EARTH OBSERVATION CLIMATE INFORMATION SERVICE

Quick Start Guide

Sea Ice

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1. Quick Start: Sea ice

The following will provide you with sufficient information to quickly get to grips with the Sea Ice dataset product(s) and to gain some familiarity with the information available.

1.1 What products are available?

Product name and acronym	Filename example	Version
Sea ice thickness grid	EOCIS-SEAICE-L3C-SITHICK-CS2-5KM-202304-fv1.0.nc	V1.0
Sea ice thickness, volume and mass time series	EOCIS-SEAICE-TIMESERIES-THICKVOL-CS2-ARCTIC-201011_202310-fv1.0.nc	V1.0

Table 1 Dataset Products covered in this document

1.2 Summary information

Product Name	**Sea ice thickness**
Main observed variable(s)	Sea ice thickness
Geographical range of dataset	Arctic ocean
Temporal range of dataset	November 2010 - present
Spatial resolution / gridding	5 km^2
Temporal sampling characteristics	Monthly
Level of processing	L3 gridded data
Main auxiliary content	uncertainty from standard deviation of gridded measurements, number of measurements
Dataset citation	Tilling, R.L., et al. Estimating Arctic sea ice thickness and volume using CryoSat-2 radar altimeter data. Adv. Space Res. (2018), https://doi.org/10.1016/j.asr.2017.10.051
Dataset journal reference	NA

Table 2 Summary Information for Sea ice thickness

Product Name	**Sea ice thickness, volume and mass**
Main observed variable(s)	Sea ice thickness, volume and mass time series.
Geographical range of dataset	Arctic ocean and subdivided in to 17 geographic basins.
Temporal range of dataset	2010-present

Spatial resolution / gridding	Whole Arctic and 17 NSIDC basins.
Temporal sampling characteristics	Monthly
Level of processing	L3 time series data
Main auxiliary content	NA
Dataset citation	Tilling, R.L., et al. Estimating Arctic sea ice thickness and volume using CryoSat-2 radar altimeter data. Adv. Space Res. (2018), https://doi.org/10.1016/j.asr.2017.10.051
Dataset journal reference	NA

Table 3 Summary Information for Sea ice volume and mass

1.2.1 Variables summary information

The sea ice products provide a 5x5 km grid of Arctic sea ice thickness and a time-series of Arctic thickness and volume (containing the time-series of the whole Arctic region and of 17 sub-regions), both delivered as NetCDF files.

Sea Ice Thickness file name:
EOCIS-SEAICE-L3C-SITHICK-CS2-5KM-<*YYYYMM*>-fv1.0.nc
where <YYYYMM> is the year and month of the measurement period. For example: 202310

Name of variable in file	Description
sea_ice_thickness	Mean sea ice thickness (m) derived from radar altimetry in the grid cell.
sea_ice_thickness_stdev	The standard deviation (m) of the sea ice thickness measurements in a grid cell used to calculate the mean
n_thickness_measurements	Number of thickness measurements used to calculate the mean thickness in each grid cell

Table 5: Summary information for each variable in gridded sea ice thickness product

Sea Ice Thickness and Volume time-series file name:
EOCIS-SEAICE-TIMESERIES-THICKVOL-CS2-ARCTIC-<*YYYYMM*[1]>_<*YYYYMM*[2]>-fv1.0.nc
where <YYYYMM[1]> is the year and month of the first monthly time-series value, and <YYYYMM[2]> is the year and month of the final time-series value.

Name of variable in file	Description
time	time corresponding to each time step in the time-series (units of days since 1990-01-01 00:00:00)
sea_ice_thickness	Monthly mean sea ice thickness (m) derived from radar altimetry for each Arctic basin
sea_ice_volume	Monthly sea ice volume (km^3) derived from radar altimetry for each Arctic basin

sea_ice_mass	Monthly sea ice mass (Gt) derived from radar altimetry for each Arctic basin
basin_names	Basin names corresponding to the full Arctic and to each of the 17 Arctic basins: "Arctic", "Amerasian Basin", "Eurasian Basin", "Canadian Archipelago", "Hudson & Foxe Bays", "Baffin Bay", "Greenland Sea", "Iceland Sea", "Norwegian Sea", "Barents Sea", "White Sea", "Kara Sea", "Siberian Shelf Seas", "Bering Sea", "Sea of Okhotsk", "Baltic Sea & Gulfs", "Gulf of St Lawrence & Nova Scotia Peninsular", "Labrador Sea"

Table 5: Summary information for each variable in time series product

1.3 What can these products be used for?

The products can be used to investigate the temporal and spatial variability in rates of change in sea ice thickness, volume and mass across the Arctic. These products can be used to study sea ice dynamics and the mechanisms that drive changes in the Arctic sea ice. They could also be used as model inputs to forecast sea ice conditions, increasingly important for shipping routes.

It is crucial to observe and understand changes in the Arctic sea ice cover, as it is a major element of the Earth's climate system (Tiling et al, 2018). Sea ice influences the freshwater (Aagaard and Carmack, 1989, Serreze et al., 2006) and surface heat (Sedlar et al., 2011) budgets of the Arctic, and subsequently the global climate. The melting of sea ice could disrupt the oceanic global thermohaline circulation (Vellinga and Wood, 2002) and atmospheric circulation patterns (Singarayer et al., 2006, Schweiger et al., 2008, Francis and Vavrus, 2012), with knock-on effects for regional weather patterns in Europe, America and much of the northern hemisphere, and potentially the southern hemisphere (Vellinga and Wood, 2002).

1.4 Where to find these products for download

To access the dataset products(s) navigate to the following locations using the links below:

- Sea ice data portal http://www.cpom.ucl.ac.uk/eocis/seaice/index.php
- The EOCIS website https://eocis.org/dataset-arctic-sea-ice/ also has a link to the data portal.

1.5 Using downloaded data

Examples of tools and code using the sea ice products will be provided under the following categories:

- Ingest/Read data
- Re-gridding/formatting
- Data reduction / sub setting
- Display/Viewing

The data are stored in NetCDF files using the latest CF metadata conventions (CF-1.10). Information about the CF conventions can be found at CF Conventions Home Page.

1.5.1 Import Data

An example in python of ingesting/reading the gridded thickness data product is shown below:

```
"""Example of reading the sea ice thickness, latitude and longitude variables
from an example EOCIS sea ice thickness file:
'EOCIS-SEAICE-L3C-SITHICK-CS2-5KM-202310-fv1.0.nc"""

import netCDF4 as nc
import matplotlib.pyplot as plt
import cartopy.crs as ccrs
import numpy as np

# Step 1: Read the NetCDF file
dataset = nc.Dataset('EOCIS-SEAICE-L3C-SITHICK-CS2-5KM-202310-fv1.0.nc', 'r')

# Step 2: Extract the sea ice thickness, latitude, and longitude data
sea_ice_thickness = dataset.variables['sea_ice_thickness'][:]
lat = dataset.variables['lat'][:]
lon = dataset.variables['lon'][:]
```

1.5.2 Re-Gridding/Formatting

The Sea Ice data product is delivered in the EPSG:3413 (NSIDC Sea Ice Polar Stereo North) map projection. Information about the map projections can be found at https://epsg.io/3413.

To re-grid or change the projection of the data you will need to use suitable GIS software, such as QGIS or implement scripts in python (or an alternative coding language of choice).

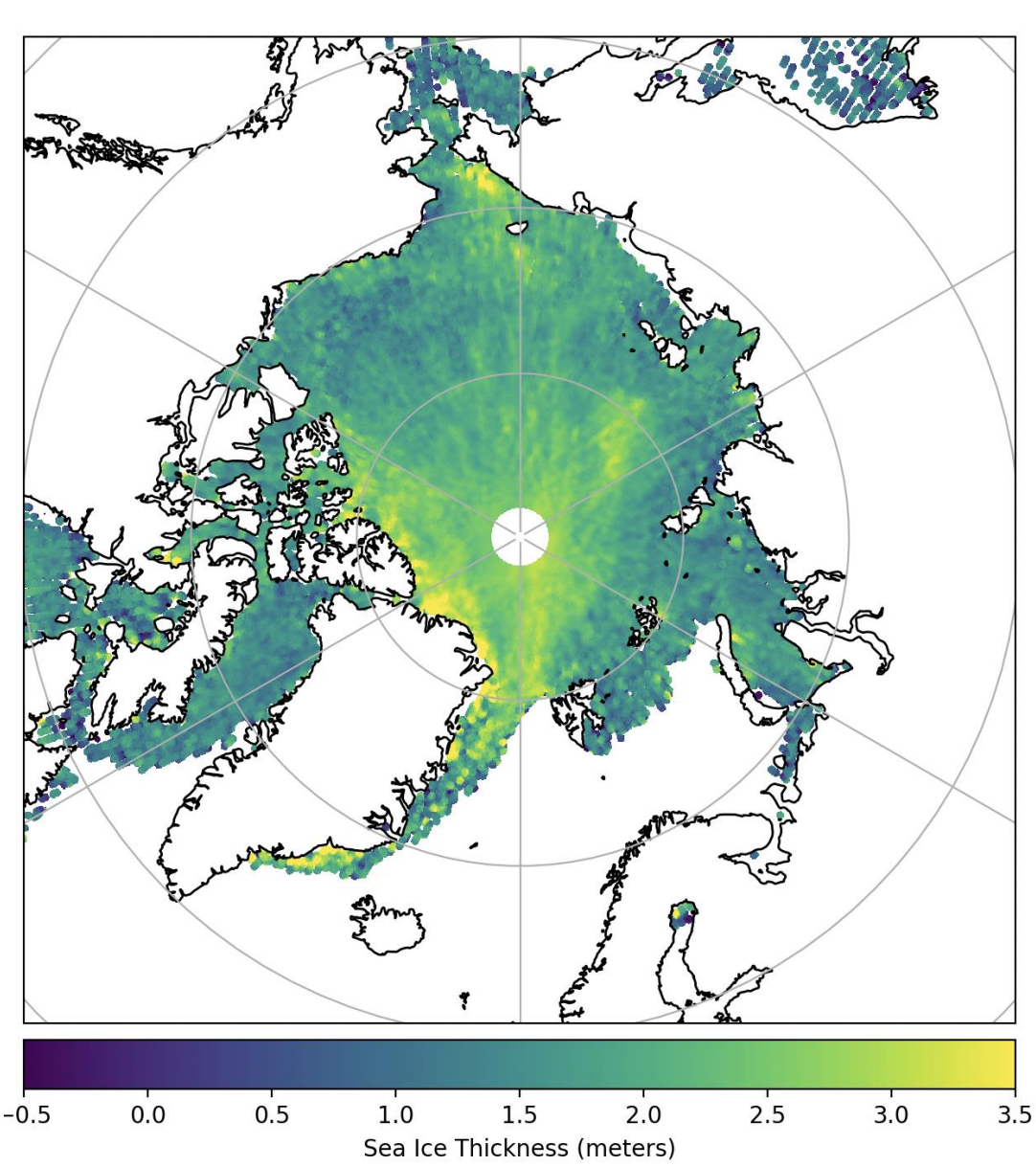
1.5.3 Display/Viewing

To display the data, you will need to use suitable software, such as Panoply, QGIS or python. An example of plotting the gridded thickness product in python is shown below.

```
"""Example of reading and plotting the gridded sea ice thickness data from an example
EOCIS product: EOCIS-SEAICE-L3C-SITHICK-CS2-5KM-202403-fv1.0.nc """

import netCDF4 as nc
import matplotlib.pyplot as plt
import cartopy.crs as ccrs
from mpl_toolkits.axes_grid1 import make_axes_locatable
import numpy as np

# Step 1: Read the NetCDF file
filename='EOCIS-SEAICE-L3C-SITHICK-CS2-5KM-202403-fv1.0.nc'
dataset = nc.Dataset(filename, 'r')

# Step 2: Extract the sea ice thickness, latitude, and longitude data
```

```
sea_ice_thickness = dataset.variables['sea_ice_thickness'][:]
lat = dataset.variables['lat'][:]
lon = dataset.variables['lon'][:]

# Step 3: Create a larger figure
plt.figure(figsize=(12, 8))

# Step 4: Prepare the map using cartopy, set to the Arctic stereographic projection
ax = plt.axes(projection=ccrs.NorthPolarStereo())
ax.set_extent([-180, 180, 60, 90], crs=ccrs.PlateCarree())  # Focus on the Arctic

# Step 5: Plot the data with a specified range of -0.5 to 3.5m
sea_ice_map = ax.pcolormesh(
    lon, lat, sea_ice_thickness[0, :, :],
    transform=ccrs.PlateCarree(),
    vmin=-0.5, vmax=3.5  # Set the range to -0.5 to 3.5 meters
)

# Step 6: Add features to the map
ax.coastlines(resolution='50m')
ax.gridlines()

# Step 7: Add a color bar with a title, aligned with the plot width
divider = make_axes_locatable(ax)
cax = divider.append_axes("bottom", size="5%", pad=0.1, axes_class=plt.Axes)
cbar = plt.colorbar(sea_ice_map, cax=cax, orientation='horizontal')
cbar.set_label('Sea Ice Thickness (meters)')  # Set the title for the color bar

# Step 8: Add the main title above the figure
plt.suptitle(filename, fontsize=14, y=0.95)

# Step 9: Show the plot
plt.subplots_adjust(top=0.9)  # Adjust the top to make space for the title
plt.show()
```

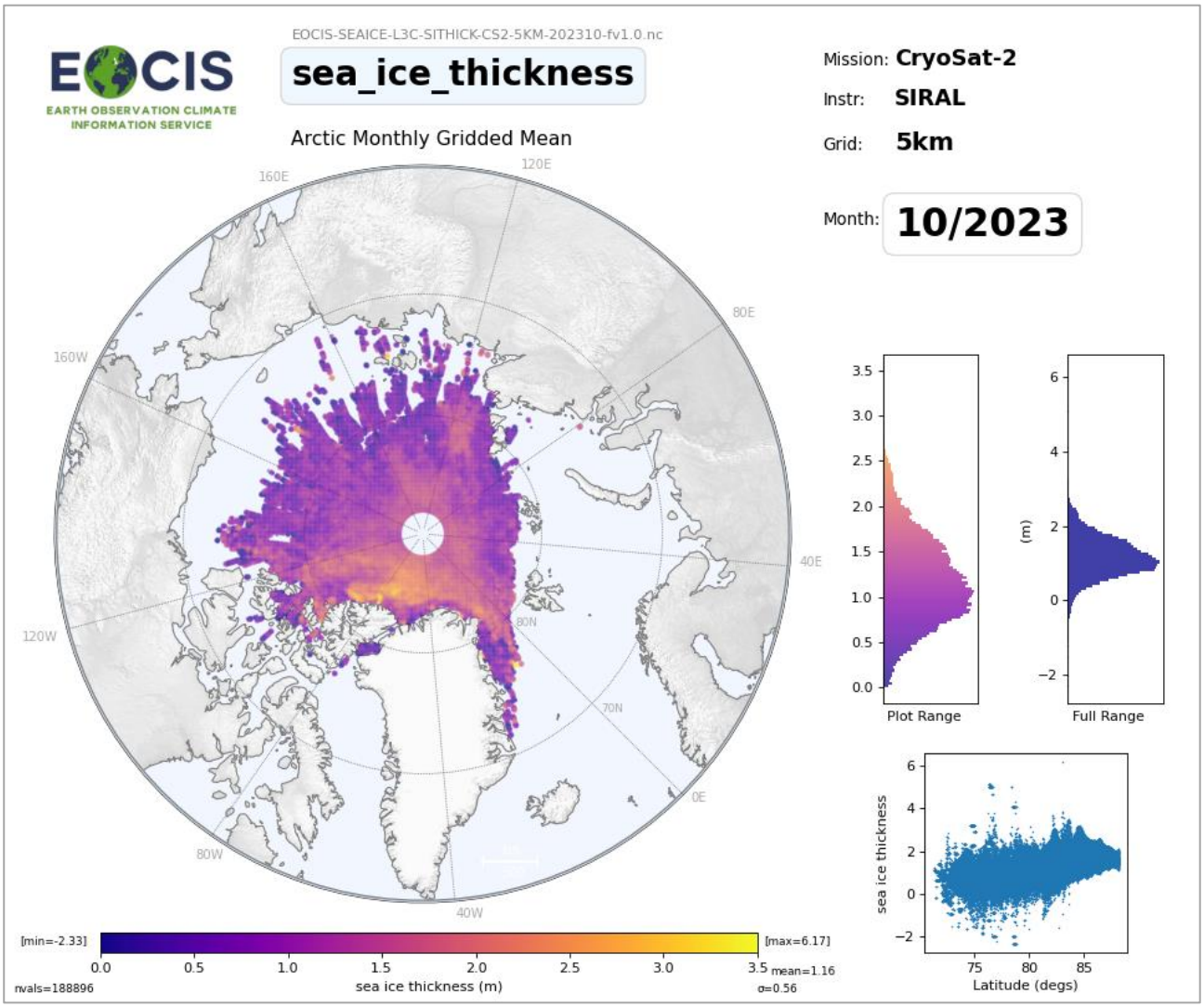
This produces the following plot:



1.6 Interactive visualisation / data access

Online data browsing and visualization tools are available on the product portal: www.cpom.ucl.ac.uk/eocis/seaice.

A typical product visualization of monthly Arctic sea ice thickness gridded product is shown below:



1.7 Your obligations when using these products

By accessing the Sea Ice Product, you agree to cite the dataset digital object identifier (doi) and corresponding journal article describing the dataset every time you publish results obtained in whole or in part by use of UK EOCIS products. These citations are given under Summary Information.

The reference to the dataset should mention "created by the UK Earth Observation Climate Information Service". The product name and acronym in Table 1 and should be used to avoid confusion and enable traceability.

1.8 Further Information

Sea ice thickness and subsequently volume and mass are measured using ESA CryoSat-2 radar altimetry data and complementary snow and ice density models.

The primary source of radar altimetry input data to the sea ice processor is ESA CryoSat L1b (Baseline-E).

The technique of measuring sea ice thickness from space (as described in Tiling et al, 2018) requires discrimination between radar height measurements of sea ice floes and leads (areas of ocean between sea ice). The difference between these measurements results in a radar freeboard measurement from which thickness can be estimated. During Arctic summer month, melt ponds form on the sea ice floes making it impossible (using standard techniques) to distinguish between floe and leads and calculate freeboard. For this reason, sea ice thickness, volume and mass are only calculated during the Arctic winter (Oct-May).

History of modifications / Change Log

Version	Date	Changes	Person
0.1	28-Apr-2023	Initial Draft	JM, AM
2.0	25-Apr-2024	Finalised document for published product.	JM, AM

Related Documents / Reference Documents

Document	Author	Reference
Product User Guide.		

Acronyms and/or Abbreviations

Acronym / Abbreviation	Definition

General definitions

Term	Definition

References

Aagaard, Ko, and Eddy C. Carmack. "The role of sea ice and other fresh water in the Arctic circulation." *Journal of Geophysical Research: Oceans* 94.C10 (1989): 14485-14498.

Serreze, Mark C., et al. "The large-scale freshwater cycle of the Arctic." *Journal of Geophysical Research: Oceans* 111.C11 (2006).

Sedlar, Joseph, et al. "A transitioning Arctic surface energy budget: the impacts of solar zenith angle, surface albedo and cloud radiative forcing." *Climate dynamics* 37 (2011): 1643-1660.

Singarayer, Joy S., Jonathan L. Bamber, and Paul J. Valdes. "Twenty-first-century climate impacts from a declining Arctic sea ice cover." *Journal of Climate* 19.7 (2006): 1109-1125.

Schweiger, A. J., et al. "Did unusually sunny skies help drive the record sea ice minimum of 2007?." *Geophysical Research Letters* 35.10 (2008).

Francis, Jennifer A., and Stephen J. Vavrus. "Evidence linking Arctic amplification to extreme weather in mid-latitudes." *Geophysical research letters* 39.6 (2012).

Vellinga, Michael, and Richard A. Wood. "Global climatic impacts of a collapse of the Atlantic thermohaline circulation." *Climatic change* 54.3 (2002): 251-267.