A monthly gridded oxygen product for a Labrador Sea basin transect from August 2020 to July 2022

Website: https://www.bco-dmo.org/dataset/995975
Data Type: model results
Version: 1
Version Date: 2026-05-14

Project
» Collaborative Research: Gases in the Overturning and Horizontal circulation of the Subpolar North Atlantic Program (GOHSNAP) (GOHSNAP)

Contributors	Affiliation	Role
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Abstract
This is a monthly gridded oxygen product for a transect across the Labrador Sea from August 2020 to July 2022, which was designed to calculate oxygen transport across this line. This product is created using a random forest regression trained on data from 60 carefully-calibrated oxygen optodes deployed along this line during this period. This algorithm was validated using both ship CTD and BGC-Argo oxygen profiles. The transect follows the OSNAP West line and provides mean monthly oxygen values across the entire water column.

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Coverage

Location: Transect across Labrador Sea (OSNAP West line) from surface to bottom
Spatial Extent: **N**:60.19 **E**:-45.09 **S**:52.02 **W**:-56.88
Temporal Extent: 2020-08-15 - 2022-07-15

Dataset Description

Summary of datasets used for model training and testing. Full citation and doi links of these datasets can be found in the "Related Dataset" section below.

Training and testing the random forest (RF) model

- Mean, daily oxygen values from 60 calibrated optodes - GOHSNAP moored oxygen timeserie (Miller et al., 2026)

Predictor variables

- Co-located CTD data associated with GOHSNAP moored oxygen timeseries (Miller et al., 2026)
- OSNAP gridded temperature and salinity fields (Fu et al., 2025)
- GEBCO 2025 Gridded Bathymetry Data (GEBCO Bathymetric Compilation Group 2025 (2025)

Validation

- AR45 CTD oxygen profiles (Fogaren & Palevsky, 2024)
- AR46 CTD oxygen profiles (Fogaren & Palevsky, 2023)
- AR69-01 CTD oxygen profiles (Fogaren & Palevsky, 2023)
- AR69-03 CTD oxygen profiles (Fogaren & Palevsky, 2024)
- MSM94 CTD oxygen profiles (Karstensen & Krahmann, 2023)
- M184 CTD oxygen profiles (Karstensen & Krahmann, 2025)
- BGC-Argo oxygen profiles (Argo, 2026)

Bias correction

- World Ocean Atlas oxygen data, version 2018 (Reagan et al., 2023)

Methods & Sampling

60 calibrated and drift-corrected optodes deployed on the OSNAP array (for details on calibration see Miller et al., 2025) were used in this study. These optodes sampled every 15 minutes for the length of the 2-year deployment. Mean daily oxygen values from all 60 optodes spanning the 2-year deployment period (summer 2020-summer 2022) were used in this study. The dataset can be accessed at Miller et al., 2026.

The oxygen optodes were deployed with co-located CTD sensors (SBE37 microcats) for the duration of the 2-year deployment as a part of OSNAP. These co-located CTD sensors are used to generate daily and monthly, gap-free, gridded temperature and salinity fields across the OSNAP West and East lines (Fu et al., 2025). OSNAP data were collected and made freely available by the OSNAP (Overturning in the Subpolar North Atlantic Program) project and all the national programs that contribute to it (o-snap.org).

Instruments used:
* Oxygen optodes: Aanderaa 4330 optodes integrated with RBR loggers
* CTD sensors co-located with oxygen optodes: SBE37 microcats
* CTD sensors from shipboard profiles depend on specific cruise and research vessel. Please see relevant cruise reports for specifics.
* BGC-Argo oxygen: Floats are equipped with oxygen optodes. The specific model (i.e. Aanderaa vs. SBE) depends on the float type. Data calibration and processing also depends on the float owner. For additional information see Thierry et al, 2025 (related publications).
* Winkler-calibrated CTD oxygen profiles from optode deployment and recovery cruises were used to validate the trained random forest.

Data Processing Description

Mean, daily oxygen values from 60 calibrated optodes deployed on the OSNAP array (for details on calibration see Miller et al., 2025) were used to train a random forest (RF) regressor to estimate oxygen from temperature, salinity, depth, longitude, bathymetry, year and day of year. Daily temperature and salinity measurements came from co-located CTDs that were deployed at the same depth as every optode. Bathymetry data was obtained from GEBCO. For all datasets, the bathymetric depth was assigned using nearest-neighbor to the closest GEBCO grid point. No quality control filters were applied to the training data, and data were not normalized, etc. prior to training the RF, as this is not required for this machine learning algorithm.

A random 80% of the data set was used for training the random forest, and the remaining 20% was used for testing the random forest. The root-mean-squared error (RMSE) for training and testing was 2.5 µmol/kg and

2.9 µmol/kg, respectively. The trained RF can be accessed through github/zenodo: Ellen Park, 2026 (see related software).

The trained RF was validated by applying the RF to multiple validation datasets and comparing the RF-predicted oxygen values to the true oxygen values from these datasets. The following datasets were used for validation: 1) CTD oxygen profiles from deployment and recovery cruises (AR-45 (n = 150 profiles), AR-46 (n = 18 profiles), AR69-01 (n = 14 profiles), AR69-03 (n = 113 profiles), MSM94 (n = 23 profiles), M184 (n = 23 profiles)) within 50km of the OSNAP West line and 2) BGC-Argo oxygen profiles within +/- 3 degrees latitude and +/- 1.5 degrees longitude of the OSNAP West line with data with quality-control flags of 1, 2, or 8 (n = 219 profiles). The RMSEs for each data set are as follows: AR-45 (7.8 µmol/kg), AR-46 (6.6 µmol/kg). AR69-01 (n = 3.4 µmol/kg), AR69-03 (6.8 µmol/kg), MSM94 (4.6 µmol/kg), M184 (4.3 µmol/kg), and BGC-Argo (5.3 µmol/kg).

The trained RF was then applied to the daily OSNAP gridded temperature and salinity fields and averaged to generate monthly oxygen estimates for this line. These daily temperature and salinity fields are gap-free and generated CTDs deployed across the OSNAP array using objective analysis (see Lozier et al., 2019 and Fu et al., 2023) at ~0.1º longitude and 20m resolution from the surface to bottom. Monthly versions of temperature and salinity fields are available (Fu et al., 2025). OSNAP data were collected and made freely available by the OSNAP (Overturning in the Subpolar North Atlantic Program) project and all the national programs that contribute to it (o-snap.org).

BCO-DMO Curation Notes

* added summary description of all datasets used for this model (reviewed by submitter)

Problem Description

We identified a potential bias in the RF predicted oxygen in the Denmark Strait Overflow Water (DSOW) due to a limited number of observations in this water mass. As a result a bias term (defined for the western, central, and eastern Labrador Sea) was included. This bias term was defined using World Ocean Atlas and CTD oxygen profiles from deployment and recovery. Both are included in this dataset and should be added (ex: DOXY + DOXY_BIAS_WOA) to get the final oxygen product. This bias term only applies to data with a potential density greater than 1028.XX kg/m3.

The gridded monthly OSNAP temperature and salinity sections are a part of Fu et al., 2025. They only publish monthly values, but the daily values are used to create these sections. We received the daily values from the scientists but they are not freely available.

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Data Files

File

gohsnap_doxy_final.nc (NetCDF, 19.91 MB)
MD5:cd0b1bc67cf90582b31d5c629403b9e2

Monthly, gridded estimates of dissolved oxygen along the OSNAP West section from August 2020 through July 2022. Oxygen is stored as a three-dimensional field with dimensions time (24 monthly steps), depth (199 levels from 15 m to 3975 m at 20 m spacing), and along-section position (78 points defined by longitude). Latitude is provided as a coordinate paired with longitude. The primary variable, DOXY, represents dissolved oxygen concentration (µmol kg^{-1}) estimated using a validated random-forest regression model.

Coordinates
* TIME : Monthly time stamps (datetime64)
* DEPTH: Water column depth (m)
* LONGITUDE: Longitude of points (degrees east),
* LATITUDE: Latitude corresponding to each longitude point (degrees north).

Data variables
* DOXY (TIME, DEPTH, LONGITUDE): Random forest predicted oxygen (µmol/kg)
* DOXY_ERROR_SE (TIME, DEPTH, LONGITUDE): Oxygen standard error calculated from the daily oxygen values (µmol/kg)
* DOXY_ERROR_RF (TIME, DEPTH, LONGITUDE): Oxygen error calculated estimated as a function of potential density (µmol/kg)
* DOXY_ERROR_TOTAL (TIME, DEPTH, LONGITUDE):Total error defined as the square root of (DOXY_ERROR_SE^2 + DOXY_ERROR_RF^2) (µmol/kg)
* SIGMA0 (TIME, DEPTH, LONGITUDE): Potential density (kg/m^3)
* DOXY_BIAS_WOA (TIME, DEPTH, LONGITUDE):Bias in Denmark Strait Overflow Water oxygen derived from WOA18 (µmol/kg)
* DOXY_BIAS_CTD (TIME, DEPTH, LONGITUDE): Bias in Denmark Strait Overflow Water oxygen derived from CTD oxygen profiles from deployment and recovery cruises (µmol/kg)

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Related Publications

Ellen Park. (2026). *ellenrpark/gohsnap_rf: v1.0.0* (Version v1.0.0) [Computer software]. Zenodo. https://doi.org/10.5281/ZENODO.19486861 https://doi.org/10.5281/zenodo.19486861
Software

Miller, U. K., Fogaren, K. E., Atamanchuk, D., Johnson, C., Koelling, J., Le Bras, I., Lindeman, M., Nagao, H., Nicholson, D. P., Palevsky, H., Park, E., Yoder, M., & Palter, J. B. (2024). Oxygen optodes on oceanographic moorings: recommendations for deployment and in situ calibration. Frontiers in Marine Science, 11. https://doi.org/10.3389/fmars.2024.1441976
Methods

Overturning in the Subpolar North Atlantic Program. (n.d.). OSNAP. https://www.o-snap.org/
References

Thierry Virginie, Bittig Henry, The Argo-Bgc team (2025). Argo quality control manual for dissolved oxygen concentration. Argo-BGC group. https://doi.org/10.13155/46542
Methods

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Related Datasets

IsRelatedTo

Argo. (2026). *Argo float data and metadata from Global Data Assembly Centre (Argo GDAC)* [Dataset]. SEANOE. https://doi.org/10.17882/42182

Boyer, Tim P.; García, Hernán E.; Locarnini, Ricardo A.; Zweng, Melissa M.; Mishonov, Alexey V.; Reagan, James R.; Weathers, Katharine A.; Baranova, Olga K.; Paver, Christopher R.; Seidov, Dan; Smolyar, Igor V. (2018). World Ocean Atlas 2018. [indicate subset used]. NOAA National Centers for Environmental Information. Dataset. https://www.ncei.noaa.gov/archive/accession/NCEI-WOA18. Accessed [date]

Fogaren, K. E., Palevsky, H. I. (2023) **Bottle-calibrated dissolved oxygen profiles from yearly turn-around cruises for the Ocean Observations Initiative (OOI) Irminger Sea Array 2014 – 2022.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2023-

07-19 doi:10.26008/1912/bco-dmo.904721.1 [view at BCO-DMO]
Relationship Description: Dataset used for validation: cruise AR-46 (n = 18 profiles) and AR69-01 (n = 14 profiles)

Fogaren, K. E., Palevsky, H. I. (2024) **Bottle-calibrated dissolved oxygen (DO) profiles from US Overturning in the Subpolar North Atlantic Program (OSNAP) cruises in 2020 and 2022 (AR45 and AR69-03).** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2024-08-30 doi:10.26008/1912/bco-dmo.933743.1 [view at BCO-DMO]
Relationship Description: Dataset used for validation: cruise AR-45 (n = 150 profiles) and AR69-03 (n = 113 profiles)

Fu, Y., Lozier, M. S., Bower, A. S., Burmeister, K., Biló, T. C., Cyr, F., et al. (2025). Meridional Overturning Circulation Observed by the Overturning in the Subpolar North Atlantic Program (OSNAP) Array from August 2014 to July 2022. Georgia Tech Digital Repository. https://doi.org/10.35090/gatech/78023

GEBCO Bathymetric Compilation Group 2025. (2025). *The GEBCO_2025 Grid - a continuous terrain model for oceans and land at 15 arc-second intervals* (Version 7) [Data set]. NERC EDS British Oceanographic Data Centre NOC. https://doi.org/10.5285/37C52E96-24EA-67CE-E063-7086ABC05F29 https://doi.org/10.5285/37c52e96-24ea-67ce-e063-7086abc05f29

Karstensen, J., & Krahmann, G. (2023). *Physical oceanography (CTD) during Maria S. Merian cruise MSM94* [Data set]. PANGAEA. https://doi.org/10.1594/PANGAEA.963675

Karstensen, J., Krahmann, G., & Dilmahamod, A. F. (2025). *Physical oceanography (CTD) during METEOR cruise M184* [Data set]. PANGAEA. https://doi.org/10.1594/PANGAEA.986330

Miller, U. K., Palter, J. B., Fogaren, K. E., Atamanchuk, D., Johnson, C., Koelling, J., Le Bras, I., Lindeman, M., Nagao, H., Nicholson, D. P., Palevsky, H. I., Park, E., Yoder, M. (2026) **Dissolved oxygen time series measured on the Overturning in the Subpolar North Atlantic Program (OSNAP) moorings within the boundary currents of the Labrador and Irminger Seas from summer 2020 to summer 2022.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2025-10-13 doi:10.26008/1912/bco-dmo.986667.1 [view at BCO-DMO]
Relationship Description: 60 calibrated and drift-corrected optodes deployed on the OSNAP array

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Parameters

Parameters for this dataset have not yet been identified

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Deployments

AR45

Website	https://www.bco-dmo.org/deployment/933794
Platform	R/V Neil Armstrong
Report	https://doi.org/10.35090/gatech/66767
Start Date	2020-06-23
End Date	2020-08-01

AR46

Website	https://www.bco-dmo.org/deployment/904871
Platform	R/V Neil Armstrong
Start Date	2020-08-07
End Date	2020-09-07

AR69-01

Website	https://www.bco-dmo.org/deployment/904879
Platform	R/V Neil Armstrong
Start Date	2022-06-20
End Date	2022-07-19

AR69-03

Website	https://www.bco-dmo.org/deployment/933797
Platform	R/V Neil Armstrong
Report	https://cchdo.ucsd.edu/cruise/33VB20220819
Start Date	2022-08-19
End Date	2022-09-24

MSM94

Website	https://www.bco-dmo.org/deployment/990149
Platform	R/V Maria S. Merian
Report	https://www.ldf.uni-hamburg.de/merian/wochenberichte/wochenberichte-merian/msm94-msm97-2/exp-msm94.pdf
Start Date	2020-08-02
End Date	2020-09-06

M184

Website	https://www.bco-dmo.org/deployment/990154
Platform	R/V Meteor
Report	https://www.ldf.uni-hamburg.de/meteor/wochenberichte/wochenberichte-meteor/m181-m190/scr-m184.pdf
Start Date	2022-08-12
End Date	2022-09-15

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Project Information

Collaborative Research: Gases in the Overturning and Horizontal circulation of the Subpolar North Atlantic Program (GOHSNAP) (GOHSNAP)

Coverage: Subpolar North Atlantic

NSF Award Abstract:
Every winter, frigid winds blowing eastward from the North American continent cool the surface waters of the Labrador Sea, which is situated between Canada and Greenland. As the ocean cools, oxygen and carbon

dioxide are mixed from the atmosphere into a thick layer of water that ultimately spreads southward to fill a large volume of the North Atlantic and beyond. The presence of this water mass prevents the North Atlantic anywhere from becoming completely devoid of oxygen. Vertical mixing in the Labrador Sea also redistributes carbon dioxide into the deep ocean, where it can remain for hundreds of years, preventing it from contributing to the greenhouse effect. Yet, the processes governing the uptake of gases by the ocean are not well understood or quantified. Given that, over the last century, the ocean has become steadily more depleted in oxygen while also absorbing a large fraction of anthropogenic carbon dioxide, observing gas exchange processes is essential for understanding and predicting the evolution of the ocean and climate system. The circulation of the Labrador Sea has been monitored since 2014 with an array of instrumented cables extending from the seafloor to nearly the ocean surface. This project adds gas sensors to this array to investigate the rates and processes governing gas exchange. Through this project, a student and postdoc will be trained in interdisciplinary oceanography with a rich network of international collaborators. Responding to the need to increase public ocean literacy, the project scientists will work with University of Rhode Island's Inner Space Center to broadcast live, interactive science sessions to educators at partner high schools and will follow-up with in-person science cafés at three participating schools.

Given the unique role of the Labrador Sea in providing a pathway for oxygen (O2) and carbon dioxide (CO2) to enter the intermediate depths of the ocean, a quantification and mechanistic understanding of the gas uptake and transport in the basin is a leading scientific priority. Oxygenation of Labrador Sea water prevents large-scale hypoxia from developing anywhere in the Atlantic Ocean and anthropogenic CO2 storage in the basin is the highest in the global ocean. The assumption that, in the Atlantic Ocean, O2 and CO2 uptake and their variability are tied to the dynamics of heat loss and the overturning circulation pervades the literature but has never been evaluated on the basis of direct observations. Thus, GOHSNAP (Gases in the Overturning and Horizontal circulation of the Subpolar North Atlantic Program) addresses this gap and the urgent need to better understand interactions between gas uptake, transport, and the overturning circulation. Specifically, this program will provide a continuous 2-year record of the trans-basin, full water column transport of O2 across the southern boundary of the Labrador Sea, leveraging the mooring infrastructure of the US-lead, international Overturning in the Subpolar North Atlantic Program (OSNAP). The addition of O2 sensors at various depths on this array, supplemented by observations collected by autonomous platforms will allow for the quantification of O2 export from the Labrador Sea. The data will further be used to empirically model carbon concentrations and estimate carbon export. Proposed instruments will also measure the mixed layer O2 and pCO2 for two winters, from which air-sea gas exchange will be calculated and compared against analogous observations in the convective interior of the Labrador Sea.

This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1947829
NSF Division of Ocean Sciences (NSF OCE)	OCE-1947567

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