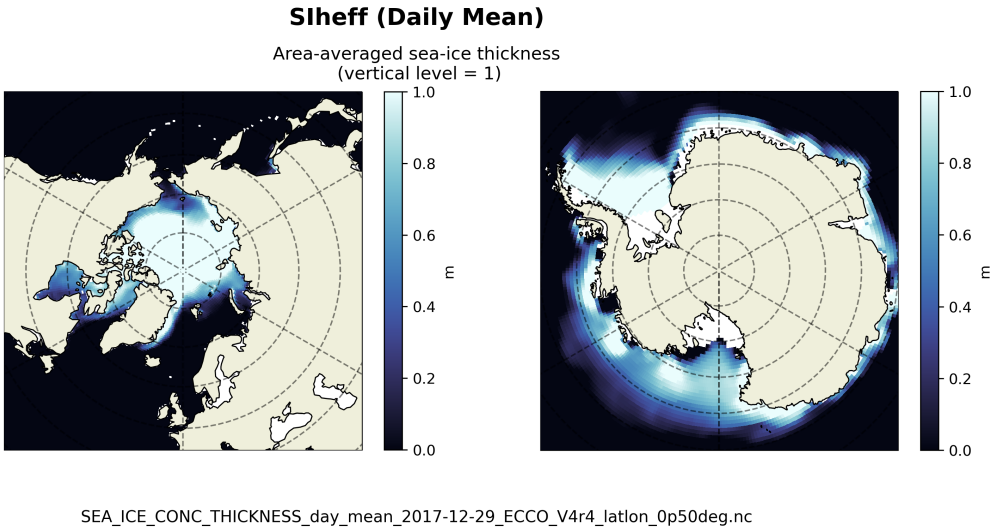


Figure 169: Dataset: SEA_ICE_CONC_THICKNESS, Variable: SIheff

13.11.4 Latlon Variable: SIhsnow

Table 13.61: Attributes description of the variable 'SIhsnow' from SEA_ICE_CONC_THICKNESS's dataset.

Storage Type	Variable Name	Description	Unit
float32	SIhsnow	Area-averaged snow thickness	m

Description of the variable in Common Data language (CDL)

```
float32 SIhsnow(time, latitude, longitude)
   SIhsnow:  _FillValue = 9.96921e+36
   SIhsnow:  coordinates = time
   SIhsnow:  coverage_content_type = modelResult
   SIhsnow:  long_name = Area-averaged snow thickness
   SIhsnow:  standard_name = surface snow thickness
   SIhsnow:  units = m
   SIhsnow:  valid_max = 2.5671639442443848
   SIhsnow:  valid_min = -0.0004725505714304745
```

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

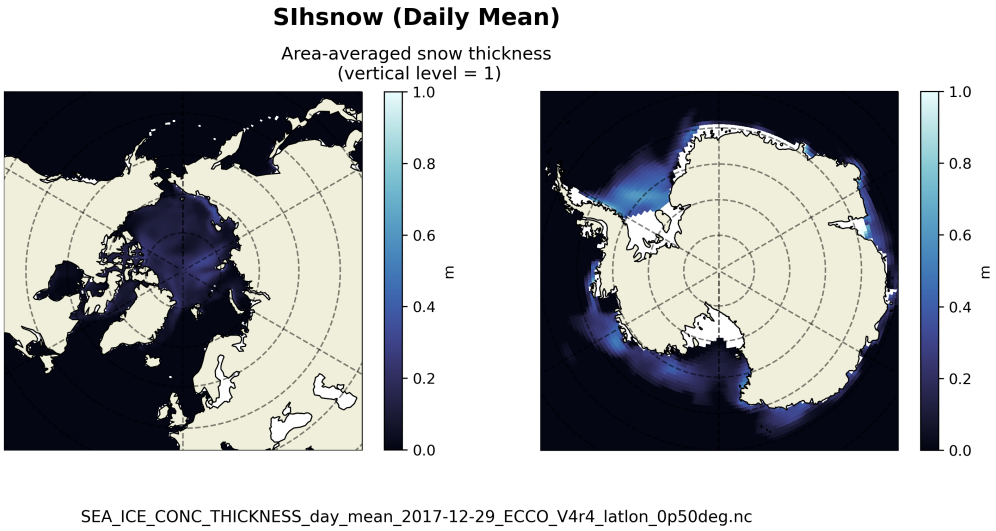


Figure 170: Dataset: SEA_ICE_CONC_THICKNESS, Variable: SIhsnow

13.11.5 Latlon Variable: sIceLoad

Table 13.62: Attributes description of the variable 'sIceLoad' from SEA_ICE_CONC_THICKNESS's dataset.

Storage Type	Variable Name	Description	Unit
float32	sIceLoad	Average sea-ice and snow mass per unit area	kg m-2

Description of the variable in Common Data language (CDL)

```
float32 sIceLoad(time, latitude, longitude)
   sIceLoad:  _FillValue = 9.96921e+36
   sIceLoad:  coordinates = time
   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:  valid_max = 8729.935546875
   sIceLoad:  valid_min = -0.0015558383893221617
```

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.

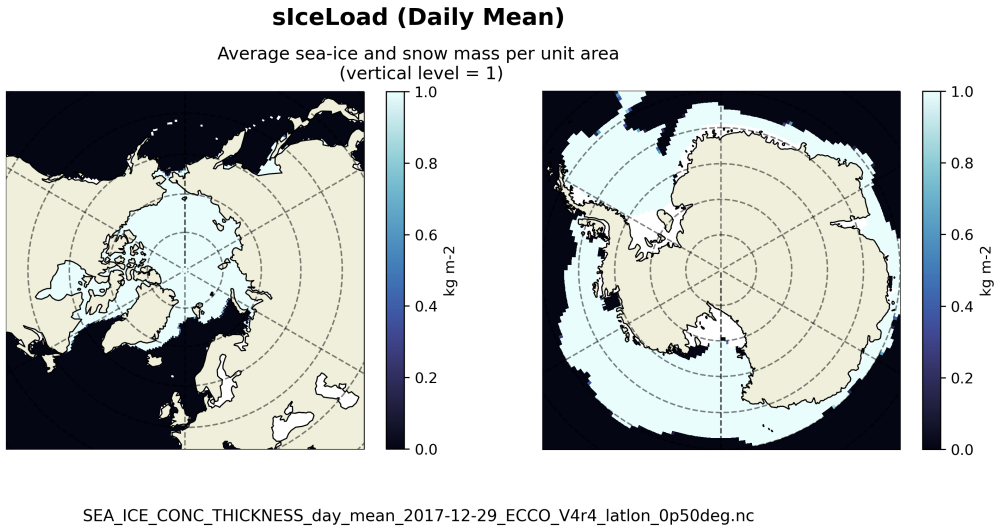


Figure 171: Dataset: SEA_ICE_CONC_THICKNESS, Variable: sIceLoad

13.12 Latlon dataset of SEA_ICE_VELOCITY

13.12.1 Overview

This dataset provides 2D fields of sea-ice velocity interpolated to a regular 0.5-degree grid from the ECCO Version 4 Release 4 (V4r4) ocean and sea-ice state estimate. The dataset is provided on daily-average and monthly-average time resolution.

Table 13.63: Coordinates and Variables in the dataset SEA_ICE_VELOCITY

Coordinates	Description of data coordinates	Unit
time	Center time of averaging period	–none–
latitude	Latitude at grid cell center	degrees_north
longitude	Longitude at grid cell center	degrees_east
time_bnds	Time bounds of averaging period	–none–
latitude_bnds	Latitude bounds grid cells	–none–
longitude_bnds	Longitude bounds grid cells	–none–
Variables	**Description of data variables**	**Unit**
SIeice	Zonal (east-west) sea-ice velocity	m s-1
SInice	Meridional (north-south) sea-ice velocity	m s-1

13.12.2 Latlon Variable: SIeice

Table 13.64: Attributes description of the variable 'SIeice' from SEA_ICE_VELOCITY's dataset.

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

Description of the variable in Common Data language (CDL)

```
float32 SIeice(time, latitude, longitude)
   SIeice:  _FillValue = 9.96921e+36
   SIeice:  coordinates = time
   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:  valid_max = 0.5656854510307312
   SIeice:  valid_min = -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.

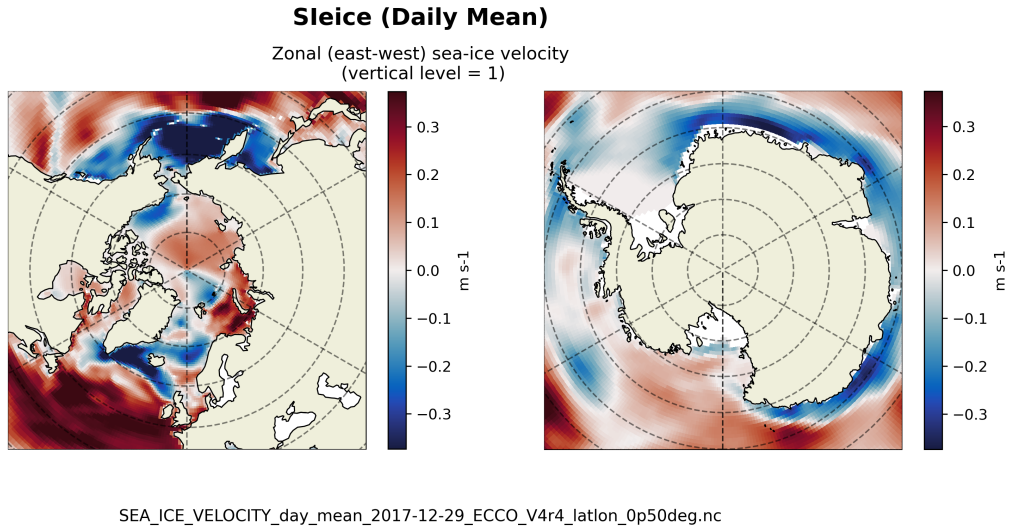


Figure 172: Dataset: SEA_ICE_VELOCITY, Variable: SIeice

13.12.3 Latlon Variable: SInice

Table 13.65: Attributes description of the variable 'SInice' from SEA_ICE_VELOCITY's dataset.

Storage Type	Variable Name	Description	Unit
float32	SInice	Meridional (north-south) sea-ice velocity	m s-1

Description of the variable in Common Data language (CDL)

```
float32 SInice(time, latitude, longitude)
   SInice:  _FillValue = 9.96921e+36
   SInice:  coordinates = time
   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:  valid_max = 0.5656854510307312
   SInice:  valid_min = -0.5615208148956299
```

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.

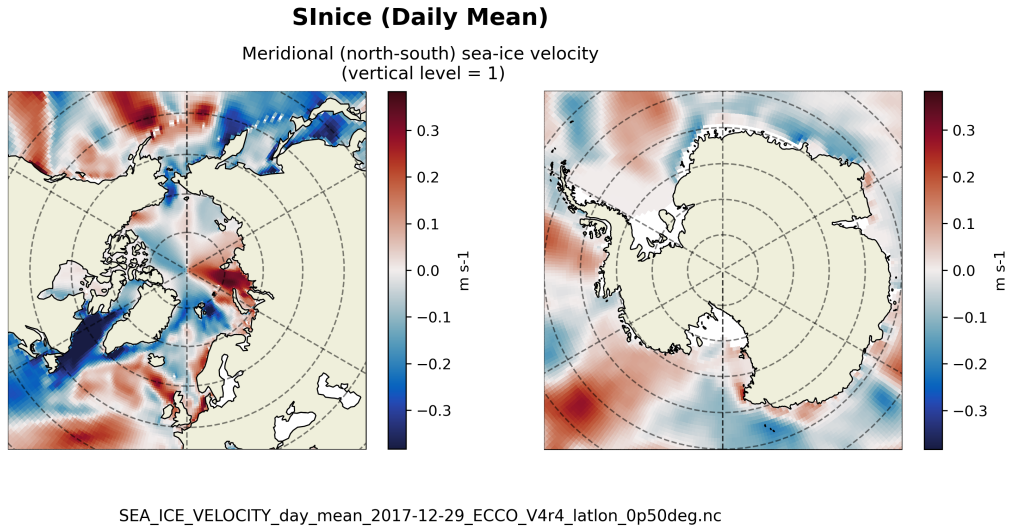


Figure 173: Dataset: SEA_ICE_VELOCITY, Variable: SInice

13.13 Latlon dataset of SEA_SURFACE_HEIGHT

13.13.1 Overview

This dataset provides 2D fields of dynamic sea surface height interpolated to a regular 0.5-degree grid from the ECCO Version 4 Release 4 (V4r4) ocean and sea-ice state estimate. The dataset is provided on daily-average and monthly-average time resolution. SSH (dynamic sea surface height) = SSHNOIBC (dynamic sea surface without the inverse barometer correction) - SSHIBC (inverse barometer correction). The inverted barometer correction accounts for variations in sea surface height due to atmospheric pressure variations.

Table 13.66: Coordinates and Variables in the dataset SEA_SURFACE_HEIGHT

Coordinates	Description of data coordinates	Unit
time	Center time of averaging period	–none–
latitude	Latitude at grid cell center	degrees_north
longitude	Longitude at grid cell center	degrees_east
time_bnds	Time bounds of averaging period	–none–
latitude_bnds	Latitude bounds grid cells	–none–
longitude_bnds	Longitude bounds grid cells	–none–
Variables	**Description of data variables**	**Unit**
SSH	Dynamic sea surface height anomaly	m
SSHIBC	The inverted barometer (ib) correction to sea surface height due to atmospheric pressure loading	m
SSHNOIBC	Sea surface height anomaly without the inverted barometer (ib) correction	m

13.13.2 Latlon Variable: SSH

Table 13.67: Attributes description of the variable 'SSH' from SEA_SURFACE_HEIGHT's dataset.

Storage Type	Variable Name	Description	Unit
float32	SSH	Dynamic sea surface height anomaly	m

Description of the variable in Common Data language (CDL)

```
float32 SSH(time, latitude, longitude)
   SSH: _FillValue = 9.96921e+36
   SSH: coordinates = time
   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: valid_max = 2.2875382900238037
   SSH: valid_min = -2.4861555099487305
```

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.

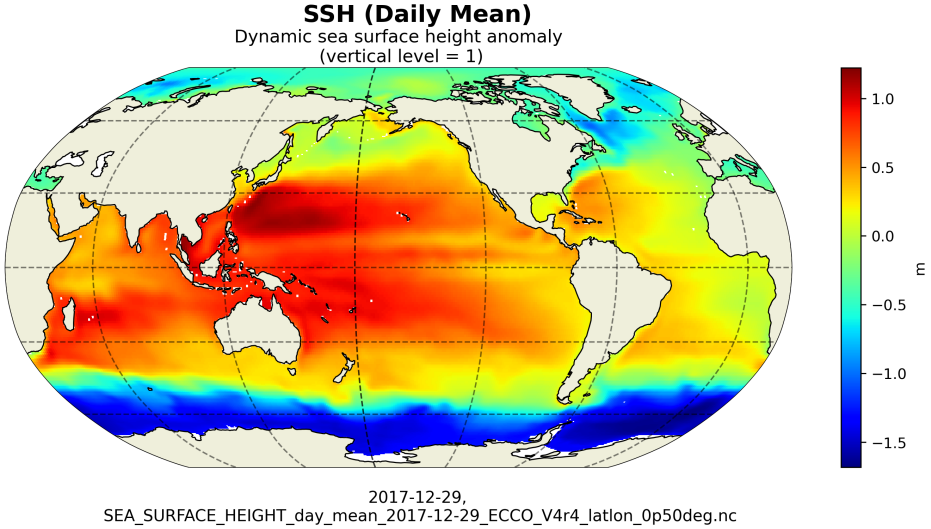


Figure 174: Dataset: SEA_SURFACE_HEIGHT, Variable: SSH

13.13.3 Latlon Variable: SSHIBC

Table 13.68: Attributes description of the variable 'SSHIBC' from SEA_SURFACE_HEIGHT's dataset.

Storage Type	Variable Name	Description	Unit
float32	SSHIBC	The inverted barometer (ib) correction to sea surface height due to atmospheric pressure loading	m

Description of the variable in Common Data language (CDL)

```
float32 SSHIBC(time, latitude, longitude)
   SSHIBC: _FillValue = 9.96921e+36
   SSHIBC: coordinates = time
   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: valid_max = 0.8955588340759277
   SSHIBC: valid_min = -0.5228679180145264
```

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.

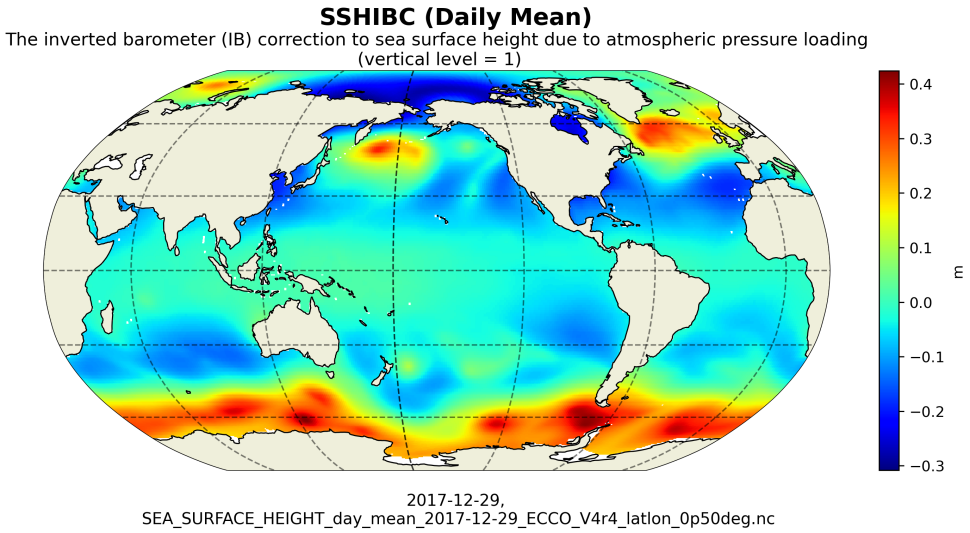


Figure 175: Dataset: SEA_SURFACE_HEIGHT, Variable: SSHIBC

13.13.4 Latlon Variable: SSHNOIBC

Table 13.69: Attributes description of the variable 'SSHNOIBC' from SEA_SURFACE_HEIGHT's dataset.

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

Description of the variable in Common Data language (CDL)

```
float32 SSHNOIBC(time, latitude, longitude)
    SSHNOIBC: _FillValue = 9.96921e+36
    SSHNOIBC: coordinates = time
    SSHNOIBC: coverage_content_type = modelResult
    SSHNOIBC: long_name = Sea surface height anomaly without the inverted barometer (IB) correction
    SSHNOIBC: units = m
    SSHNOIBC: valid_max = 2.2390522956848145
    SSHNOIBC: valid_min = -2.45104718208313
```

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.

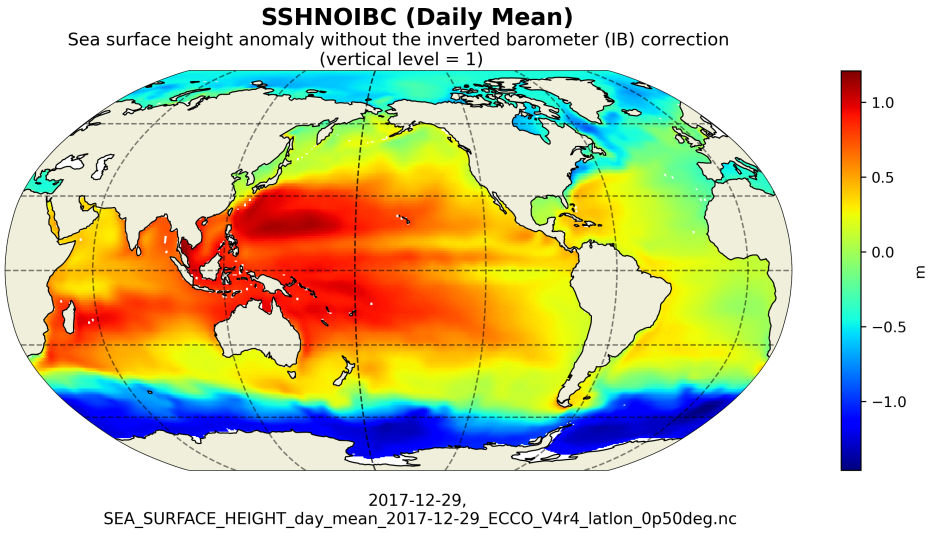


Figure 176: Dataset: SEA_SURFACE_HEIGHT, Variable: SSHNOIBC

14 1-D Dataset Groupings

14.1 1D dataset of GLOBAL_MEAN_ATM_SURFACE_PRES

14.1.1 Overview

This dataset provides a 1D field of global mean atmospheric surface pressure over the ocean and sea-ice from the ECCO Version 4 Release 4 (V4r4) ocean and sea-ice state estimate. The dataset is provided on instantaneous hourly, daily-average and monthly-average time resolution.

Table 14.1: Coordinates and Variables in the dataset GLOBAL_MEAN_ATM_SURFACE_PRES

Coordinates	Description of data coordinates	Unit
time	Snapshot time	–none–
Variables	**Description of data variables**	**Unit**
Pa_global	Global mean atmospheric surface pressure over the ocean and sea-ice	N m-2

14.1.2 1D Variable: Pa_global

Table 14.2: Attributes description of the variable 'Pa_global' from GLOBAL_MEAN_ATM_SURFACE_PRES's dataset.

Storage Type	Variable Name	Description	Unit
float64	Pa_global	Global mean atmospheric surface pressure over the ocean and sea-ice	N m-2

Description of the variable in Common Data language (CDL)

```
float64 Pa_global(time)
    Pa_global:  _FillValue = 9.969209968386869e+36
    Pa_global:  coordinates = time
    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_max = 101257.45252296235
    Pa_global:  valid_min = 100873.14755283327
```

Comments

N/a

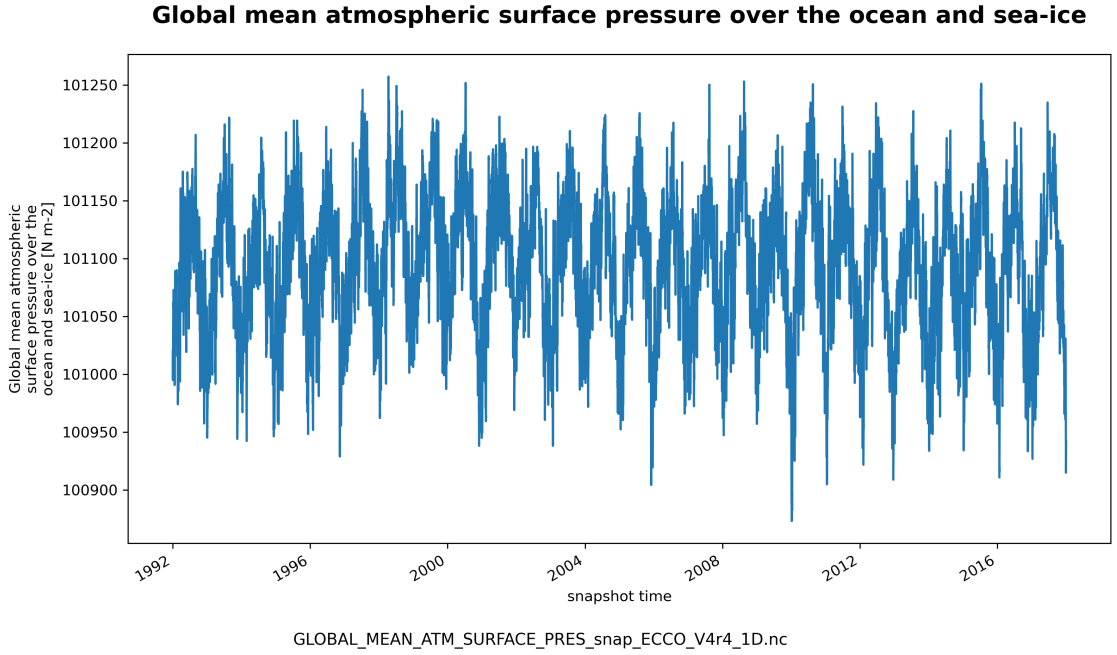


Figure 177: Dataset: GLOBAL_MEAN_ATM_SURFACE_PRES, Variable: Pa_global

14.2 1D dataset of GLOBAL_MEAN_SEA_LEVEL

14.2.1 Overview

This dataset provides a 1D field of global mean sea level anomalies including barystatic and sterodynamic terms from the ECCO Version 4 Release 4 (V4r4) ocean and sea-ice state estimate. The dataset is provided on daily-average and monthly-average time resolution.

Table 14.3: Coordinates and Variables in the dataset GLOBAL_MEAN_SEA_LEVEL

Coordinates	Description of data coordinates	Unit
time	Center time of averaging period	–none–
Variables	**Description of data variables**	**Unit**
global_mean_barystatic_sea_level_anomaly	Global mean of barystatic sea level anomaly	m
global_mean_sea_level_anomaly	Global mean of dynamic ssh	m
global_mean_sterodynamic_sea_level_anomaly	Global mean of sterodynamic sea level anomaly	m

14.2.2 1D Variable: global_mean_barystatic_sea_level_anomaly

Table 14.4: Attributes description of the variable 'global_mean_barystatic_sea_level_anomaly' from GLOBAL_MEAN_SEA_LEVEL's dataset.

Storage Type	Variable Name	Description	Unit
float32	global_mean_barystatic_sea_level_anomaly	Global mean of barystatic sea level anomaly	m

Description of the variable in Common Data language (CDL)

```
float32 global_mean_barystatic_sea_level_anomaly(time)
    global_mean_barystatic_sea_level_anomaly:  _FillValue = 9.96921e+36
    global_mean_barystatic_sea_level_anomaly:  coordinates = time
    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_max = 0.043493364
    global_mean_barystatic_sea_level_anomaly:  valid_min = -0.045110904
```

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

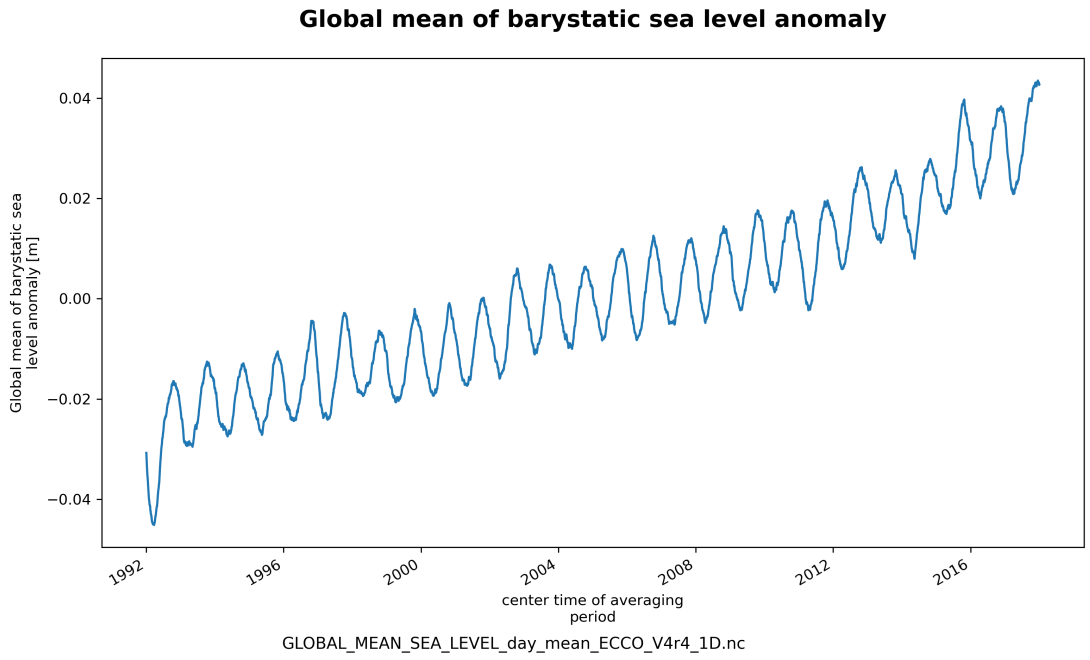


Figure 178: Dataset: GLOBAL_MEAN_SEA_LEVEL, Variable: global_mean_barystatic_sea_level_anomaly

14.2.3 1D Variable: global_mean_sea_level_anomaly

Table 14.5: Attributes description of the variable 'global_mean_sea_level_anomaly' from GLOBAL_MEAN_SEA_LEVEL's dataset.

Storage Type	Variable Name	Description	Unit
float32	global_mean_sea_level_anomaly	Global mean of dynamic ssh	m

Description of the variable in Common Data language (CDL)

```
float32 global_mean_sea_level_anomaly(time)
   global_mean_sea_level_anomaly:  _FillValue = 9.96921e+36
   global_mean_sea_level_anomaly:  coordinates = time
   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_max = 0.05520557
   global_mean_sea_level_anomaly:  valid_min = -0.055836163
```

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

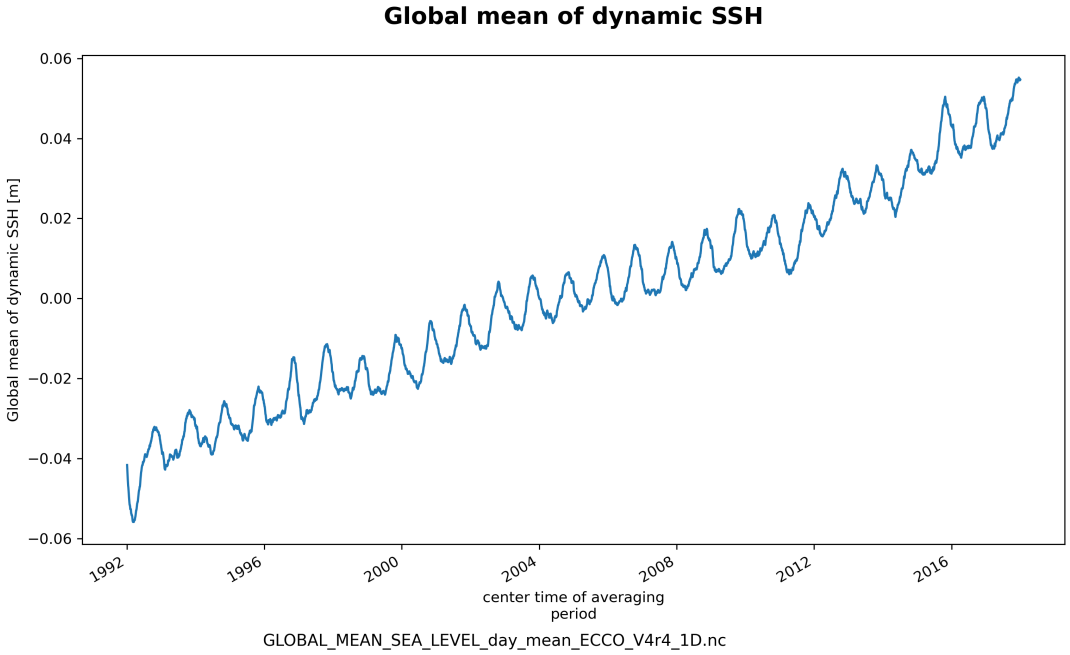


Figure 179: Dataset: GLOBAL_MEAN_SEA_LEVEL, Variable: global_mean_sea_level_anomaly

14.2.4 1D Variable: global_mean_sterodynamic_sea_level_anomaly

Table 14.6: Attributes description of the variable 'global_mean_sterodynamic_sea_level_anomaly' from GLOBAL_MEAN_SEA_LEVEL's dataset.

Storage Type	Variable Name	Description	Unit
float64	global_mean_sterodynamic_sea_level_anomaly	Global mean of sterodynamic sea level anomaly	m

Description of the variable in Common Data language (CDL)

```
float64 global_mean_sterodynamic_sea_level_anomaly(time)
    global_mean_sterodynamic_sea_level_anomaly:  _FillValue = 9.969209968386869e+36
    global_mean_sterodynamic_sea_level_anomaly:  coordinates = time
    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_max = 0.017642477223663407
    global_mean_sterodynamic_sea_level_anomaly:  valid_min = -0.017658796143049296
```

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

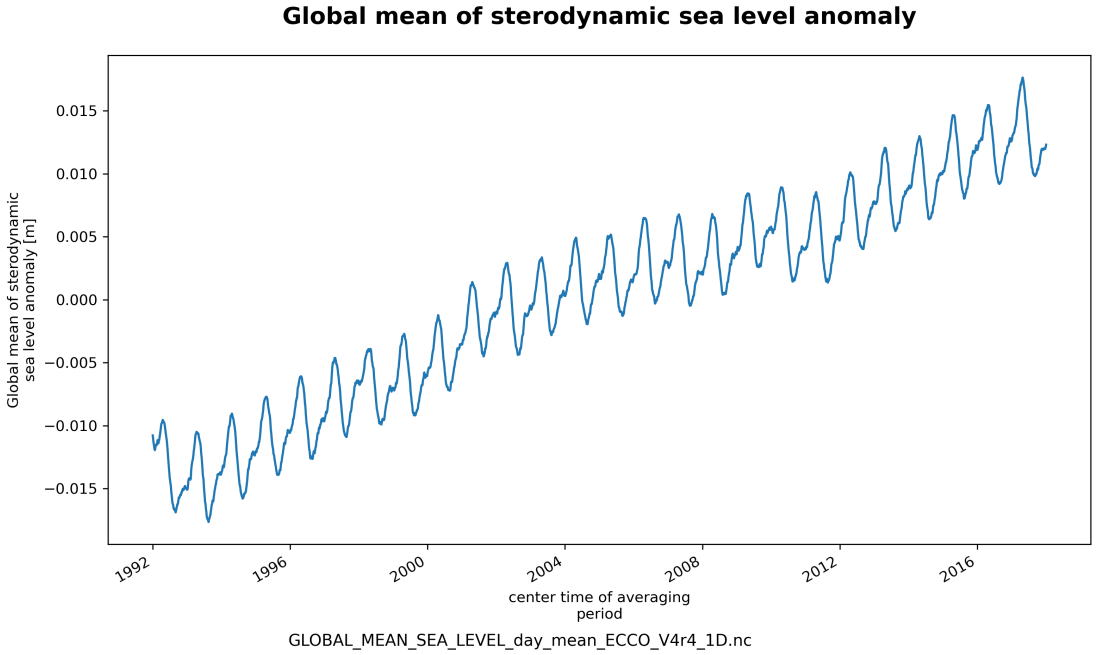


Figure 180: Dataset: GLOBAL_MEAN_SEA_LEVEL, Variable: global_mean_sterodynamic_sea_level_anomaly

14.3 1D dataset of SBO_CORE_PRODUCTS

14.3.1 Overview

This dataset provides a 1D field of the core products of the IERS Special Bureau for the Oceans from the ECCO Version 4 Release 4 (V4r4) ocean and sea-ice state estimate. The dataset is provided on instantaneous hourly snapshot aas well as daily-average and monthly-average time resolution. Dataset fields include core products of the IERS Special Bureau for the Oceans (https://euler.jpl.nasa.gov/sbo/sbo_home.html), including ocean angular momentum (OAM), center of mass (COM) and global ocean mass, calculated using the basic formulation of Gross et al. (2000). Further details on the available fields are provided in Quinn et al. (2019).

Table 14.7: Coordinates and Variables in the dataset SBO_CORE_PRODUCTS

Coordinates	Description of data coordinates	Unit
time	Snapshot time	–none–
Variables	**Description of data variables**	**Unit**
xoamc	X-comp of oceanic angular momentum due to currents	kg m2 s-1
yoamc	Y-comp of oceanic angular momentum due to currents	kg m2 s-1
zoamc	Z-comp of oceanic angular momentum due to currents	kg m2 s-1
xoamp	X-comp of oceanic angular momentum due to pressure	kg m2 s-1
yoamp	Y-comp of oceanic angular momentum due to pressure	kg m2 s-1
zoamp	Z-comp of oceanic angular momentum due to pressure	kg m2 s-1
mass	Ocean mass	kg
xcom	X-comp of center-of-mass of ocean	m
ycom	Y-comp of center-of-mass of ocean	m
zcom	Z-comp of center-of-mass of ocean	m
sboarea	Surface area of oceans	m2
xoamc_si	X-comp of oceanic angular momentum due to sea-ice motion	kg m2 s-1
yoamc_si	Y-comp of oceanic angular momentum due to sea-ice motion	kg m2 s-1
zoamc_si	Z-comp of oceanic angular momentum due to sea-ice motion	kg m2 s-1
mass_si	Sea-ice mass	kg
xoamp_fw	X-comp of oceanic angular momentum due to freshwater flux	kg m2 s-1
yoamp_fw	Y-comp of oceanic angular momentum due to freshwater flux	kg m2 s-1
zoamp_fw	Z-comp of oceanic angular momentum due to freshwater flux	kg m2 s-1
mass_fw	Mass due to freshwater flux	kg
xcom_fw	X-comp of center-of-mass of freshwater flux	m
ycom_fw	Y-comp of center-of-mass of freshwater flux	m
zcom_fw	Z-comp of center-of-mass of freshater flux	m
mass_gc	Mass due to the greatbatch correction	kg
xoamp_dsl	X-comp of oceanic angular momentum due to pressure based on dynamic (ib-corrected) sea level	kg m2 s-1
yoamp_dsl	Y-comp of oceanic angular momentum due to pressure based on dynamic (ib-corrected) sea level	kg m2 s-1
zoamp_dsl	Z-comp of oceanic angular momentum due to pressure based on dynamic (ib-corrected) sea level	kg m2 s-1

14.3.2 1D Variable: mass

Table 14.8: Attributes description of the variable 'mass' from SBO_CORE_PRODUCTS's dataset.

Storage Type	Variable Name	Description	Unit
float64	mass	Ocean mass	kg

Description of the variable in Common Data language (CDL)

```
float64 mass(time)
    mass:  _FillValue = 9.969209968386869e+36
    mass:  coordinates = time
    mass:  coverage_content_type = modelResult
    mass:  long_name = ocean    mass
    mass:  units = kg
    mass:  valid_max = 1.3737832079900274e+21
    mass:  valid_min = 1.3737507447512265e+21
```

Comments

N/a

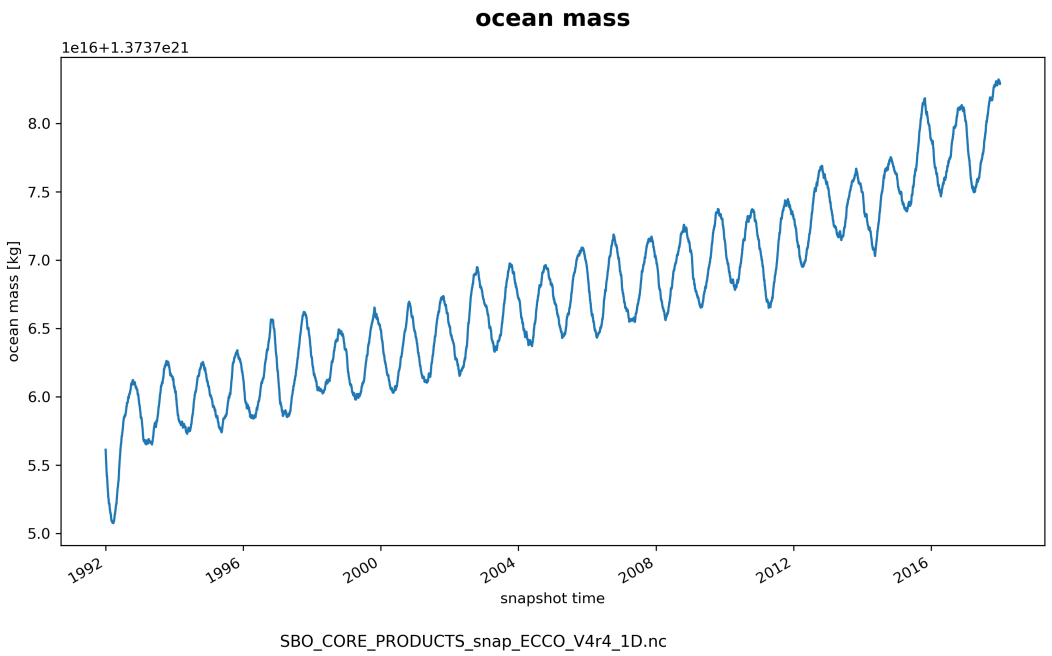


Figure 181: Dataset: SBO_CORE_PRODUCTS, Variable: mass

14.3.3 1D Variable: mass_fw

Table 14.9: Attributes description of the variable 'mass_fw' from SBO_CORE_PRODUCTS's dataset.

Storage Type	Variable Name	Description	Unit
float64	mass_fw	Mass due to freshwater flux	kg

Description of the variable in Common Data language (CDL)

```
float64 mass_fw(time)
    mass_fw:  _FillValue = 9.969209968386869e+36
    mass_fw:  coordinates = time
    mass_fw:  coverage_content_type = modelResult
    mass_fw:  long_name = mass due to freshwater flux
    mass_fw:  units = kg
    mass_fw:  valid_max = 7.0392619494226936e+16
    mass_fw:  valid_min = 3.7929380693921944e+16
```

Comments

N/a

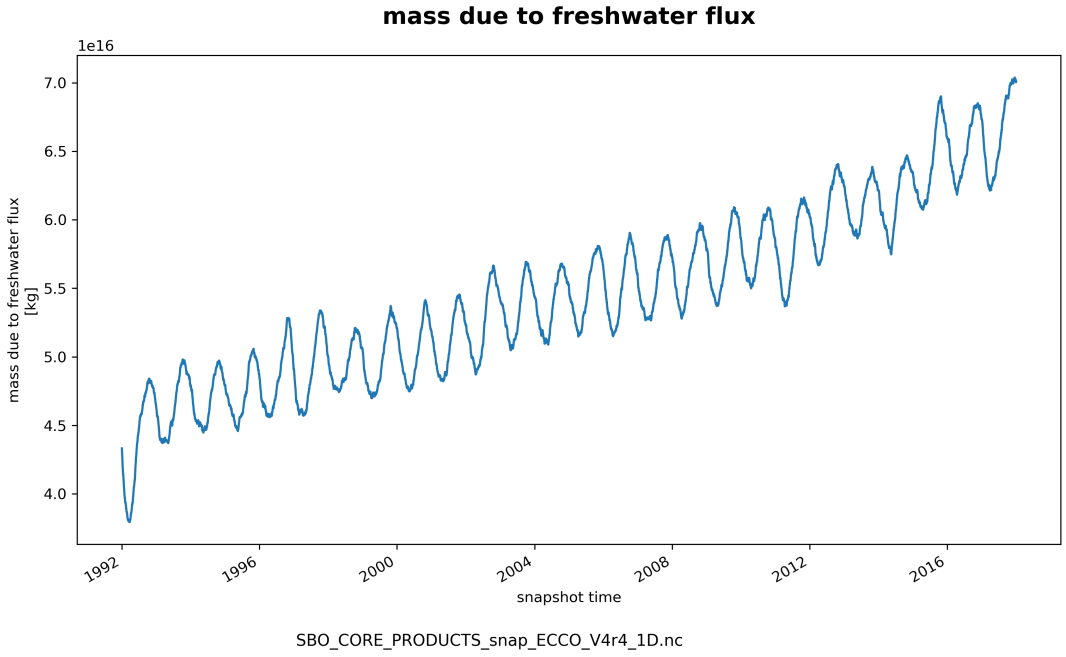


Figure 182: Dataset: SBO_CORE_PRODUCTS, Variable: mass_fw

14.3.4 1D Variable: mass_gc

Table 14.10: Attributes description of the variable 'mass_gc' from SBO_CORE_PRODUCTS's dataset.

Storage Type	Variable Name	Description	Unit
float64	mass_gc	Mass due to the greatbatch correction	kg

Description of the variable in Common Data language (CDL)

```
float64 mass_gc(time)
    mass_gc:  _FillValue = 9.969209968386869e+36
    mass_gc:  coordinates = time
    mass_gc:  coverage_content_type = modelResult
    mass_gc:  long_name = mass due to the Greatbatch correction
    mass_gc:  units = kg
    mass_gc:  valid_max = -1.1388436906537843e+19
    mass_gc:  valid_min = -1.140148294309558e+19
```

Comments

N/a

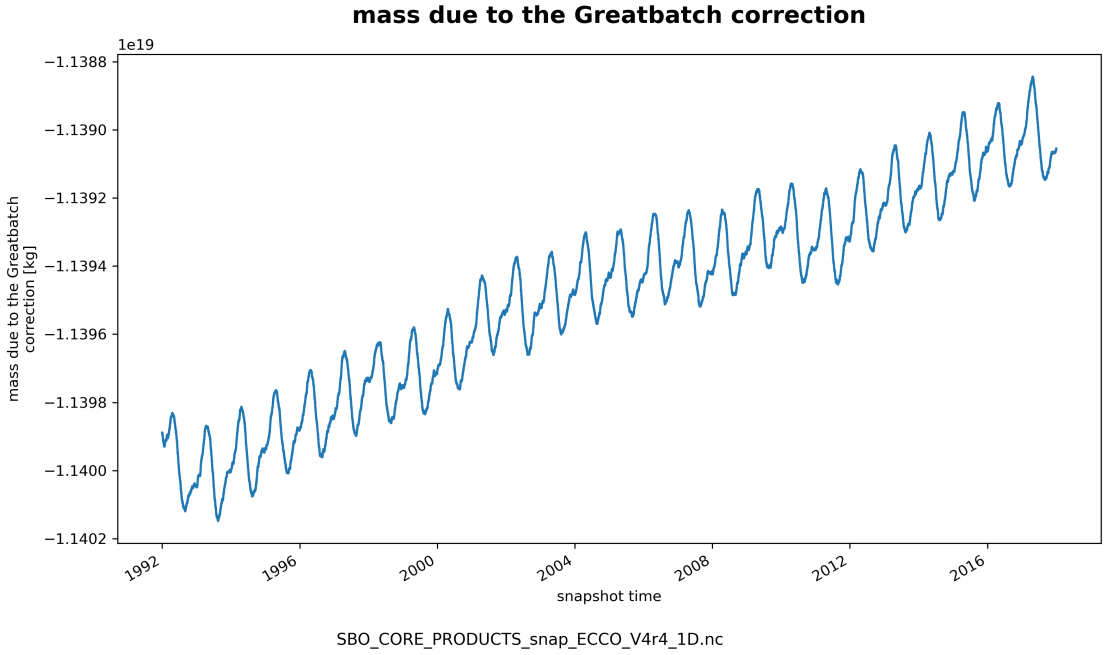


Figure 183: Dataset: SBO_CORE_PRODUCTS, Variable: mass_gc

14.3.5 1D Variable: mass_si

Table 14.11: Attributes description of the variable 'mass_si' from SBO_CORE_PRODUCTS's dataset.

Storage Type	Variable Name	Description	Unit
float64	mass_si	Sea-ice mass	kg

Description of the variable in Common Data language (CDL)

```
float64 mass_si(time)
    mass_si:  _FillValue = 9.969209968386869e+36
    mass_si:  coordinates = time
    mass_si:  coverage_content_type = modelResult
    mass_si:  long_name = sea-ice mass
    mass_si:  units = kg
    mass_si:  valid_max = 3.372421224523182e+16
    mass_si:  valid_min = 1.5801085624300974e+16
```

Comments

N/a

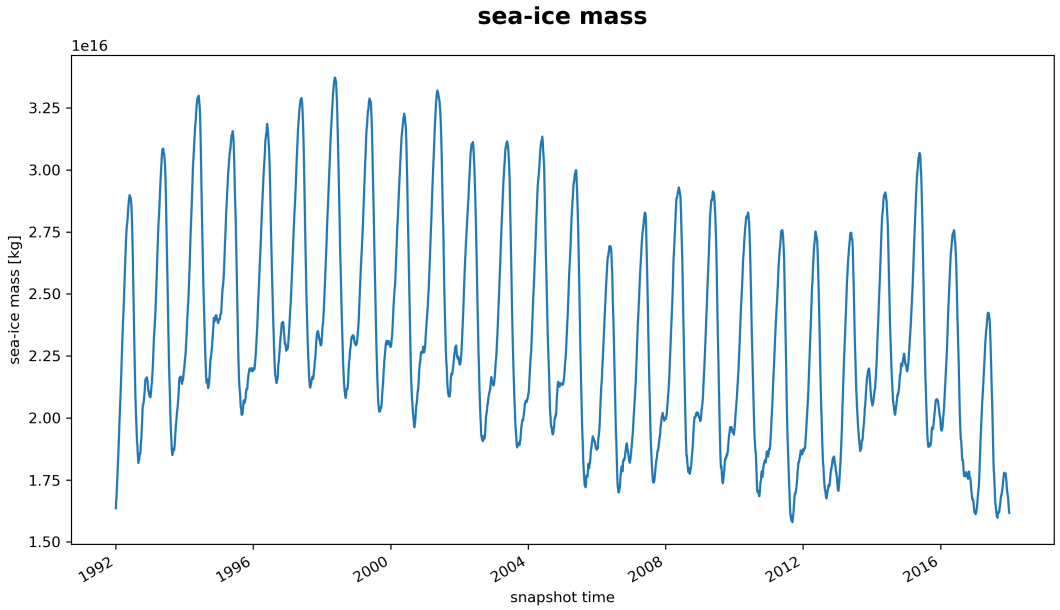


Figure 184: Dataset: SBO_CORE_PRODUCTS, Variable: mass_si

14.3.6 1D Variable: sboarea

Table 14.12: Attributes description of the variable 'sboarea' from SBO_CORE_PRODUCTS's dataset.

Storage Type	Variable Name	Description	Unit
float64	sboarea	Surface area of oceans	m2

Description of the variable in Common Data language (CDL)

```
float64 sboarea(time)
    sboarea:  _FillValue = 9.969209968386869e+36
    sboarea:  coordinates = time
    sboarea:  coverage_content_type = modelResult
    sboarea:  long_name = surface area of oceans
    sboarea:  units = m2
    sboarea:  valid_max = 358013861149443.5
    sboarea:  valid_min = 358013861149443.5
```

Comments

Note: ocean surface area is constant but provided as time series for convenience

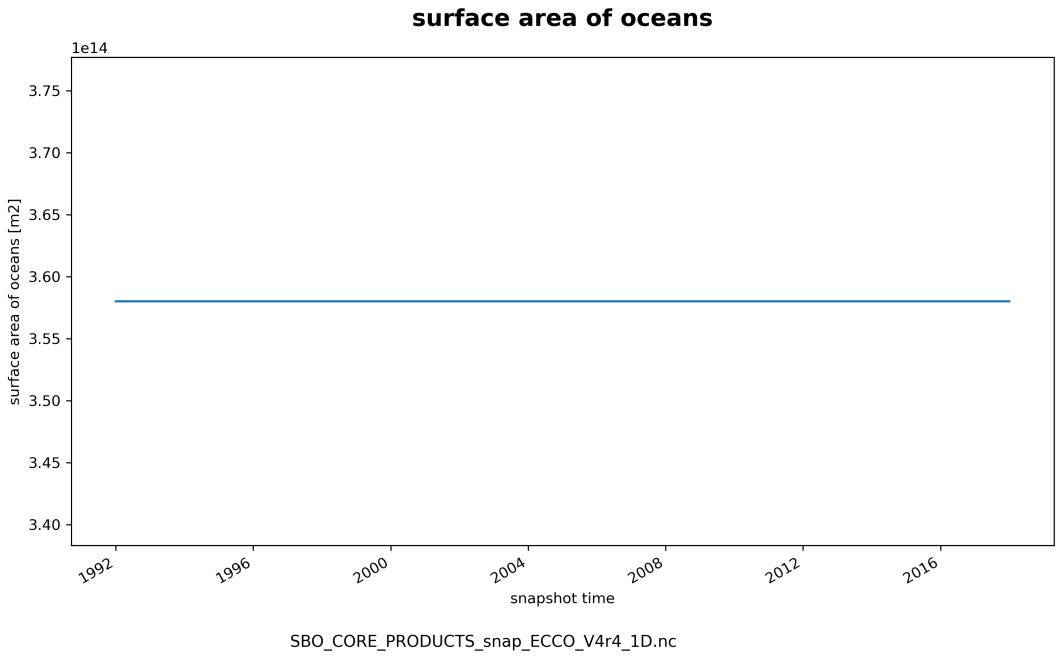


Figure 185: Dataset: SBO_CORE_PRODUCTS, Variable: sboarea

14.3.7 1D Variable: xcom

Table 14.13: Attributes description of the variable 'xcom' from SBO_CORE_PRODUCTS's dataset.

Storage Type	Variable Name	Description	Unit
float64	xcom	X-comp of center-of-mass of ocean	m

Description of the variable in Common Data language (CDL)

```
float64 xcom(time)
    xcom:  _FillValue = 9.969209968386869e+36
    xcom:  coordinates = time
    xcom:  coverage_content_type = modelResult
    xcom:  long_name = x-comp of center-of-mass of ocean
    xcom:  units = m
    xcom:  valid_max = -763667.0104211655
    xcom:  valid_min = -763730.0399730895
```

Comments

N/a

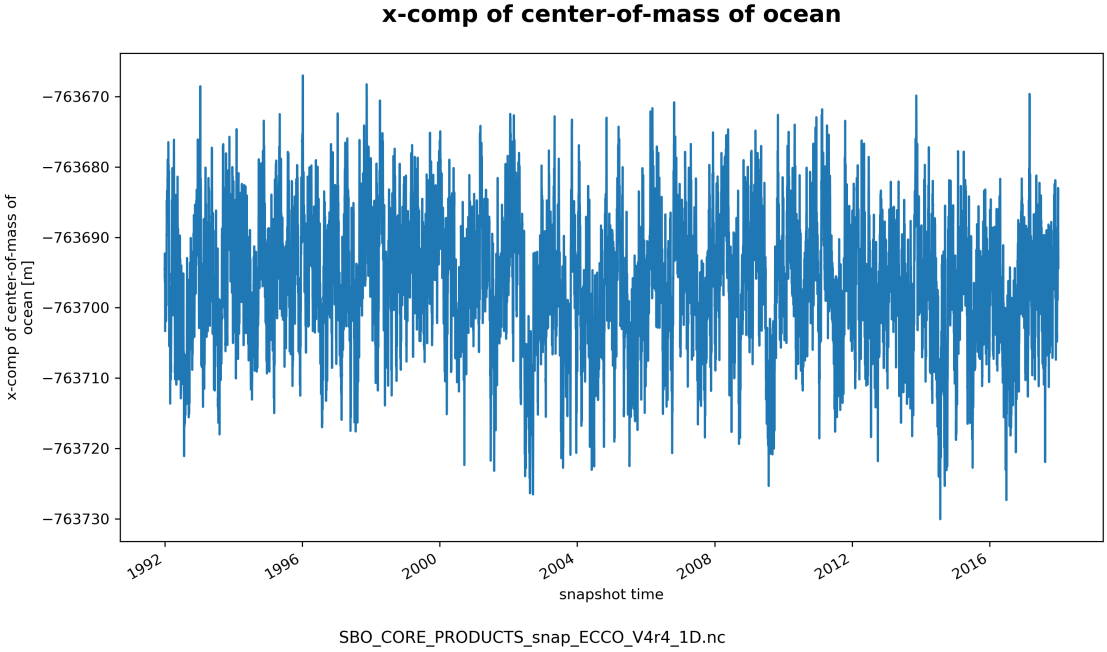


Figure 186: Dataset: SBO_CORE_PRODUCTS, Variable: xcom

14.3.8 1D Variable: xcom_fw

Table 14.14: Attributes description of the variable 'xcom_fw' from SBO_CORE_PRODUCTS's dataset.

Storage Type	Variable Name	Description	Unit
float64	xcom_fw	X-comp of center-of-mass of freshwater flux	m

Description of the variable in Common Data language (CDL)

```
float64 xcom_fw(time)
    xcom_fw:  _FillValue = 9.969209968386869e+36
    xcom_fw:  coordinates = time
    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_max = -573864.6948562652
    xcom_fw:  valid_min = -573864.6948562702
```

Comments

N/a

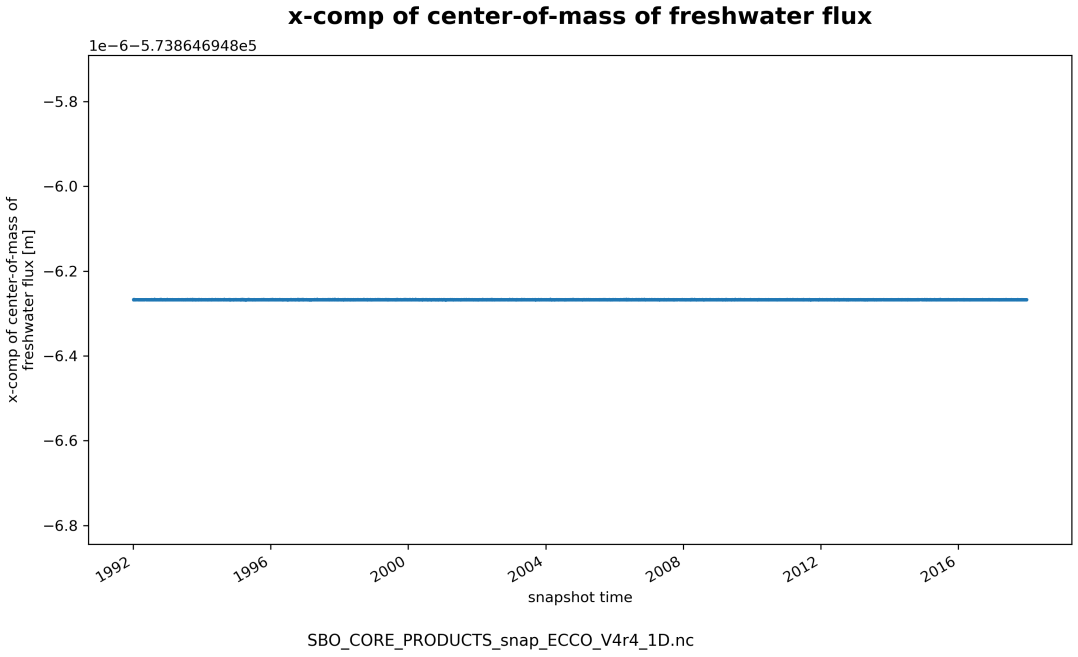


Figure 187: Dataset: SBO_CORE_PRODUCTS, Variable: xcom_fw

14.3.9 1D Variable: xoamc

Table 14.15: Attributes description of the variable 'xoamc' from SBO_CORE_PRODUCTS's dataset.

Storage Type	Variable Name	Description	Unit
float64	xoamc	X-comp of oceanic angular momentum due to currents	kg m2 s-1

Description of the variable in Common Data language (CDL)

```
float64 xoamc(time)
    xoamc:  _FillValue = 9.969209968386869e+36
    xoamc:  coordinates = time
    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_max = 2.555331552045857e+24
    xoamc:  valid_min = -3.783733447704127e+24
```

Comments

N/a

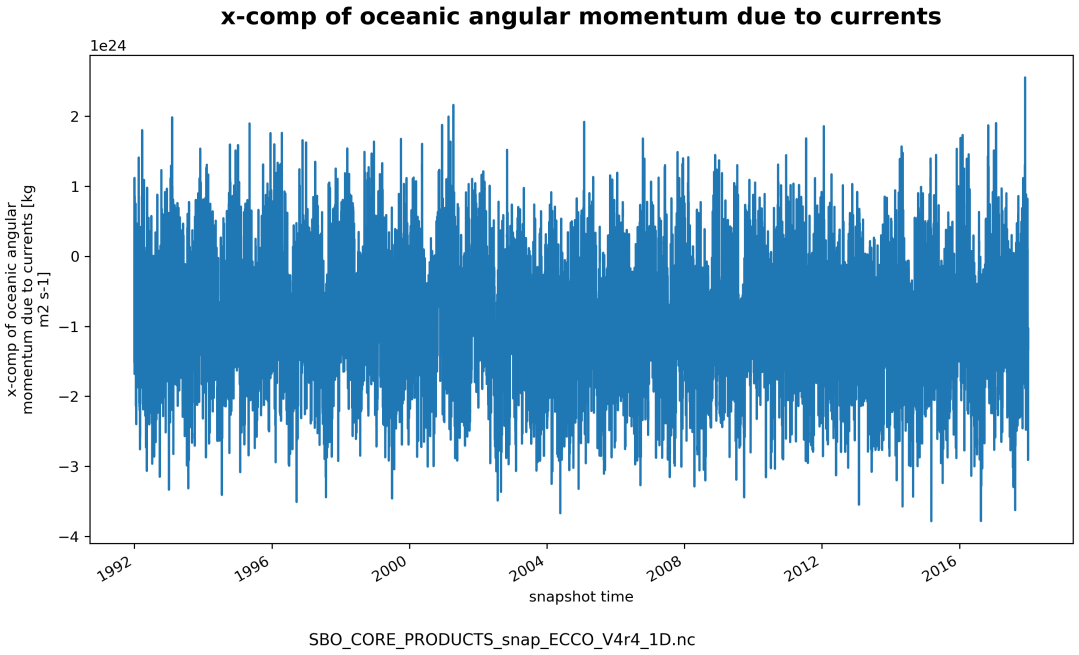


Figure 188: Dataset: SBO_CORE_PRODUCTS, Variable: xoamc

14.3.10 1D Variable: xoamc_si

Table 14.16: Attributes description of the variable 'xoamc_si' from SBO_CORE_PRODUCTS's dataset.

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

Description of the variable in Common Data language (CDL)

```
float64 xoamc_si(time)
    xoamc_si:  _FillValue = 9.969209968386869e+36
    xoamc_si:  coordinates = time
    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_max = 1.3721188892065168e+22
    xoamc_si:  valid_min = -9.76342837969224e+21
```

Comments

N/a

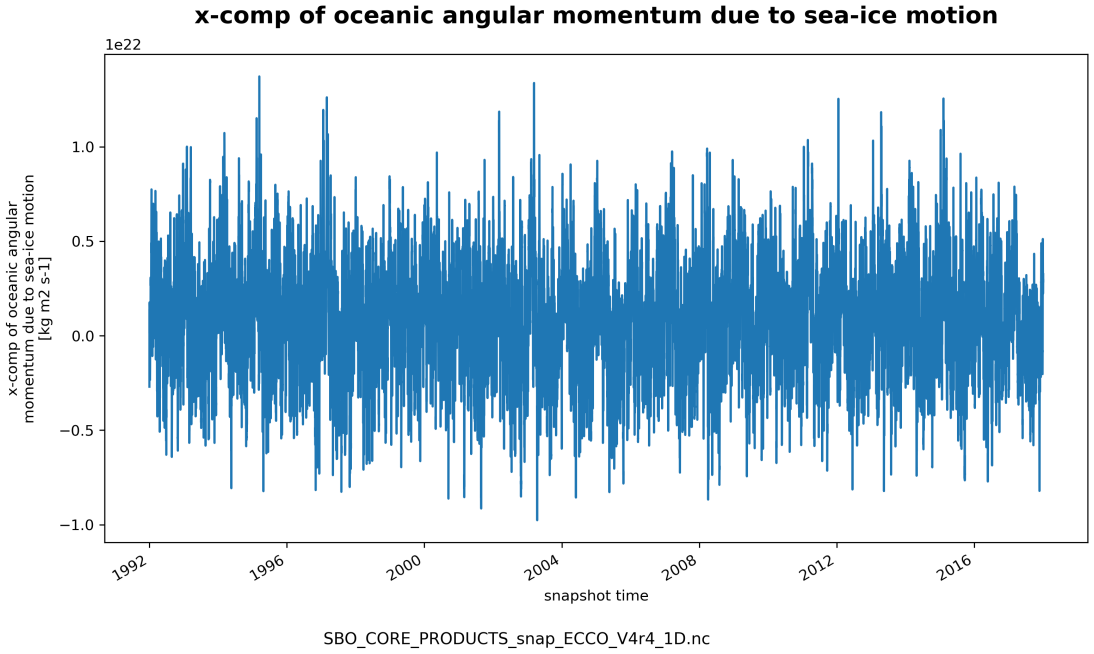


Figure 189: Dataset: SBO_CORE_PRODUCTS, Variable: xoamc_si

14.3.11 1D Variable: xoamp

Table 14.17: Attributes description of the variable 'xoamp' from SBO_CORE_PRODUCTS's dataset.

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

Description of the variable in Common Data language (CDL)

```
float64 xoamp(time)
   xoamp:  _FillValue = 9.969209968386869e+36
   xoamp:  coordinates = time
   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_max = 1.3546098666231897e+29
   xoamp:  valid_min = 1.3543642768158851e+29
```

Comments

N/a

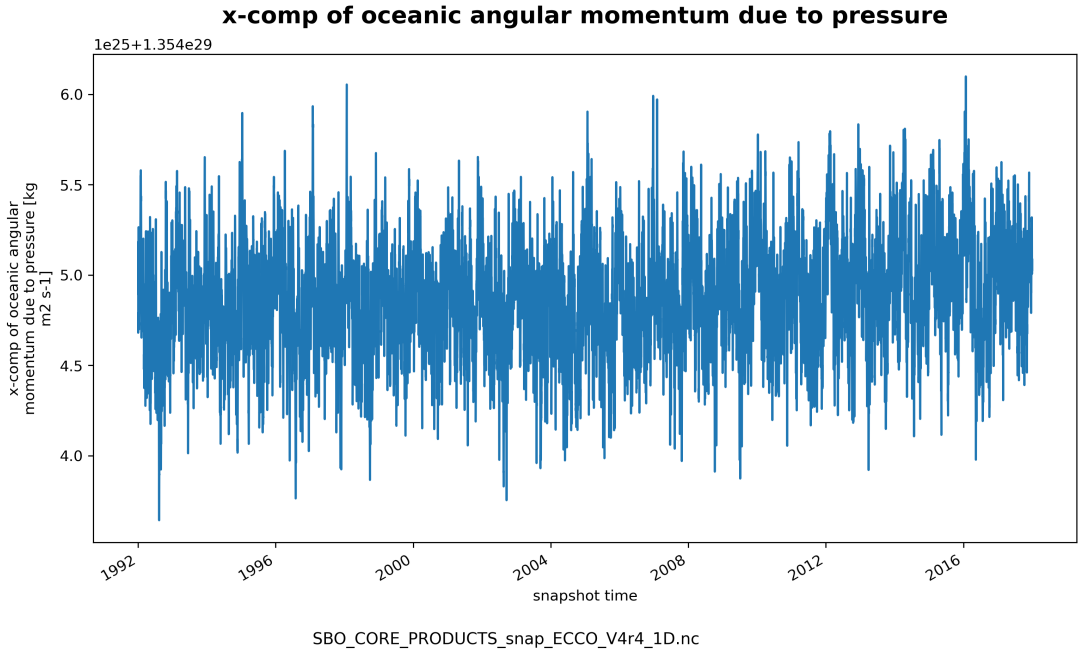


Figure 190: Dataset: SBO_CORE_PRODUCTS, Variable: xoamp

14.3.12 1D Variable: xoamp_dsl

Table 14.18: Attributes description of the variable 'xoamp_dsl' from SBO_CORE_PRODUCTS's dataset.

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

Description of the variable in Common Data language (CDL)

```
float64 xoamp_dsl(time)
   xoamp_dsl:  _FillValue = 9.969209968386869e+36
   xoamp_dsl:  coordinates = time
   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_max = 1.3545518352698056e+29
   xoamp_dsl:  valid_min = 1.354440386439953e+29
```

Comments

N/a

x-comp of oceanic angular momentum due to pressure based on dynamic (IB-corrected) sea level

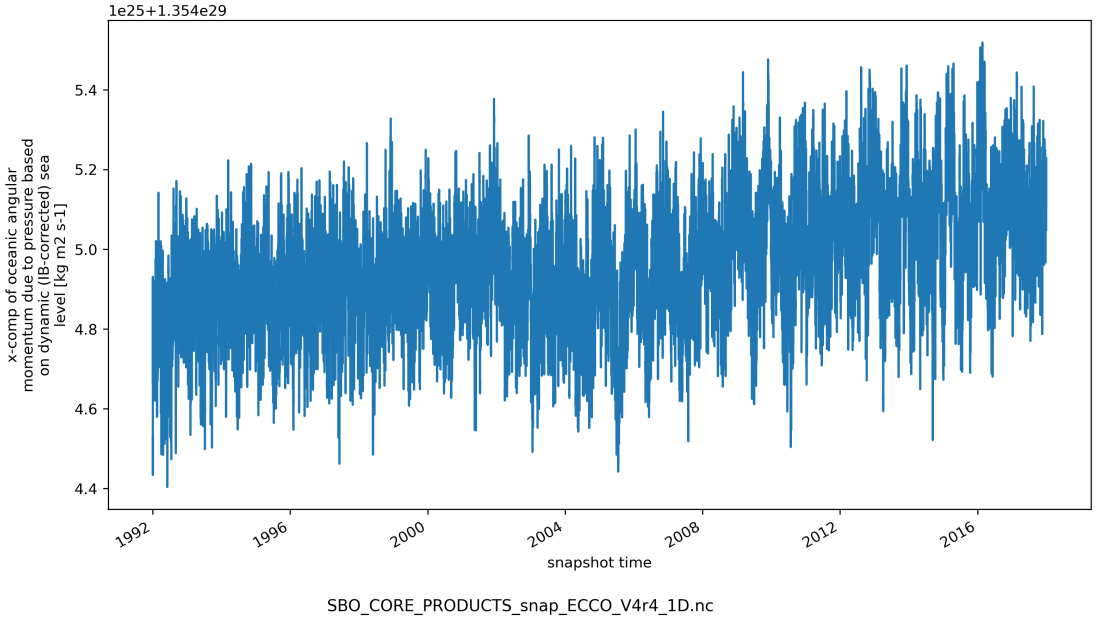


Figure 191: Dataset: SBO_CORE_PRODUCTS, Variable: xoamp_dsl

14.3.13 1D Variable: xoamp_fw

Table 14.19: Attributes description of the variable 'xoamp_fw' from SBO_CORE_PRODUCTS's dataset.

Storage Type	Variable Name	Description	Unit
float64	xoamp_fw	X-comp of oceanic angular momentum due to freshwater flux	kg m2 s-1

Description of the variable in Common Data language (CDL)

```
float64 xoamp_fw(time)
   xoamp_fw:  _FillValue = 9.969209968386869e+36
   xoamp_fw:  coordinates = time
   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_max = 3.351358892803656e+24
   xoamp_fw:  valid_min = 1.805799644912138e+24
```

Comments

N/a

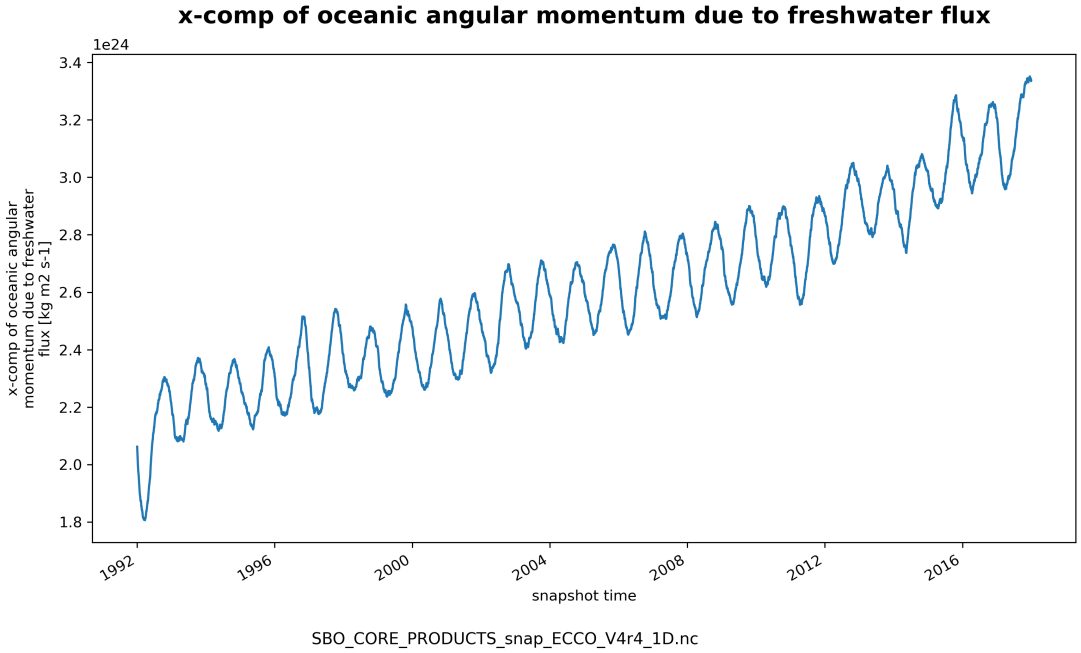


Figure 192: Dataset: SBO_CORE_PRODUCTS, Variable: xoamp_fw

14.3.14 1D Variable: ycom

Table 14.20: Attributes description of the variable 'ycom' from SBO_CORE_PRODUCTS's dataset.

Storage Type	Variable Name	Description	Unit
float64	ycom	Y-comp of center-of-mass of ocean	m

Description of the variable in Common Data language (CDL)

```
float64 ycom(time)
    ycom:  _FillValue = 9.969209968386869e+36
    ycom:  coordinates = time
    ycom:  coverage_content_type = modelResult
    ycom:  long_name = y-comp of center-of-mass of ocean
    ycom:  units = m
    ycom:  valid_max = -466327.21844756586
    ycom:  valid_min = -466387.24450374383
```

Comments

N/a

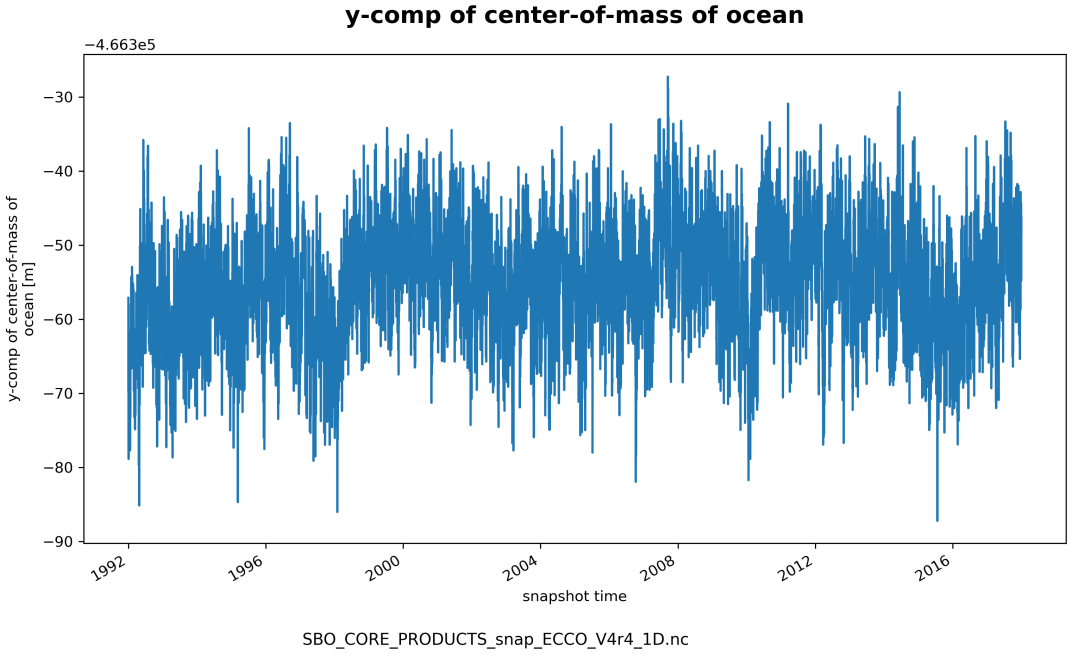


Figure 193: Dataset: SBO_CORE_PRODUCTS, Variable: ycom

14.3.15 1D Variable: ycom_fw

Table 14.21: Attributes description of the variable 'ycom_fw' from SBO_CORE_PRODUCTS's dataset.

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

Description of the variable in Common Data language (CDL)

```
float64 ycom_fw(time)
    ycom_fw:  _FillValue = 9.969209968386869e+36
    ycom_fw:  coordinates = time
    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_max = -324750.4152921157
    ycom_fw:  valid_min = -324750.41529212013
```

Comments

N/a

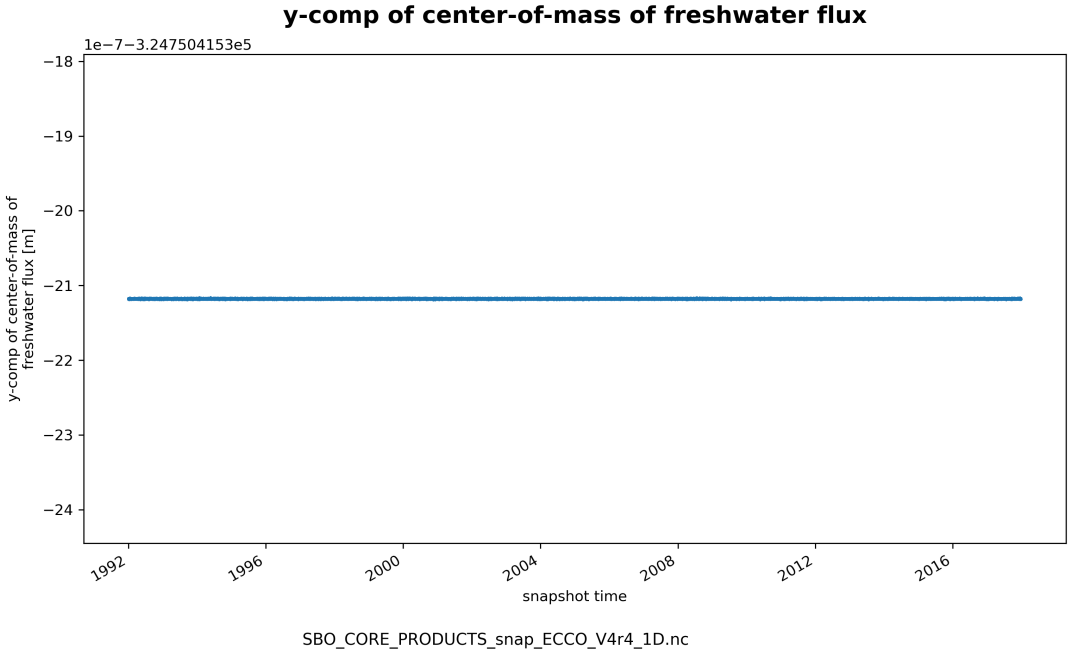


Figure 194: Dataset: SBO_CORE_PRODUCTS, Variable: ycom_fw

14.3.16 1D Variable: yoamc

Table 14.22: Attributes description of the variable 'yoamc' from SBO_CORE_PRODUCTS's dataset.

Storage Type	Variable Name	Description	Unit
float64	yoamc	Y-comp of oceanic angular momentum due to currents	kg m2 s-1

Description of the variable in Common Data language (CDL)

```
float64 yoamc(time)
    yoamc:  _FillValue = 9.969209968386869e+36
    yoamc:  coordinates = time
    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_max = 4.179441018940977e+24
    yoamc:  valid_min = -2.19249690136359e+24
```

Comments

N/a

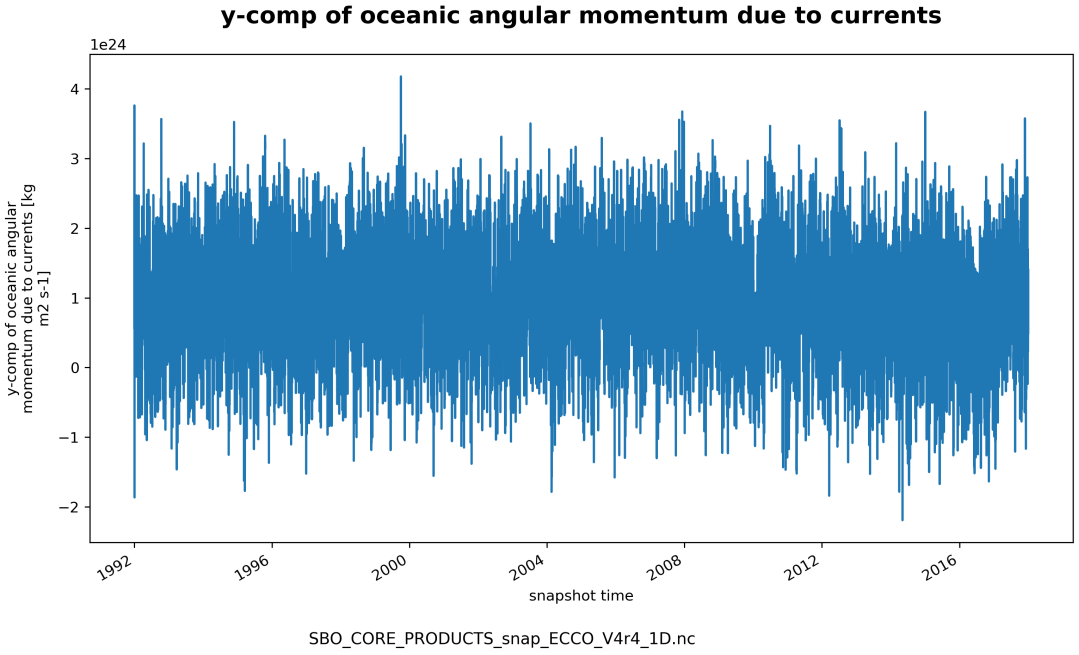


Figure 195: Dataset: SBO_CORE_PRODUCTS, Variable: yoamc

14.3.17 1D Variable: yoamc_si

Table 14.23: Attributes description of the variable 'yoamc_si' from SBO_CORE_PRODUCTS's dataset.

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

Description of the variable in Common Data language (CDL)

```
float64 yoamc_si(time)
   yoamc_si:  _FillValue = 9.969209968386869e+36
   yoamc_si:  coordinates = time
   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_max = 1.6107851446370722e+22
   yoamc_si:  valid_min = -1.176556337395274e+22
```

Comments

N/a

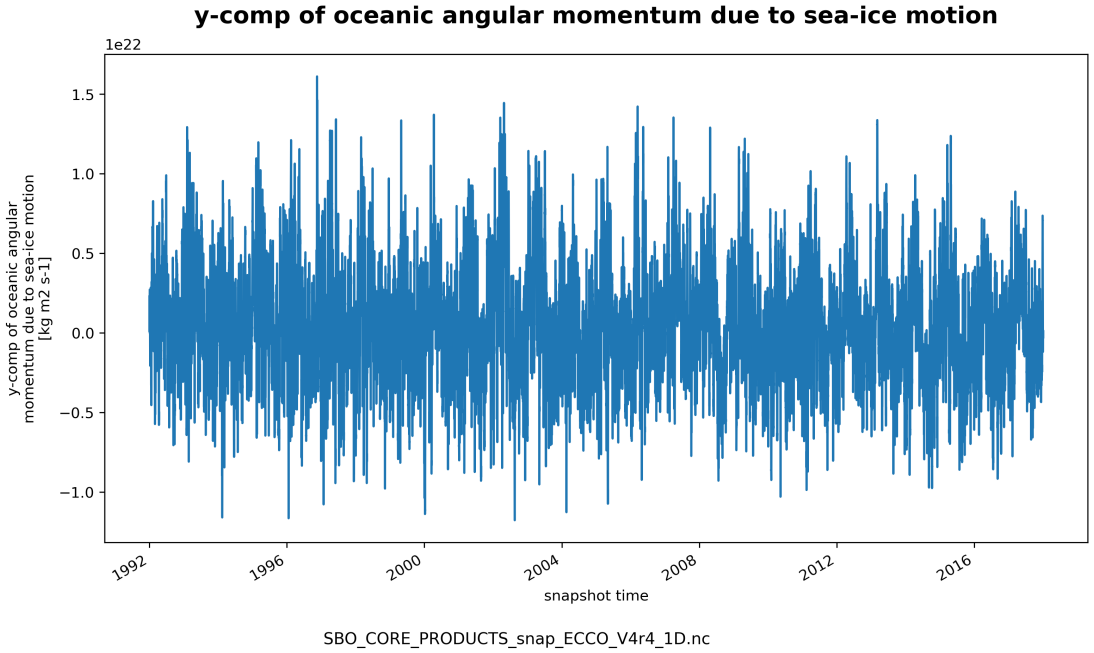


Figure 196: Dataset: SBO_CORE_PRODUCTS, Variable: yoamc_si

14.3.18 1D Variable: yoamp

Table 14.24: Attributes description of the variable 'yoamp' from SBO_CORE_PRODUCTS's dataset.

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

Description of the variable in Common Data language (CDL)

```
float64 yoamp(time)
    yoamp:  _FillValue = 9.969209968386869e+36
    yoamp:  coordinates = time
    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_max = 1.0478581623131764e+29
    yoamp:  valid_min = 1.0476388397938864e+29
```

Comments

N/a

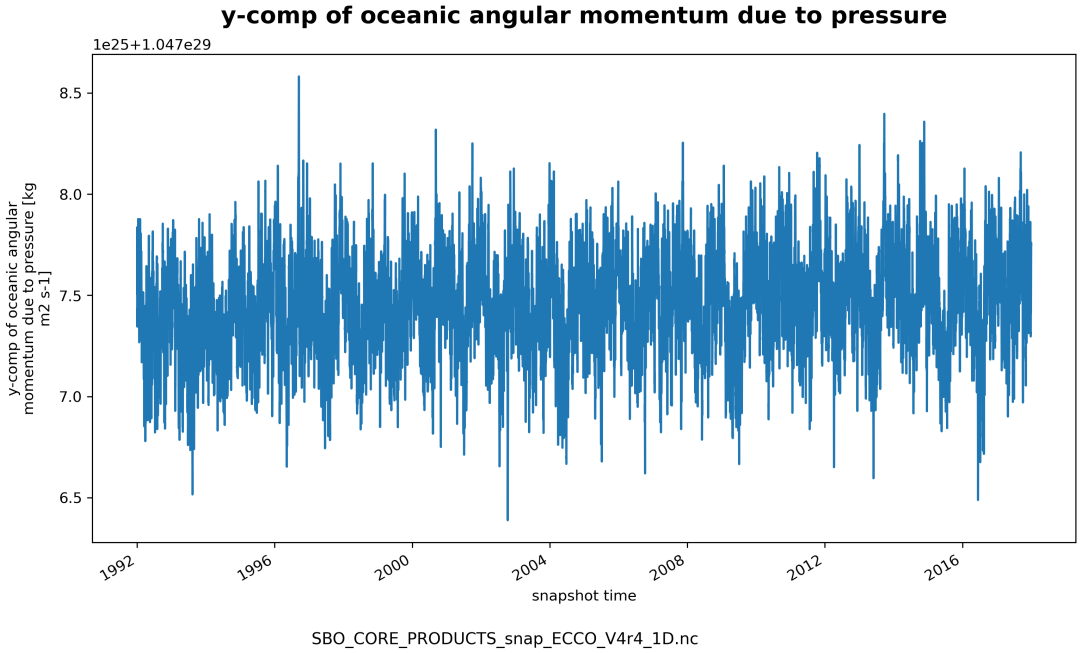


Figure 197: Dataset: SBO_CORE_PRODUCTS, Variable: yoamp

14.3.19 1D Variable: yoamp_dsl

Table 14.25: Attributes description of the variable 'yoamp_dsl' from SBO_CORE_PRODUCTS's dataset.

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

Description of the variable in Common Data language (CDL)

```
float64 yoamp_dsl(time)
   yoamp_dsl:  _FillValue = 9.969209968386869e+36
   yoamp_dsl:  coordinates = time
   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_max = 1.0478187262074598e+29
   yoamp_dsl:  valid_min = 1.0476994334049981e+29
```

Comments

N/a

y-comp of oceanic angular momentum due to pressure based on dynamic (IB-corrected) sea level

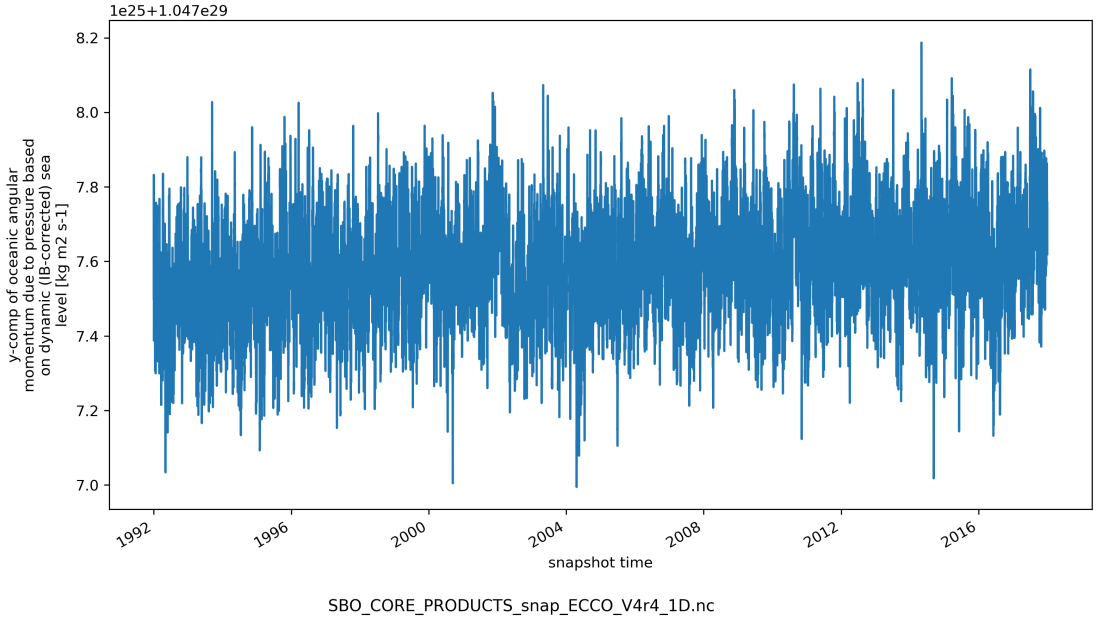


Figure 198: Dataset: SBO_CORE_PRODUCTS, Variable: yoamp_dsl

14.3.20 1D Variable: yoamp_fw

Table 14.26: Attributes description of the variable 'yoamp_fw' from SBO_CORE_PRODUCTS's dataset.

Storage Type	Variable Name	Description	Unit
float64	yoamp_fw	Y-comp of oceanic angular momentum due to freshwater flux	kg m2 s-1

Description of the variable in Common Data language (CDL)

```
float64 yoamp_fw(time)
   yoamp_fw:  _FillValue = 9.969209968386869e+36
   yoamp_fw:  coordinates = time
   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_max = 4.872705717529432e+24
   yoamp_fw:  valid_min = 2.6255410225894626e+24
```

Comments

N/a

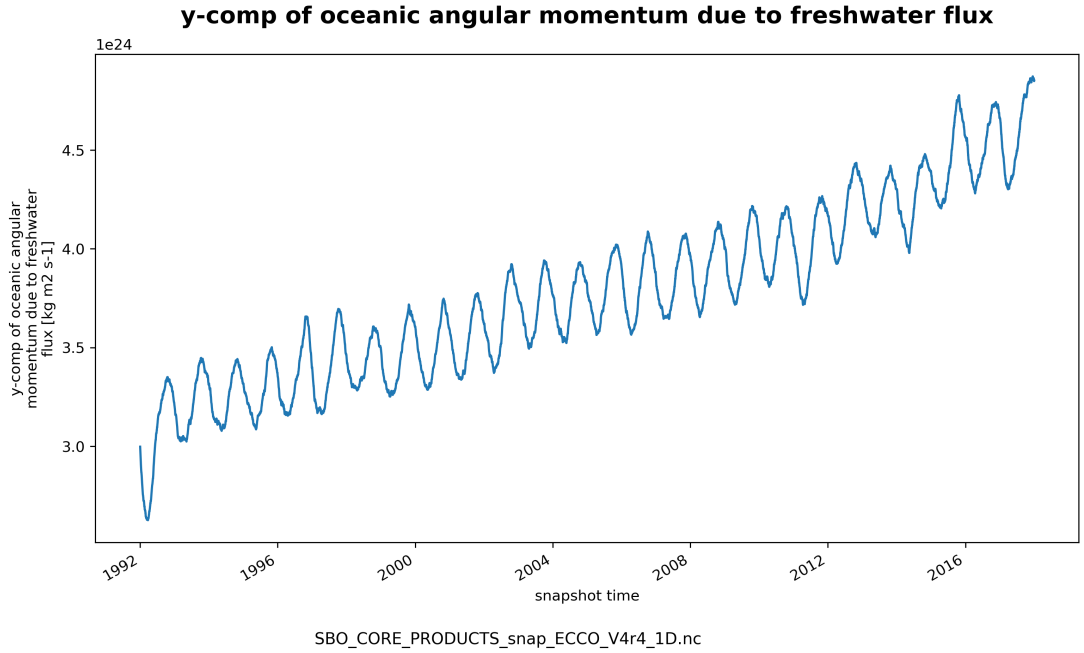


Figure 199: Dataset: SBO_CORE_PRODUCTS, Variable: yoamp_fw

14.3.21 1D Variable: zcom

Table 14.27: Attributes description of the variable 'zcom' from SBO_CORE_PRODUCTS's dataset.

Storage Type	Variable Name	Description	Unit
float64	zcom	Z-comp of center-of-mass of ocean	m

Description of the variable in Common Data language (CDL)

```
float64 zcom(time)
    zcom:  _FillValue = 9.969209968386869e+36
    zcom:  coordinates = time
    zcom:  coverage_content_type = modelResult
    zcom:  long_name = z-comp of center-of-mass of ocean
    zcom:  units = m
    zcom:  valid_max = -875350.3238026679
    zcom:  valid_min = -875420.3898804963
```

Comments

N/a

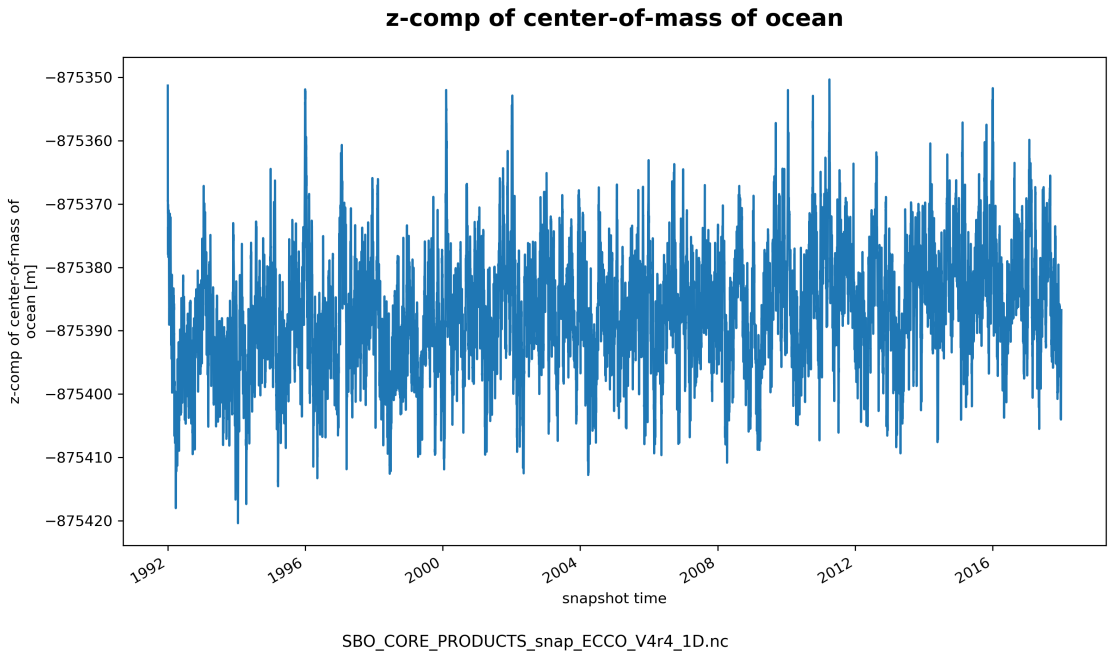


Figure 200: Dataset: SBO_CORE_PRODUCTS, Variable: zcom

14.3.22 1D Variable: zcom_fw

Table 14.28: Attributes description of the variable 'zcom_fw' from SBO_CORE_PRODUCTS's dataset.

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

Description of the variable in Common Data language (CDL)

```
float64 zcom_fw(time)
    zcom_fw:  _FillValue = 9.969209968386869e+36
    zcom_fw:  coordinates = time
    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_max = -648386.5781734567
    zcom_fw:  valid_min = -648386.5781734617
```

Comments

N/a

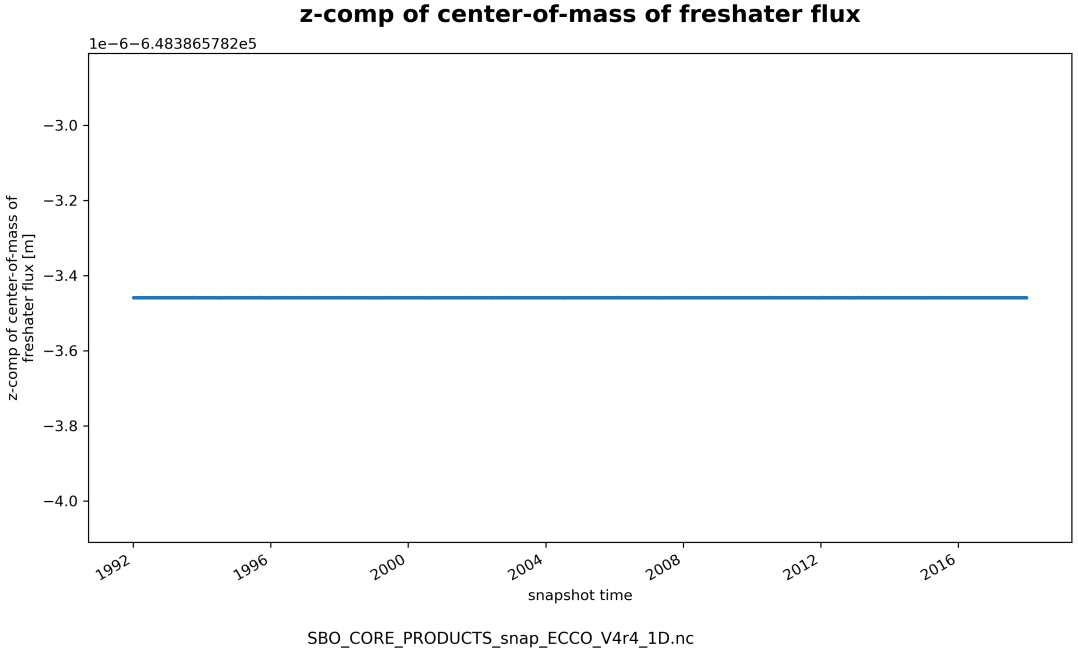


Figure 201: Dataset: SBO_CORE_PRODUCTS, Variable: zcom_fw

14.3.23 1D Variable: zoamc

Table 14.29: Attributes description of the variable 'zoamc' from SBO_CORE_PRODUCTS's dataset.

Storage Type	Variable Name	Description	Unit
float64	zoamc	Z-comp of oceanic angular momentum due to currents	kg m2 s-1

Description of the variable in Common Data language (CDL)

```
float64 zoamc(time)
    zoamc:  _FillValue = 9.969209968386869e+36
    zoamc:  coordinates = time
    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_max = 2.207264300276968e+25
    zoamc:  valid_min = 7.331764457927521e+24
```

Comments

N/a

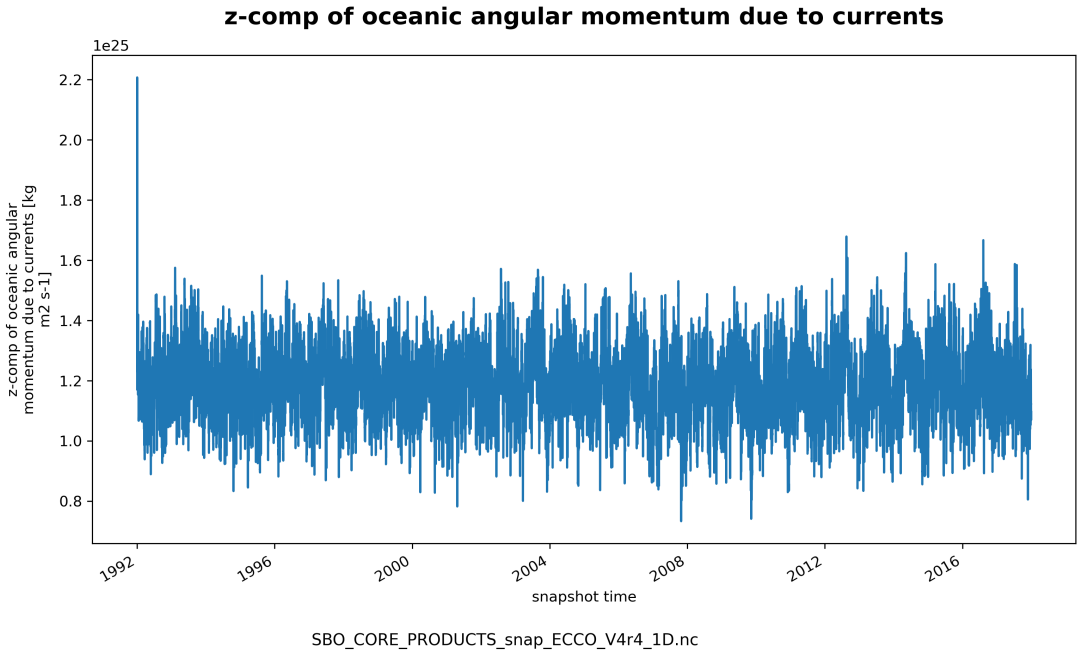


Figure 202: Dataset: SBO_CORE_PRODUCTS, Variable: zoamc

14.3.24 1D Variable: zoamc_si

Table 14.30: Attributes description of the variable 'zoamc_si' from SBO_CORE_PRODUCTS's dataset.

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

Description of the variable in Common Data language (CDL)

```
float64 zoamc_si(time)
   zoamc_si:  _FillValue = 9.969209968386869e+36
   zoamc_si:  coordinates = time
   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_max = 5.930388258256482e+21
   zoamc_si:  valid_min = -5.909426721868294e+21
```

Comments

N/a

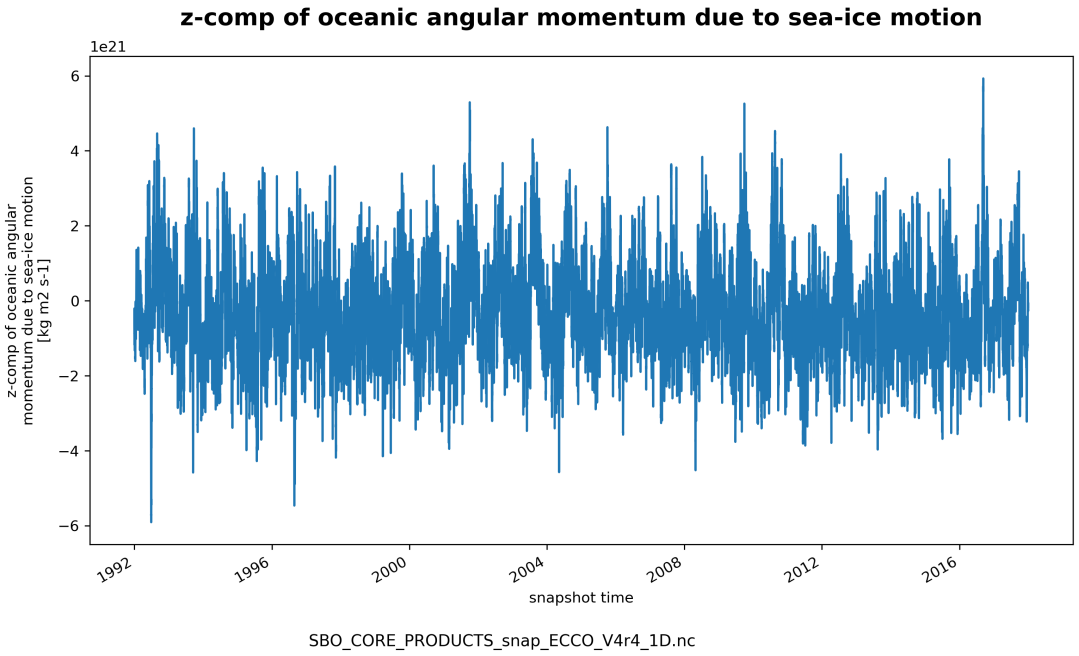


Figure 203: Dataset: SBO_CORE_PRODUCTS, Variable: zoamc_si

14.3.25 1D Variable: zoamp

Table 14.31: Attributes description of the variable 'zoamp' from SBO_CORE_PRODUCTS's dataset.

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

Description of the variable in Common Data language (CDL)

```
float64 zoamp(time)
   zoamp:  _FillValue = 9.969209968386869e+36
   zoamp:  coordinates = time
   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_max = 2.9277200254389854e+30
   zoamp:  valid_min = 2.927645942668479e+30
```

Comments

N/a

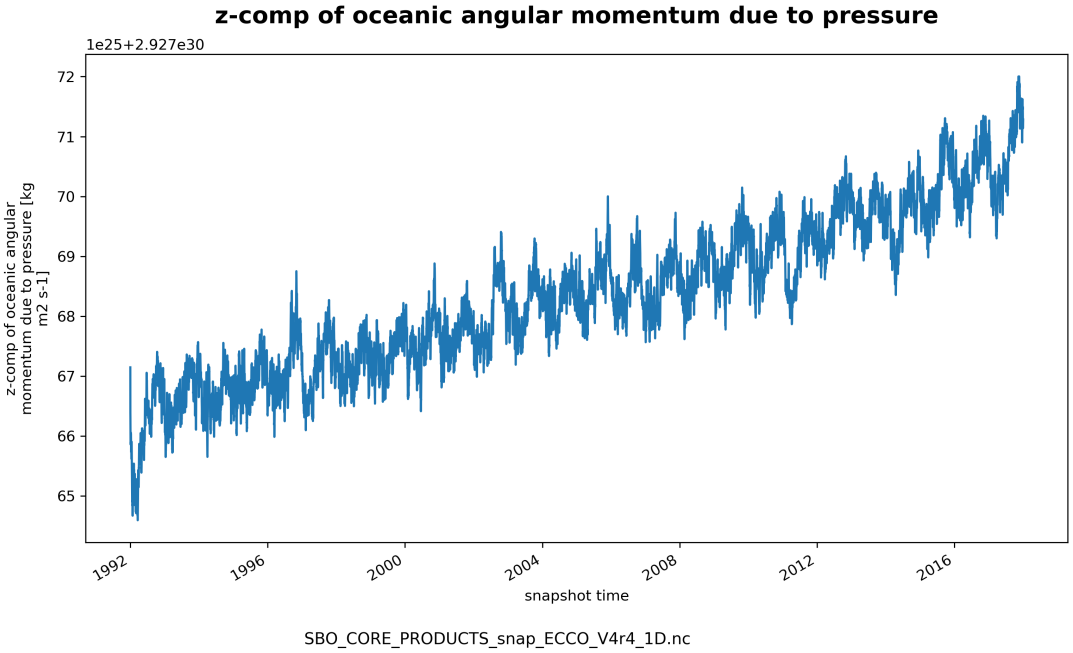


Figure 204: Dataset: SBO_CORE_PRODUCTS, Variable: zoamp

14.3.26 1D Variable: zoamp_dsl

Table 14.32: Attributes description of the variable 'zoamp_dsl' from SBO_CORE_PRODUCTS's dataset.

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

Description of the variable in Common Data language (CDL)

```
float64 zoamp_dsl(time)
   zoamp_dsl:  _FillValue = 9.969209968386869e+36
   zoamp_dsl:  coordinates = time
   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_max = 2.9277328440911863e+30
   zoamp_dsl:  valid_min = 2.9276609546728614e+30
```

Comments

N/a

z-comp of oceanic angular momentum due to pressure based on dynamic (IB-corrected) sea level

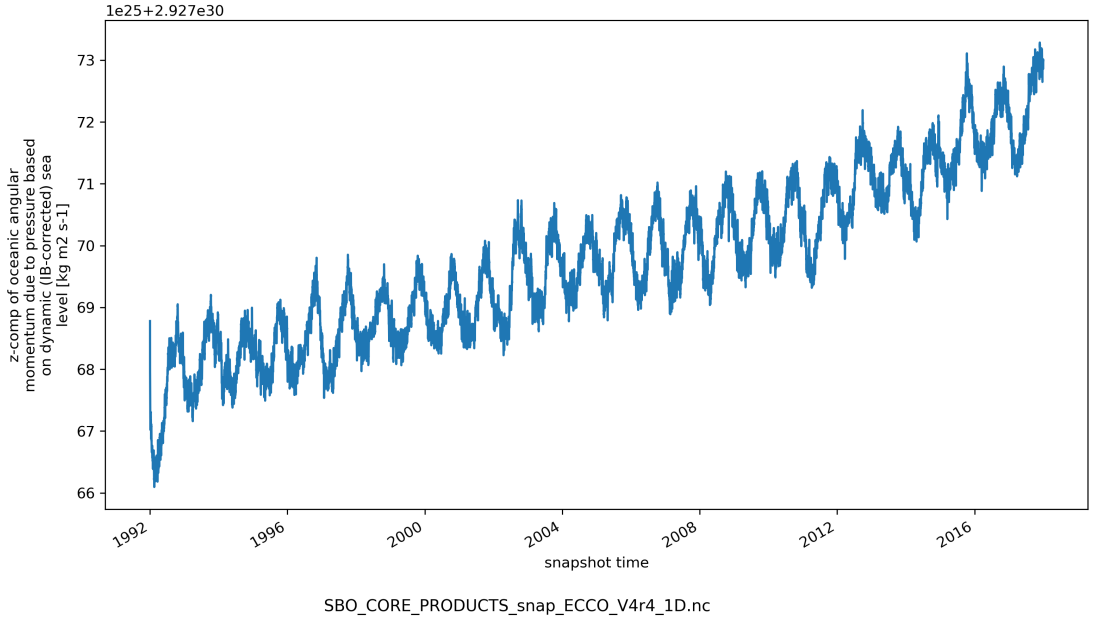


Figure 205: Dataset: SBO_CORE_PRODUCTS, Variable: zoamp_dsl

14.3.27 1D Variable: zoamp_fw

Table 14.33: Attributes description of the variable 'zoamp_fw' from SBO_CORE_PRODUCTS's dataset.

Storage Type	Variable Name	Description	Unit
float64	zoamp_fw	Z-comp of oceanic angular momentum due to freshwater flux	kg m2 s-1

Description of the variable in Common Data language (CDL)

```
float64 zoamp_fw(time)
   zoamp_fw:  _FillValue = 9.969209968386869e+36
   zoamp_fw:  coordinates = time
   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_max = 1.442874536478883e+26
   zoamp_fw:  valid_min = 7.774584605728723e+25
```

Comments

N/a

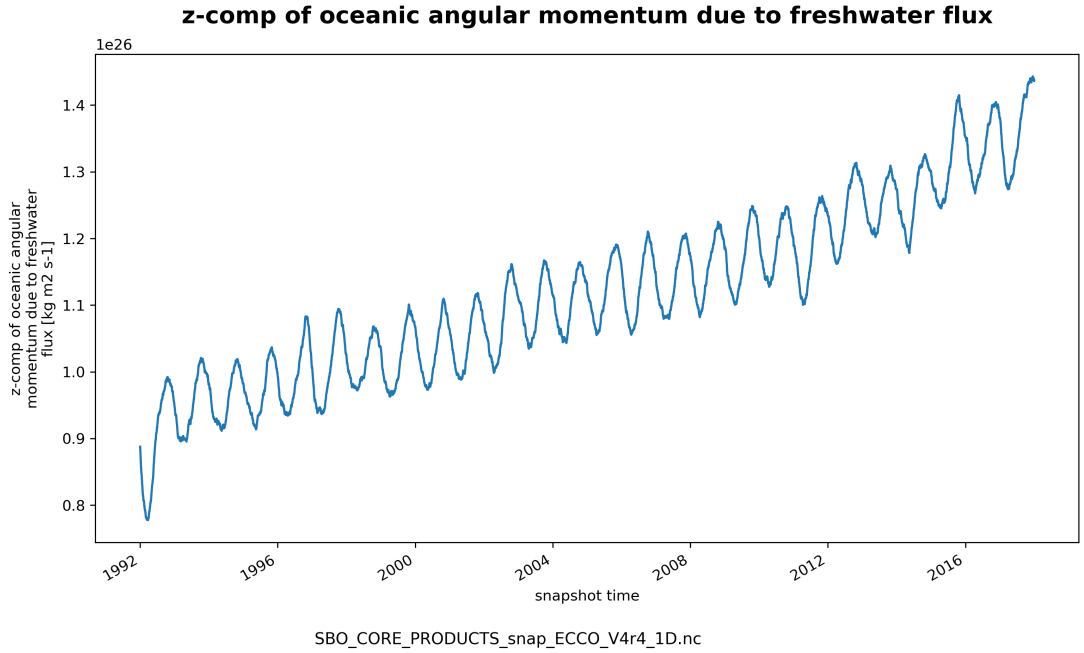


Figure 206: Dataset: SBO_CORE_PRODUCTS, Variable: zoamp_fw

15 How to find out more about ECCO

A complete description of ECCO V4r4 together with all project documentation can be found at the following web spaces:

Main ECCO portal	https://ecco-group.org/home.htm
ECCO History	https://ecco-group.org/about.htm
ECCO data analysis tools	https://ecco-group.org/analysis-tools.htm
ECCO tutorial with Python language	https://ecco-v4-python-tutorial.readthedocs.io/
ECCO tutorial with Julia language	https://ecco-group.org/storymaps.htm?id=69
ECCO Tube (Images, Movies, StoryMaps and Brochures)	https://ecco-group.org/media.htm
ECCO Visualizations	https://ecco-group.org/world-of-ecco.htm#series
To contact ECCO team	https://ecco-group.org/contact.htm