

Oceans Melting Greenland (OMG) Narwhals Ocean Mooring Data, Ver. 1

User's Guide

Data Set

OMG Narwhals Ocean Mooring Level 3 Data

Authors

Marie J. Zahn¹, Kristin L. Laidre^{2,3}, Malene Simon⁴, Ian Fenty⁵

¹School of Aquatic and Fishery Sciences, University of Washington, Seattle, WA 98105, USA

²Polar Science Center, Applied Physics Laboratory, University of Washington, Seattle, WA 98105, USA

³Department of Birds and Mammals, Greenland Institute of Natural Resources, 3900 Nuuk, Greenland

⁴Greenland Climate Research Centre, Greenland Institute of Natural Resources, 3900 Nuuk, Greenland

⁵Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109, USA

Abstract

NASA's Oceans Melting Greenland (OMG) campaign obtained oceanographic observations around Greenland at an unprecedented spatial scale and confirmed that the ocean plays a key role in Greenland glacier acceleration and retreat. Yet, ocean observations along Greenland's margins are biased toward summer months with relatively few year-round measurements. OMG Narwhals, a project coupled with NASA's OMG mission, seeks to understand the ecological importance of glacial habitats to narwhals. Narwhals return to glacial outlets and fjords each summer with high site fidelity but what attracts them to specific glacier fronts remains unclear. Between 2018 and 2020, five bottom-mounted moorings with marine mammal acoustic recorders and oceanographic instruments were deployed year-round near three glacier fronts: Sverdrup Glacier, Kong Oscar Glacier, and Rink Glacier. **This OMG Narwhals L3 dataset contains daily-averaged temperature and salinity measurements from CTD and temperature loggers from the same mooring.**

Citation

This research was conducted by the University of Washington, the Greenland Institute of Natural Resources, and the Jet Propulsion Laboratory, managed by the California Institute of Technology under a contract with the National Aeronautics and Space Administration. Use of these data should be cited as follows:

Zahn MJ, Laidre KL, Simon MJ, Fenty I. 2023. OMG Narwhals oceanographic data from moorings, 2018-2020. Ver. 1. PO.DAAC, CA, USA. Dataset accessed [YYYY-MM-DD] at <https://doi.org/10.5067/OMGNW-MOOR1>

Contact

For questions about access to the data product please email podaac@podaac.jpl.nasa.gov or visit the [PO.DAAC forum](#). For questions about the data product itself please email Marie Zahn, mzahn@uw.edu, or Ian Fenty, ian.fenty@jpl.nasa.gov.

Introduction

Mass loss of the Greenland ice sheet has contributed substantially to global sea level rise with impacts to local ecosystems and the global climate. The Greenland ice sheet connects to the ocean via hundreds of glaciers that terminate in deep troughs and valleys. These marine-terminating glaciers are important sites of heat transfer from the ocean to the ice through complex mechanisms shaped by the interaction between Arctic and Atlantic waters, local bathymetry, and atmospheric forcing. Over six years (2015–2021), NASA’s Oceans Melting Greenland (OMG) mission studied ice-ocean interactions around the entirety of Greenland by measuring ocean temperature and salinity, bathymetry, and ice elevations along the continental shelf. While OMG obtained observations at an unprecedented spatial scale, they were largely restricted to summer months and therefore could not adequately capture seasonal variability.

OMG Narwhals, a project coupled with NASA’s OMG mission and funded by the Office of Naval Research, deployed ocean moorings near three glacier fronts with known narwhal presence in Melville Bay, northwest Greenland spanning two years. The primary goal of OMG Narwhals is to understand the ecological importance of glacial habitats to narwhals. Greenland’s coastal margins are rich ecosystems that host a variety of marine organisms from fish to marine mammals. Narwhals return to glacial outlets and fjords each summer with high site fidelity but what attracts them to specific glacier fronts remains unclear. Between 2018 and 2020, five bottom-mounted moorings with a suite of instrumentation were deployed year-round near three glacier fronts: Sverdrup Glacier, Kong Oscar Glacier, and Rink Glacier. The moorings carried equipment with two primary objectives: 1) identify Arctic toothed whale (beluga and narwhal) presence using passive acoustic recorders to record their sounds, and 2) describe year-round hydrographic variability using oceanographic instruments. Moored hydrographic measurements provide foundational knowledge about how Melville Bay marine ecosystems evolve throughout the year.

Examination of water properties at these sites demonstrate the presence and seasonality of warm, salty Atlantic Water intrusion into Melville Bay tidewater glaciers. These data will be used to investigate what physical properties of glacier front marine ecosystems attract narwhals. Results from this work increase our understanding of narwhal habitat-use and Greenland ice-ocean interactions and enable improvements in observation methods to better monitor Arctic whales and Greenland’s surrounding oceans.

This Level 3 dataset contains daily-averaged hydrographic measurements from the same mooring that carried two CTDs and a series of temperature loggers. Five L3 datasets are available that pertain to each of the five moorings deployed at three stations in Melville Bay: Rink/Fisher, Kong Oscar, and Sverdrup.

Campaigns

The OMG Narwhals field effort spanned three years (2018–2020) where moorings were deployed and/or recovered in August each year. All mooring operations were conducted aboard the R/V *Sanna*.

Level 3 Product Generation

Daily averages were computed for all variables from L2 CTD and L1 temperature logger datasets. Daily mean CTD and temperature logger datasets from the same mooring were combined, producing five time averaged L3 datasets. Measurements that occurred during the deployment and recovery of the mooring (i.e., when the instrument was on the deck) and flagged data (see Figure 1) were removed. The

workflow used to generate these datasets is available on GitHub:
https://github.com/mjzahn/OMG_Narwhals_hydrography-manuscript/.

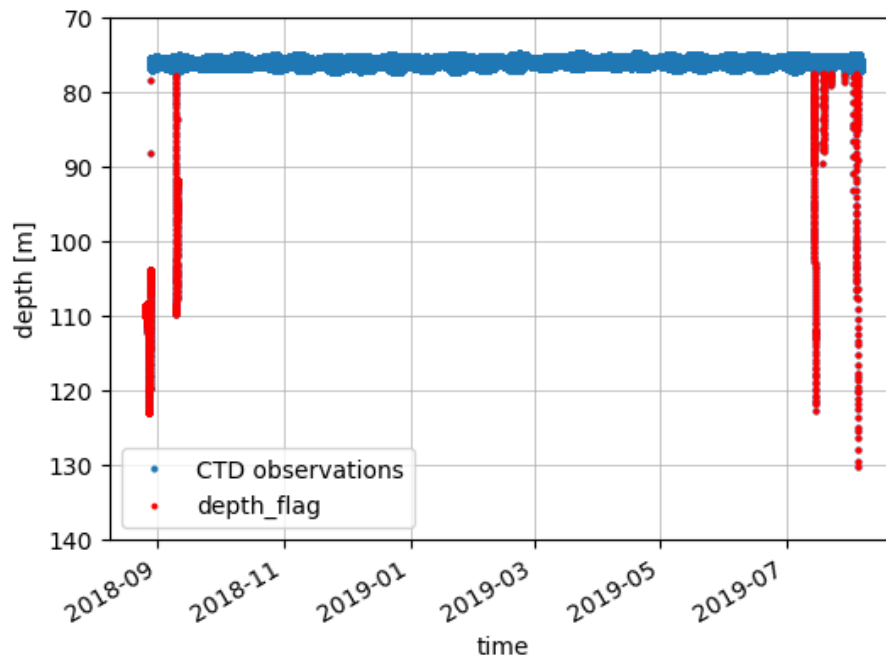


Figure 1. Example moored CTD L2 dataset showing depth measurements from the Rink Glacier mooring where flagged observations are shown in red, indicating occasions when the mooring (and instruments) were depressed in the water column. Flagged observations were removed for this L3 dataset.

Data Fields

Oceanographic Measurements

Conductivity

The conductivity variable contains sea water electrical conductivity measurements (S/m).

Salinity

The salinity variable contains sea water practical salinity (psu).

Temperature

The temperature variable contains sea water temperature measurements in °C.

Potential Temperature

The potential temperature variable contains sea water potential temperature measurements in °C.

Pressure

The pressure variable contains sea water pressure measurements in decibars.

Depth

The depth variable contains depth measurements in meters derived from pressure (positive=down).

Density

The density variable contains sea water density measurements in kg m⁻³.

Coordinate Fields

Station

Station is a dimensional coordinate (length=1) that indicates which of the three ocean mooring sites in Melville Bay (Rink/Fisher, Kong Oscar, or Sverdrup) the data were collected from.

Time

Time is a dimensional coordinate that defines the UTC time at which each measurement was taken.

Latitude

The latitude of the mooring and station location.

Longitude

The longitude of the mooring and station location.

NetCDF File Format

The file names for this dataset are of the form:

“OMG_Narwhals_Mooring_<station>_1D_L3_<time_coverage >.nc”

where <station> indicates which mooring the data are from (i.e., Rink/Fisher, Kong Oscar, or Sverdrup) and <time_coverage> refers to when (year) the mooring was deployed, formatted as “YYYY-YYYY”. The “1D” term defines the time resolution equal to one day. The data files are in NetCDF format and are compliant with the Climate and Forecast (CF) Metadata Conventions.

Each data file contains the following **data variables** and **metadata**:

Note: variables and metadata denoted with an ‘X’ represent values that differ depending on the mooring and instrument.

Dimensions and data variables:

dimensions:

```
station = 1 ;  
time = XXX ;  
depth_temperature = XX ;  
depth_CTD = 2 ;
```

variables:

```
string station(station) ;  
    station:long_name = "station" ;  
    station:standard_name = "station" ;  
    station:coverage_content_type = "coordinate" ;  
    station:comments = "One of three ocean mooring sites in Melville Bay: Rink/Fisher,  
                        Kong Oscar, and Sverdrup." ;
```

```
int time(time) ;  
    time:long_name = "time" ;  
    time:standard_name = "time" ;
```

```
time:axis = "T" ;
time:coverage_content_type = "coordinate" ;
time:units = "days since 2018-08-28 00:00:00" ;
time:calendar = "proleptic_gregorian" ;
```

```
int depth_temperature(depth_temperature) ;
depth_temperature:long_name = "temperature sensor depth" ;
depth_temperature:standard_name = "depth" ;
depth_temperature:units = "meters" ;
depth_temperature:positive = "down" ;
depth_temperature:axis = "Z" ;
depth_temperature:coverage_content_type = "coordinate" ;
depth_temperature:seabird_var_name = "depSM" ;
depth_temperature:valid_min = 0 ;
depth_temperature:valid_max = 1000 ;
depth_temperature:comments = "Depths of temperature sensors attached to mooring,
                               inclusive of CTD and temperature logger
                               instruments." ;
```

```
int depth_CTD(depth_CTD) ;
depth_CTD:long_name = "CTD depth" ;
depth_CTD:standard_name = "depth" ;
depth_CTD:units = "meters" ;
depth_CTD:positive = "down" ;
depth_CTD:axis = "Z" ;
depth_CTD:coverage_content_type = "coordinate" ;
depth_CTD:seabird_var_name = "depSM" ;
depth_CTD:valid_min = 0 ;
depth_CTD:valid_max = 1000 ;
depth_CTD:comments = "Depths of CTD instruments attached to mooring." ;
```

```
string serial_number_temperature(depth_temperature) ;
serial_number_temperature:long_name = "Temperature sensor instrument serial
                                       number" ;
serial_number_temperature:coverage_content_type = "auxiliaryInformation" ;
```

```
string serial_number_CTD(depth_CTD) ;
serial_number_CTD:long_name = "CTD instrument serial number" ;
serial_number_CTD:coverage_content_type = "auxiliaryInformation" ;
```

```
double latitude(station) ;
latitude:_FillValue = 9.96920996838687e+36 ;
latitude:long_name = "station latitude" ;
latitude:standard_name = "latitude" ;
latitude:units = "degrees_north" ;
latitude:coverage_content_type = "coordinate" ;
latitude:comments = "Latitude of mooring location." ;
```

```

double longitude(station) ;
    longitude:_FillValue = 9.96920996838687e+36 ;
    longitude:long_name = "station longitude" ;
    longitude:standard_name = "longitude" ;
    longitude:units = "degrees_east" ;
    longitude:coverage_content_type = "coordinate" ;
    longitude:comments = "Longitude of mooring location." ;

double temperature(time, depth_temperature) ;
    temperature:_FillValue = 9.96920996838687e+36 ;
    temperature:long_name = "sea water temperature" ;
    temperature:standard_name = "sea_water_temperature" ;
    temperature:units = "degrees_C" ;
    temperature:coverage_content_type = "physicalMeasurement" ;
    temperature:seabird_var_name = "tv290C" ;
    temperature:comments = "Daily-mean temperature from both CTD and temperature
        logger instruments." ;
    temperature:valid_min = -2.2 ;
    temperature:valid_max = 35. ;
    temperature:coordinates = "serial_number_temperature" ;

double salinity(time, depth_CTD) ;
    salinity:_FillValue = 9.96920996838687e+36 ;
    salinity:long_name = "sea water practical salinity" ;
    salinity:standard_name = "sea_water_practical_salinity" ;
    salinity:units = "1" ;
    salinity:coverage_content_type = "physicalMeasurement" ;
    salinity:seabird_var_name = "sal00" ;
    salinity:valid_min = 0. ;
    salinity:valid_max = 45. ;
    salinity:comments = "Daily-mean salinity from CTD instruments." ;
    salinity:coordinates = "serial_number_CTD" ;

double conductivity(time, depth_CTD) ;
    conductivity:_FillValue = 9.96920996838687e+36 ;
    conductivity:long_name = "sea water electrical conductivity" ;
    conductivity:standard_name = "sea_water_electrical_conductivity" ;
    conductivity:units = "S/m" ;
    conductivity:coverage_content_type = "physicalMeasurement" ;
    conductivity:seabird_var_name = "cond0S/m" ;
    conductivity:valid_min = 0. ;
    conductivity:valid_max = 6. ;
    conductivity:comments = "Daily-mean conductivity from CTD instruments." ;
    conductivity:coordinates = "serial_number_CTD" ;

double potential_temperature(time, depth_CTD) ;
    potential_temperature:_FillValue = 9.96920996838687e+36 ;
    potential_temperature:long_name = "sea water potential temperature" ;

```

```
potential_temperature:standard_name = "sea_water_potential_temperature" ;
potential_temperature:units = "degrees_C" ;
potential_temperature:coverage_content_type = "physicalMeasurement" ;
potential_temperature:seabird_var_name = "potemp090C" ;
potential_temperature:comments = "ITS-90; Daily-mean potential temperature from
                                CTD instruments." ;
potential_temperature:valid_min = -2.2 ;
potential_temperature:valid_max = 35. ;
potential_temperature:coordinates = "serial_number_CTD" ;
```

```
double pressure(time, depth_CTD) ;
pressure:_FillValue = 9.96920996838687e+36 ;
pressure:long_name = "sea water pressure" ;
pressure:standard_name = "sea_water_pressure" ;
pressure:units = "dBar" ;
pressure:coverage_content_type = "physicalMeasurement" ;
pressure:seabird_var_name = "prdM" ;
pressure:valid_min = 0. ;
pressure:valid_max = 1000. ;
pressure:comments = "Daily-mean pressure from CTD instruments." ;
pressure:coordinates = "serial_number_CTD" ;
```

```
double depth(time, depth_CTD) ;
depth:_FillValue = 9.96920996838687e+36 ;
depth:long_name = "depth" ;
depth:standard_name = "depth" ;
depth:units = "meters" ;
depth:positive = "down" ;
depth:axis = "Z" ;
depth:coverage_content_type = "coordinate" ;
depth:seabird_var_name = "depSM" ;
depth:valid_min = 0. ;
depth:valid_max = 1000. ;
depth:coordinates = "serial_number_CTD" ;
```

```
double density(time, depth_CTD) ;
density:_FillValue = 9.96920996838687e+36 ;
density:long_name = "sea water density" ;
density:standard_name = "sea_water_density" ;
density:units = "kg m-3" ;
density:coverage_content_type = "physicalMeasurement" ;
density:seabird_var_name = "density00" ;
density:valid_min = 999. ;
density:valid_max = 1045. ;
density:comments = "Daily-mean density from CTD instruments." ;
density:coordinates = "serial_number_CTD" ;
```

Metadata:

Global attributes:

:title = "OMG Narwhals <Station> <YYYY-YYYY> Ocean Mooring Level 3 Data" ;

:summary = "This file contains daily-averaged conductivity, temperature, and depth measurements from CTD and temperature logger instruments attached to the same mooring from one of three sites in Melville Bay, northwest Greenland. This dataset was collected by the Oceans Melting Greenland (OMG) Narwhals program that provides two years of oceanographic measurements. Between August 2018 to August 2020, three bottom-mounted moorings with a suite of instrumentation were deployed in front of three glaciers: Sverdrup Glacier, Kong Oscar Glacier, and Rink Glacier." ;

:keywords = "Conductivity, Salinity, Water Depth, Water Temperature" ;

:keywords_vocabulary = "NASA Global Change Master Directory (GCMD) Science Keywords" ;

:Conventions = "CF-1.8, ACDD-1.3" ;

:standard_name_vocabulary = "NetCDF Climate and Forecast (CF) Metadata Convention" ;

:id = "OMG_Narwhals_Mooring_XXXX_1D_L3_20XX-20XX" ;

:uuid = "XXXXXXXX-XXXX-XXXX-XXXX-XXXXXXXXXXXX" ;

:featureType = "timeSeries" ;

:cdm_data_type = "Station" ;

:platform = "mooring" ;

:region = "Melville Bay, northwest Greenland" ;

:glacier_front = "XXXX glacier" ;

:bottom_depth = "XXX meters" ;

:filename = "OMG_Narwhals_Mooring_XXXX_1D_L3_20XX-20XX.nc" ;

:history = "This dataset was created using CTD L2 datasets and temperature logger L1 datasets to combine observations from the same mooring." ;

:source = "Temperature and salinity data were collected using Conductivity Temperature Depth (CTD) and temperature logger instruments purchased from Sea-Bird Electronics, Inc. that were attached to the same mooring." ;

:processing_level = "L3" ;

:acknowledgement = "This research was carried out by the University of Washington's Applied Physics Laboratory and School of Aquatic and Fishery Sciences, the Greenland Climate Research

Centre/Greenland Institute of Natural Resources, and the Jet Propulsion Laboratory, managed by the California Institute of Technology under a contract with the National Aeronautics and Space Administration. This research was funded by the US Office of Naval Research (award no. N00014-17-1-2774) and the NASA Oceans Melting Greenland EVS-2 mission.";

```
:license = "Public Domain" ;  
:product_version = "1.0" ;  
:creator_name = "Marie J. Zahn" ;  
:creator_email = "mzahn@uw.edu" ;  
:creator_type = "person" ;  
:creator_institution = "University of Washington" ;  
:institution = "University of Washington" ;  
:project = "Oceans Melting Greenland (OMG) Narwhals" ;  
:contributor_name = "Marie J. Zahn, Kristin L. Laidre, Malene J. Simon, Ian Fenty" ;  
:contributor_role = "author, principal investigator, co-investigator, co-investigator" ;  
:contributor_email = "mzahn@uw.edu; klaidre@uw.edu; masi@natur.gi;  
ian.fenty@jpl.nasa.gov" ;  
:naming_authority = "gov.nasa.jpl" ;  
:program = "NASA Earth Venture Suborbital-2 (EVS-2) and Office of Naval Research (ONR)  
Marine Mammals and Biology Program" ;  
:publisher_name = "Physical Oceanography Distributed Active Archive Center (PO.DAAC)" ;  
:publisher_institution = "NASA Jet Propulsion Laboratory (JPL)" ;  
:publisher_email = "podaac@podaac.jpl.nasa.gov" ;  
:publisher_url = "https://podaac.jpl.nasa.gov/" ;  
:publisher_type = "group" ;  
:geospatial_lat_min = XX.XXXXXX;  
:geospatial_lat_max = XX.XXXXXX;  
:geospatial_lat_units = "degrees_north" ;  
:geospatial_lon_min = XX.XXXXXX;
```

:geospatial_lon_max = XX.XXXXXX;
:geospatial_lon_units = "degrees_east" ;
:geospatial_vertical_min = XXX;
:geospatial_vertical_max = XXX;
:geospatial_vertical_units = "meters" ;
:geospatial_vertical_positive = "down" ;
:time_coverage_start = "20XX-XX-XXT00:00:00" ;
:time_coverage_end = "20XX-XX-XXT00:00:00" ;
:time_coverage_duration = "PXXXDT0H0M0S" ;
:date_created = "20XX-XX-XXTXX:XX:XX" ;
:instrument = "SBE37SM-RS232; SBE56" ;
:time_coverage_resolution = "P1D" ;