Marginal Ice Zone 2014 Field Campaign, Version 1

USER GUIDE

How to Cite These Data

As a condition of using these data, you must include a citation:

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National Snow and Ice Data Center

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1 DATA DESCRIPTION

1.1 Summary

The U.S. Office of Naval Research (ONR) Marginal Ice Zone Departmental Research Initiative (DRI) program was conducted to better understand the atmosphere-ice-ocean interactions that are taking place as ice in the Beaufort Sea retreats in summer and a seasonal marginal ice zone (MIZ) evolves. The research initiative field program took place in the summer of 2014. The program employed an extensive array of instrumentation, with drifting, mobile, and moored autonomous platforms. Instruments deployed on and under the ice sampled through the melt season as platforms drifted westward and the ice retreated northward.

Along with data from the Arctic Sea State 2015 Field Campaign, which had an objective of better understanding how waves and ice interact as ice advances in the fall, the MIZ DRI data collection allows in-depth study of thermodynamic and dynamic processes that govern the seasonal evolution of the rapidly changing marginal ice zone in the Beaufort Sea (Lee, C.M., Thomson, J., and the Marginal Ice Zone and Arctic Sea State Teams, 2017).

Data collected in this data set have undergone analysis by MIZ team investigators. Not all data collected for or used by the MIZ program are included here. For example, this collection does not include MIZ-related numerical simulations and remote sensing imagery.

Detailed information about the campaign can be found in the MIZ Program Science and Experiment Plan (Lee et al., 2012). It includes succinct and accessible background on motivation for the MIZ program, a summary of previous investigations, and an overview of processes within the seasonal MIZ, in addition to detailing the experiment strategy and objectives.

1.2 Parameters

This data set holds the following instrument data:

- *Autonomous Ocean Flux Buoys (AOFB):* Velocity, temperature, and salinity
- *Seaglider autonomous profilers*: Profiles of temperature and salinity
- *Surface Wave Instrument Float with Tracking (SWIFT) drifters:* Peak wave period, peak wave direction, significant wave height, and wave energy spectral density as a function of frequency, as well as ocean surface salinity and temperature, ocean surface drift, surface winds, and temperature at 1 m height
- *Wave buoys*: Wave energy spectral density, significant wave height, and peak wave period
- *Wave Glider*: Peak wave period, peak wave direction, significant wave height, wind speed, wind direction

A KML file that includes the position of instruments throughout the experiment is also included.

1.3 Background

The MIZ is defined by the World Meteorological Organization (WMO) as “the region of an ice cover which is affected by waves and swell penetrating into the ice from the open ocean” (WMO, 2014). In early spring of 2014, a large group of investigators deployed instruments on ice in the Beaufort Sea (Figure 1). An international team, lead by the Applied Physics Laboratory at the University of Washington (APL-UW), representing more than a dozen organizations took part in the research program for which data were acquired. The focus of the ONR-sponsored MIZ DRI was to better understand the physics of air-ice-ocean interaction as the ice in the Beaufort Sea breaks up and retreats in the spring, forming a seasonal MIZ. The nature of these interactions may be changing as the Arctic warms, the expanse of the Beaufort Sea occupied by open water grows, and ice extent shrinks.

While the MIZ DRI focused on the physics of ice breakup in the spring, the Sea State DRI, another ONR-sponsored program led by APL-UW, focused on wave and ice interactions in fall, as ice advances. Taken together, the research and data from these programs give a picture of ice-ocean-atmosphere interactions near and into the ice edge, from pre-breakup in March, to autumn freeze-up.

The science objectives of the MIZ program are to

- Understand the physics that control sea ice breakup and melt in and around the ice edge.
- Characterize changes in physics associated with decreasing ice/increasing open water.
- Explore feedbacks in the ice-ocean-atmosphere system that might increase or decrease the speed of sea ice decline.
- Collect a benchmark data set for refining and testing models.

Under the sponsorship of ONR, NSIDC is serving as the long-term archive and distribution point for most MIZ-program in situ field experiment data. The data we hold may duplicate some of the data held in other archives. These archives are listed under the RELATED WEB SITES section.

Data from five Ice-Tethered Profiler instruments are archived by the NOAA National Centers for Environmental Information. They are Ice-Tethered Profiler 70, 77, 78, 79, and 80.

For more information on the motivation for and background of the MIZ study, see MIZ Program: Science and Experiment Plan (Lee et al., 2012), with sections on *Previous Investigations of the Permanent MIZ* and *Processes in the Seasonal MIZ* as well as detailed sections on the experiment strategy.

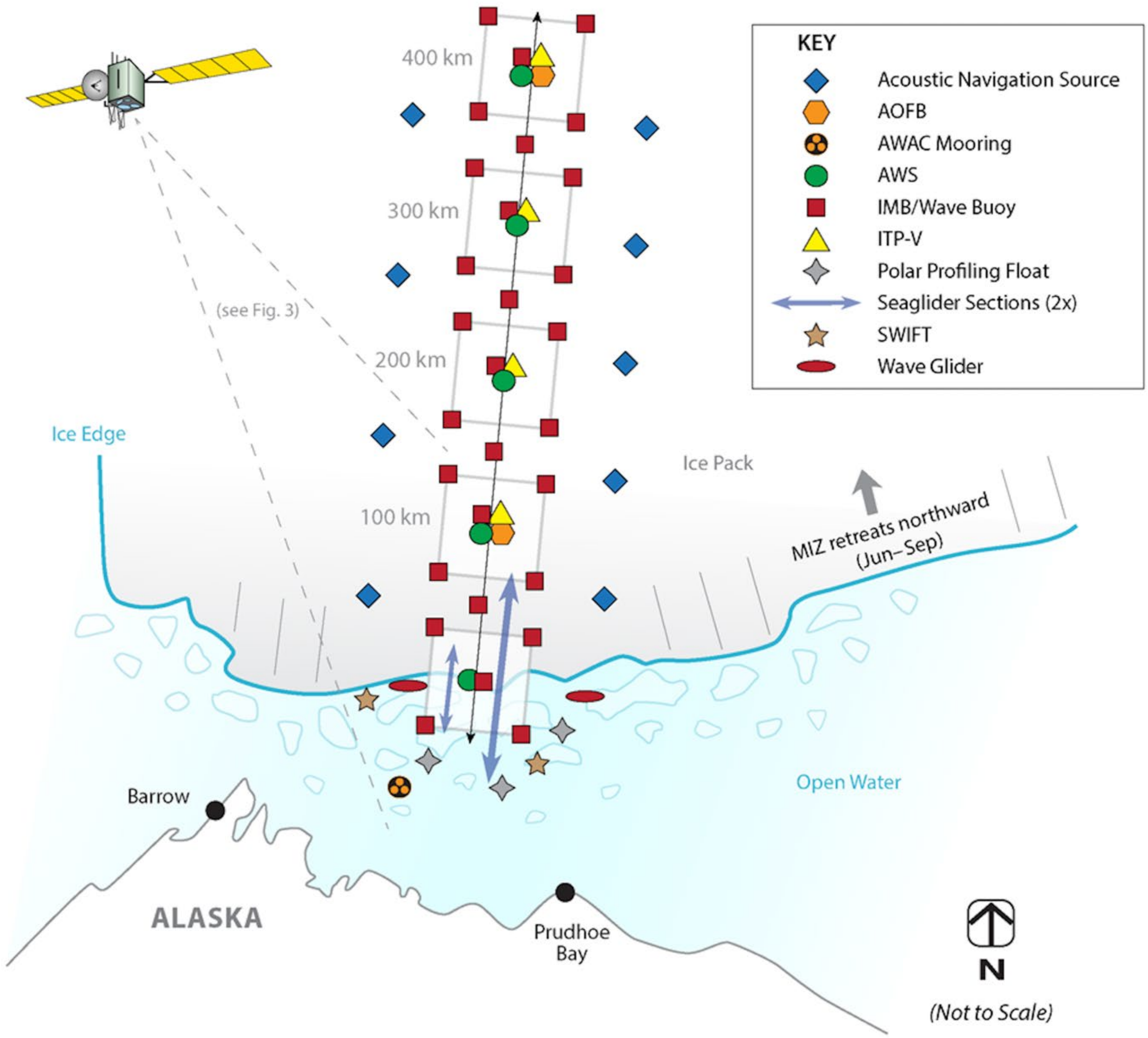

Figure 1. The planned, idealized configuration of MIZ program instrument arrays is shown here. The actual, deployed arrays deformed as the ice drifted westward. Figure from Lee et al. (2012).

1.4 Temporal and Spatial Information

The Experiment Plan describes the strategy used to access both fully ice-covered regions and MIZ regions of the Beaufort Sea over spring and summer as ice breaks up and retreats in 2014 (Lee et al., 2012, pg. 15). The Seaglider, Waveglider, and SWIFT instruments were deployed and recovered by ship. These instruments sampled from July 2014 into September 2014 with an intensive observing period that began in March 2014 and extended to September 2014. The AOFBs sampled from their deployment by aircraft in March 2014 until they stopped transmitting data, which is August 2014 for the two buoys included here. The wave buoys were deployed by aircraft. We have wave buoy data that begins in September 2014 and extends into October 2014. Table 1 lists the exact dates of the data acquisition by each instrument.

Table 1. Temporal Coverage of each Instrument

Instrument	Temporal Coverage
AOFB	Buoy 32: 18 March 2014 to 23 August 2014 Buoy 33: 10 March 2014 to 2 August 2014
Seagliders	27 July 2014 to 1 October 2014
SWIFT Drifters	SWIFT 10: 27 July 2014 to 14 September 2014 SWIFT 11: 27 July 2014 to 28 September 2014
Wave buoys	Buoy 201: 2 September 2014 to 21 September 2014 Buoy 202: 15 September 2014 to 11 October 2014 Buoy 206: 15 September 2014 to 4 October 2014 Buoy 207: 2 September 2014 to 17 September 2014 Buoy 211: 9 September 2014 to 20 September 2014 Buoy 212: 2 September 2014 to 4 October 2014 Buoy 213: 15 September 2014 to 1 October 2014 Buoy 214: 16 September 2014 to 17 September 2014 Buoy 215: 9 September 2014 to 21 September 2014
Wave glider	28 July 2014 to 18 September 2014.

1.5 File Information

The data files are organized into five directories by instrument type: AOFB, Seaglider, SWIFT, WaveBuoy, and Waveglider. A KML file with the instrument tracks resides in the top-level directory. To help give context to the intent of the data, each data type's description in the Instruments and Parameters Measured sections below begins with a quote about the deployment strategy for the collecting instrument that comes from the Experiment Plan (Lee et al., 2012).

1.5.1 Autonomous Ocean Flux Buoy (AOFB) Data

1.5.1.1 Format, Contents, and Naming Convention

The data are provided in two CSV files one for each of the buoys, 32 and 33, located in the `AOFB` directory: `buoy32_flux.csv` and `buoy33_flux.csv`. Table 2 describes the columns included in the AOFB data files. Note that we are unable to provide any information about these data other than what is included here.

Table 2. Variables in the AOFB files

Variable Name	Variable Description
Time (yyyyddd)	Year and decimal day (yyyyddd.dddd)
Latitude (deg)	Latitude (decimal degrees) -9999 for missing
Longitude (deg)	Longitude (decimal degrees) -9999 for missing

Variable Name	Variable Description
U (m/s)	Current velocity, U component (meters per second)
V (m/s)	Current velocity, V component (meters per second)
T (C)	Water temperature at depth (deg C)
S (psu)	Salinity at depth (psu)

Buoy 32 data begin on 18 March 2014 and end on 23 August 2016. Buoy 33 data begin on 10 March 2014 and end on 2 August 2014.

1.5.1.2 Instruments and Parameters Measured

… Autonomous Ocean Flux Buoys [AOFBs] will quantify vertical turbulent fluxes […] from the spring formation of the MIZ through the summertime sea ice retreat. Each buoy measures thermal structure from 5-m depth up into the ice, and measures the vertical fluxes of heat, salt, and momentum near the top of the ocean mixed layer to determine entrainment fluxes and summertime solar heating fluxes over month–year time scales. --From Lee et al. (2012, pg. 26)

NSIDC archives data from two AOFB instruments: Buoy 32 and Buoy 33. Note that the archived data are not the complete set of data as set forth in Lee et al. (2012). Figure 2 illustrates the AOFB instrument package. Figure 3 shows the tracks of the two instruments during the MIZ experiment.

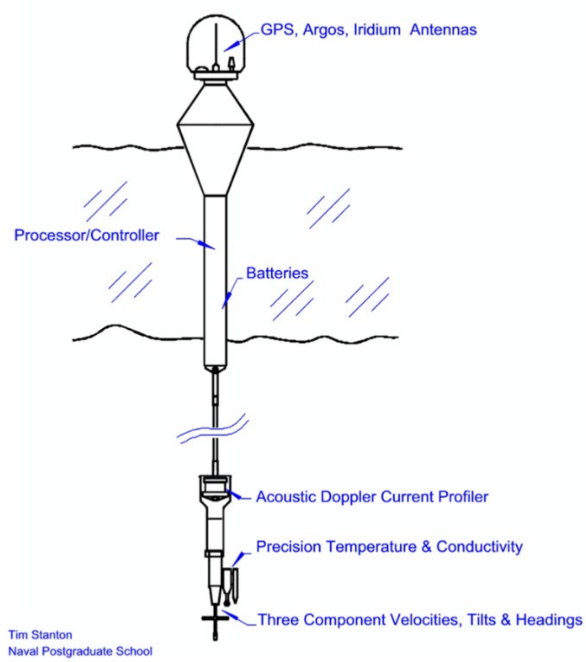

Figure 2. The autonomous flux buoy instrument package. (Figure from Lee et al. (2012).

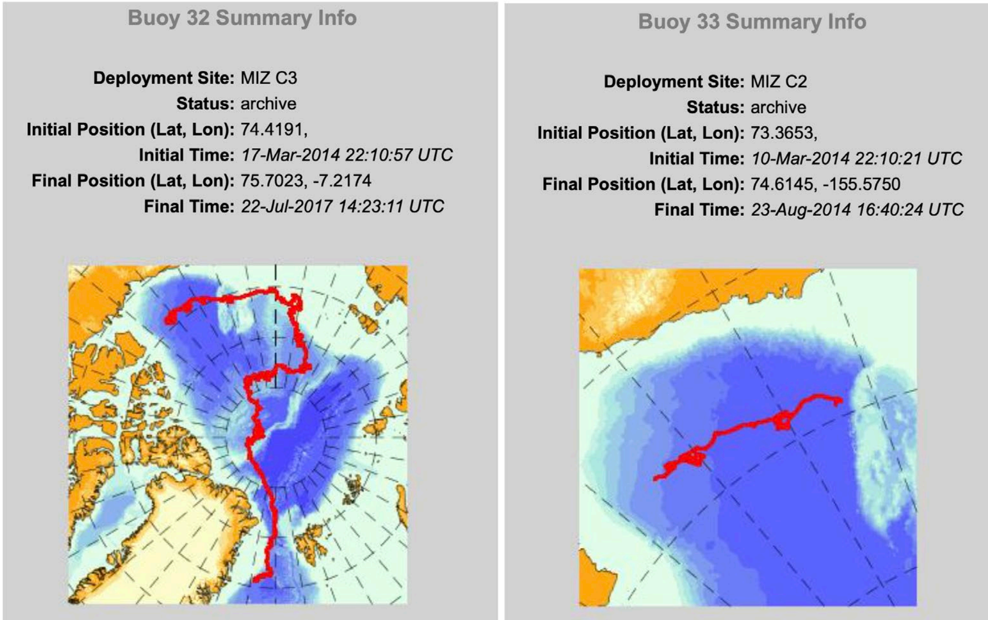

Figure 3. Overview of the two MIZ experiment AOFB tracks. From https://www.oc.nps.edu/~stanton/fluxbuoy/deploy/, accessed July 2022.

1.5.1.3 Data Acquisition and Processing

NSIDC downloaded the processed data as ASCII files from the Naval Postgraduate School Autonomous Ocean Flux Buoy Program site in April 2022. The data were processed by MIZ investigator Tim Stanton. NSIDC converted the ASCII files to CSV format for distribution.

1.5.2 Seaglider Data

1.5.2.1 Format, Contents, and Naming Convention

There are eight Seaglider data files in NetCDF-3 format. Each of the four instruments has a file for Level 2 processed data and one for Level 3 processed data. These are located in the `Seaglider` directory. They are named according to the following convention and as described in Table 3.

`sgXXX_MIZ_Jul14_levelZ.nc`

Table 3. Seaglider file naming convention

Variable	Description
sgXXX	Seaglider number where XXX is 196, 197,198, or 199
MIZ	Indicates data acquired during the ONR DRI MIZ experiment
Jul14	Data acquired on 14 Jul 2014
levelZ	Processing level where Z is 2 or 3
.nc	Identifies this as a NetCDF file.

Table 4 lists and describes all included Seaglider data file variables. If no observation is present, the value is set to `NaN`. Variable descriptions are taken from the Seaglider Data Deployment Narrative (Lee and Rainville, 2022) provided to NSIDC by Craig Lee or repeat or paraphrase those in the NetCDF files. NSIDC does not have descriptive information about the four variables that have "chan" in the name.

Table 4. Variables in all Seaglider files

Variable Name	Level 2 File Variable Description	Level 3 File Variable Description
chan1	412nm [uW/cm^2/nm]	412nm [uW/cm^2/nm]
CT	N/A	Conservative Temperature in deg C (ITS-90)
dive	Dive number	Dive number
lat	Latitude of every sample point, from the flight model when underwater [decimal degrees]	Latitude of every sample point, from the flight model when underwater [decimal degrees]
lat_dive	Averaged latitude of the dive [decimal degrees]	Averaged latitude of the dive [decimal degrees]
lon	Longitude of every sample point, from the flight model when underwater [decimal degrees]	Longitude of every sample point, from the flight model when underwater [decimal degrees]
lon_dive	Averaged longitude of the dive [decimal degrees]	Averaged longitude of the dive [decimal degrees]
N_S	Number of salinity observations in the bin	Number of salinity observations in the bin
N_T	Number of temperature observations in the bin	Number of temperature observations in the bin
N_time	Number of time observations in the bin. Note that this description is taken from the deployment narrative (Lee and Rainville, 2022) and does not match the description in the NetCDF file.	Number of time observations in the bin. Note that this description is taken from the deployment narrative (Lee and Rainville, 2022) and does not match the description in the NetCDF file.
ocr504i_chan2	444nm [uW/cm^2/nm]	444nm [uW/cm^2/nm]
ocr504i_chan3	554nm [uW/cm^2/nm]	554nm [uW/cm^2/nm]
ocr504i_chan4	PAR [umol/m^2/sec]	PAR [umol/m^2/sec]
P	N/A	Pressure [dBar]
PD	N/A	Potential density [kg/m3]
S	Corrected salinity [psu]	Corrected salinity (outliers removed, interpolated over gaps < 50 m) [psu]

Variable Name	Level 2 File Variable Description	Level 3 File Variable Description
S_flags	N/A	qc flag for salinity: 0 means no data (salinity value has been interpolated), 1 means good data
S_L2	N/A	Level-2 salinity [psu] (no despiker, not interpolated), with basestation processing (qc_good)
S_ref	N/A	Low-pass filtered salinity, over 3 or 5 days and 10 m. Note that the NetCDF file description says 3 days, while the deployment narrative (Lee and Rainville, 2022) says 5 days. We believe the narrative description to be correct but cannot confirm it.
S_rms_ref	N/A	rms of salinity within smoothing window (a measure of high-frequency variance). “Despiker” removes data more than 3 deviations from mean
SA	N/A	Absolute Salinity [g/kg]
speed	Forward speed of the glider through the water from the flight model [m/s]	Forward speed of the glider through the water from the flight model [m/s]
surface_curr_east	Surface drift in the east direction from the time at surface [m/s]	Surface drift in the east direction from the time at surface [m/s]
surface_curr_north	Surface drift in the north direction from the time at surface [m/s]	Surface drift in the north direction from the time at surface [m/s]
T	In situ temperature [deg C]	Corrected in situ temperature (outliers removed, interpolated over gaps < 50 m) [deg C]
T_flags	N/A	qc flag for temperature: 0 means no data (temperature value has been interpolated), 1 means good data
T_L2	N/A	Level-2 temperature [deg C] (no despiker, not interpolated), with basestation processing (qc_good)
T_ref	N/A	Low-pass filtered temperature, over 3 or 5 days and 10 m. Note that the NetCDF file description says 3 days, while the deployment narrative (Lee and Rainville, 2022) says 5 days. We believe the narrative description to be correct but cannot confirm it.

Variable Name	Level 2 File Variable Description	Level 3 File Variable Description
T_rms_ref	N/A	rms of temperature within smoothing window (a measure of high-frequency variance). “Despiker” removes data more than 3 deviations from mean
time	Date in seconds for every sample point [seconds since 1970-1-1 00:00:00]	Date in seconds for every sample point [seconds since 1970-1-1 00:00:00]
u_dive	Depth-average current in the east direction from the flight model [m/s]	Depth-average current in the east direction from the flight model [m/s]
v_dive	Depth-average current in the north direction from the flight model [m/s]	Depth-average current in the north direction from the flight model [m/s]
Z	Depth [m]	Depth [m]

All four Seaglider data files have data beginning on 27 July 2014 and ending on 1 October 2014.

1.5.2.2 Instruments and Parameters Measured

> *Two Liquid Robotics Wavegliders will follow the northward sea ice retreat, maintaining position close to the ice-based instruments nearest the ice edge, to provide additional acoustic navigation signals, open water measurements, and boundary layer meteorological measurements within the open water south of the MIZ. Lastly, autonomous Seagliders will follow the retreating ice edge, occupying sections that span open water, the MIZ, and full ice cover to document upper ocean evolution as a function of distance from the ice edge throughout the entire northward retreat. These high- resolution sections will bridge the regions between observations collected by the ice- based and drifting platforms, provide spatial context, and bind the array together.* --From Lee et al. (2012, pg. 20)

The following description of Seaglider data and instruments is drawn from the Experiment Plan (Lee et al., (2012), from Seaglider NetCDF files, and from the Seaglider Data Deployment Narrative (Lee and Rainville, 2022) provided to NSIDC by Craig Lee.

Seagliders are small (50 kg, 1.5 m), reusable, long-range autonomous underwater vehicles designed to glide from the ocean surface to as deep as 1000 m and back while collecting profiles of temperature, salinity, and other oceanic variables (Figure 4). Gliders steer through the water by controlling attitude (pitch and roll) and can thus navigate between waypoints to execute survey patterns. Typical horizontal speed is about 20 km per day. Iridium satellite modems provide two-way communications for command and data upload.

Figure 4. APL-UW ice-capable Seagliders. Gliders navigate survey patterns while diving from the surface/ice–ocean interface to depths up to 1000 m. Figure from Lee et al. (2012).

MIZ-DRI sampling strategy employed Seagliders to repeatedly occupy sections that extended from open water, across the MIZ, and deep into the pack ice. Four Seagliders (SG196, SG197, SG198, and SG199) were deployed at the shelf break near 72° 54’ N, offshore of Prudhoe Bay, Alaska, on 28 July 2014. Gliders transited north, collecting multiple sections into the pack ice along two roughly parallel meridional lines. Sampling extended to 75° 20’ N, with gliders working under the ice through most of September before retreating south for recovery on 2 October 2014. In total, the Seagliders completed 1,726 dives (3,452 profiles, as they sample both during the dive and the climb), including 259 completely under the ice (15% of the dives).

Gliders sampled temperature, conductivity, dissolved oxygen, chlorophyll fluorescence, optical backscatter, spectral downwelling irradiance, and temperature microstructure. Of these, only temperature and conductivity (salinity) parameters are included with these data files. Microstructure probes failed early in the deployment, likely due to interactions with small bits of floating ice.

1.5.2.3 Data Acquisition and Processing

In ice-free conditions, Seagliders communicate using Iridium satellite telemetry and geolocate using GPS. When operating under ice, Seagliders estimate their positions by multilateration from an array of drifting broadband 900 Hz acoustic navigation sources. Position estimates were further refined in post-processing.

A hydrodynamical flight model (Bennett et al., 2019) uses data from the glider's attitude sensors and from the environment to estimate glider speed through the water, and thus location during the dive. The hydrodynamical model provides an estimate of the horizontal distance travelled through water in an ocean at rest, which, when compared to the actual positions at the beginning and end of the dive, provides a good estimate of the depth-averaged current (or, more accurately, ocean current averaged along the underwater trajectory of the glider). Repeated GPS fixes obtained during the surface drift, before and after every call to the base station, provide an estimate of ocean surface velocity.

Data samples are gridded by profile and on regular 1-m depth bins from 0 m to 1000 m. The time and spatial intervals between two successive profiles are approximately 1.5 hours and 1.4 km, respectively. Profiles are provided at Level 2 (basic gridding) and Level 3 (despiked and interpolated).

Gliders record samples on a non-uniform time and depth grid, on both the down (dive) and up (climb) portion of a complete dive. These samples constitute the Level 1 time series (not included here). Level 2 data are gridded on a regular depth and separated by profile. Value is NaN if no observation is present in that depth bin. Level 3 data have been interpolated and "despiked", by removing data that are more than 2 standard deviations from a running mean.

All processing took place at APL-UW prior to delivery to NSIDC. Craig Lee provided data in NetCDF files to NSIDC in April 2022.

Each instrument's track, containing each dive location, can be viewed using file miz_network.kml (Figure 5).

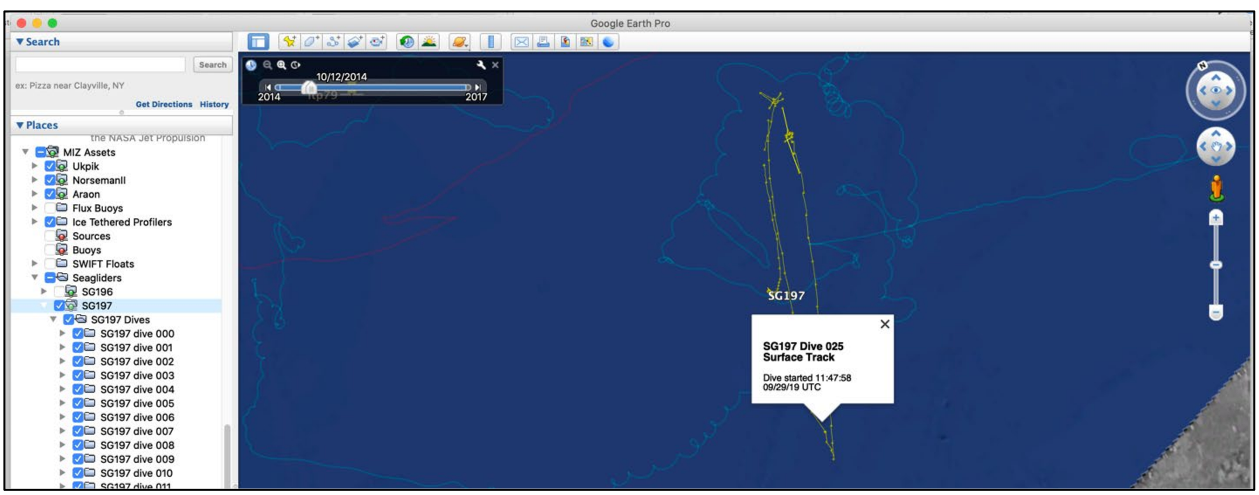

Figure 5. The surface track of Seaglider 197, with information on dive number 25 shown using miz_network.kml with Google Earth

1.5.3 SWIFT Drifters Data

1.5.3.1 Format, Contents, and Naming Convention

The SWIFT data are provided in two NetCDF-3 files, one for each of the SWIFT instruments, 10 and 11: `SWIFT10_MIZ2014.nc` and `SWIFT11_MIZ2014.nc`. These are in the `SWIFT` directory.

Table 5 describes the variables in the SWIFT buoy files. Variable descriptions repeat or paraphrase those in the NetCDF files with some additional information taken from the Arctic Sea State 2015 Field Campaign description of SWIFT data files.

Table 5. Variables in all SWIFT buoy files (alphabetical order)

Variable Name	Description
a1	Normalized spectral directional moment (positive east) (m^2/Hz)
a2	Normalized spectral directional moment (east-west) (m^2/Hz)
airtemp	Air temperature (deg C) at 1 m height above the wave-following surface (NaN for missing)
airtempstddev	Standard deviation of air temperature (deg C)
b1	Normalized spectral directional moment (positive north) (m^2/Hz)
b2	Normalized spectral directional moment (north-south) (m^2/Hz)
driftdirT	Drift direction TOWARDS (degrees True) (equivalent to "course over ground")
driftspd	Speed of SWIFT drift (m/s) (equivalent to "speed over ground")
energy	Wave energy spectral density (m^2/Hz) as a function of frequency. Note that this is derived from orbital motions and is thus insensitive to low-energy swell conditions. The technique is best suited to measuring short wind waves.
freq	Spectral frequencies (Hz)
lat_lagrangian	Latitude (decimal degrees)
lon_lagrangian	Longitude (decimal degrees)
peakwavedirT	Wave direction at energy peak (degrees from North) (9999 for missing)
peakwaveperiod	Wave period at peak of energy spectrum (s)
salinity	Water salinity (PSU) at 0.5 m below the surface
sigwaveheight	Significant wave height (m)

Variable Name	Description
time	Days since 1970-01-01 00:00:00 UTC
watertemp	Water temperature (deg C) at 0.5 m below the surface
winddirT	True wind direction (degrees from North) (NaN for missing)
winddirTstddev	Standard deviation of true wind direction (degrees)
windspd	Wind speed (m/s) at 1 m height above the wave-following surface (NaN for missing)
windspdstddev	Standard deviation of wind speed (m/s)

The SWIFT 10 data begin on 27 July 2014 and end on 14 September 2014. The SWIFT 11 data begin on 27 July 2014 and end on 28 September 2014.

1.5.3.2 Instruments and Parameters Measured

> *Surface Wave Instrument Floats with Tracking (SWIFT) drifters [were] deployed into the MIZ as part of ship-supported operations in July, after initial formation and northward retreat of the MIZ.* --From Lee et al. (2012, pg. 32)

This description of SWIFT instruments is drawn from the description contained in the User Guide for the ONR DRI Arctic Sea State 2015 Field Campaign data collection.

SWIFT drifters ride the waves and drift with ocean currents. They obtain high-resolution profiles of turbulent velocities collected within 1 m of the surface using a pulse-coherent acoustic Doppler sonar. Energy dissipation rates due to breaking waves are estimated using turbulent velocity measurements (Thomson, 2012). The drifters measure surface winds, waves, currents, air and water temperature, and salinity. Figure 6 shows a SWIFT buoy.

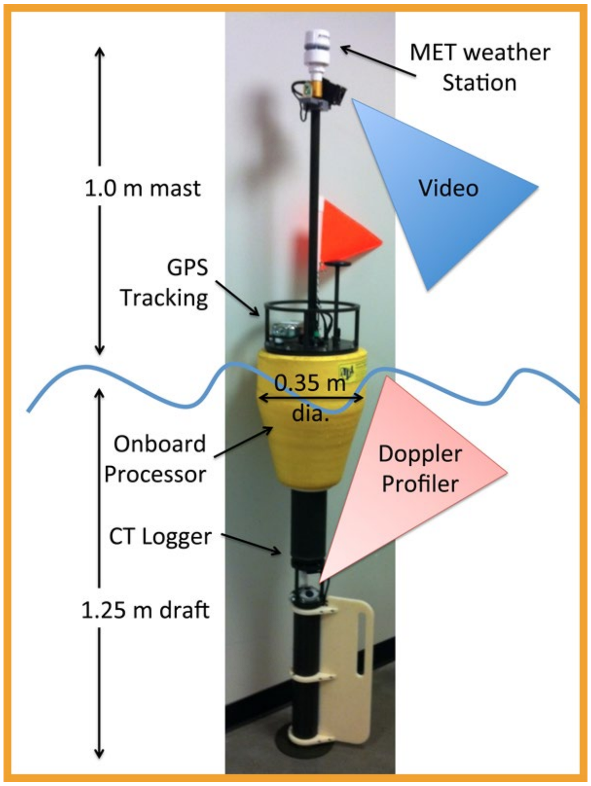

Figure 6. Dimensional drawing of a SWIFT buoy, as instrumented in 2012. From www.apl.uw.edu/SWIFT, accessed May 2023.

The following parameters were measured with SWIFT buoy data:

- Wind speed and direction
- Wave height
- Wave directional spectra
- Water temperature and salinity at 0.5 m depth
- Air temperature

1.5.3.3 Data Acquisition and Processing

All processing took place prior to delivery to NSIDC. J. Thomson provided data files to NSIDC in July 2021.

Observations of surface winds, waves, air temperature, and salinity occur in 8-minute bursts of raw data collected once per hour. These are processed and reported as ~60-minute interval data. All SWIFT processing codes are publicly available on GitHub: https://github.com/jthomson-apluw/SWIFT-codes.

Figure 7 shows significant wave height from one of the two SWIFT instruments.

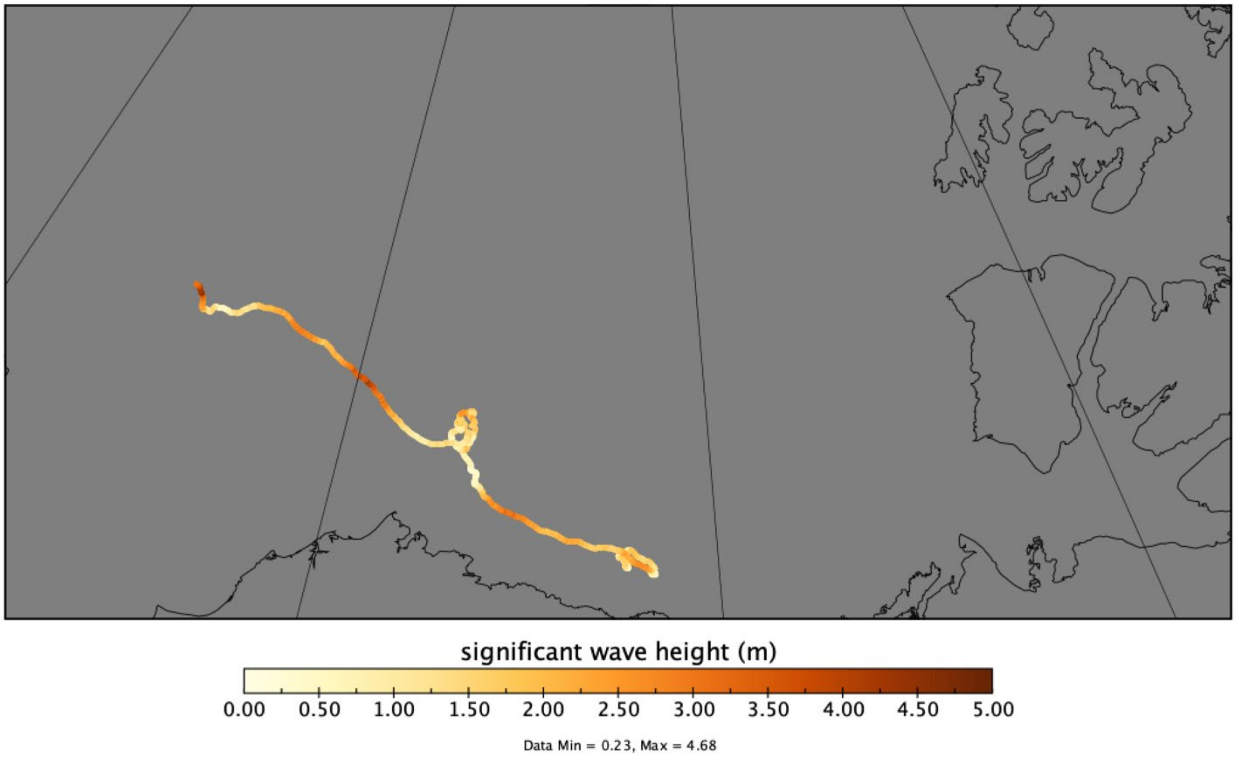

Figure 7. Significant wave height from the SWIFT11_MIZ2014.nc file plotted using the NASA Panoply NetCDF viewer.

1.5.4 Wave Buoy Data

1.5.4.1 Format, Contents, and Naming Convention

Each of the nine individual wave buoy records is in a NetCDF-4 file and reside in the `WaveBuoy` directory. They are named according to the following convention as described in Table 6.

`WBXXX_wavedata.nc`

Table 6. Wave Buoy File Naming Convention

Variable	Description
WBXXX	Wave buoy number where XXX is 201, 202, 206, 207, 211, 212, 213, 214, or 215.
wavedata	Indicates this file contains wave buoy data.
.nc	Identifies this as a NetCDF file.

Table 7 describes all wave buoy data file variables. Variable descriptions repeat or paraphrase those in the NetCDF files.

Table 7. Variables in all wave buoy files

Variable Name	Description
checkfactor	Quality metric for the wave spectra (1 represents high quality results). See Eq 2 in Thomson et al. (2015)
energy	Wave energy spectral density as a function of frequency (m^2/Hz)
frequency	Frequency corresponding to wave energy spectra values (Hz)
latitude	Latitude at the beginning of the 30 min wave measurement time period (decimal degrees)
longitude	Longitude at the beginning of the 30 min wave measurement time period (decimal degrees)
peakWavePeriod	Wave period at peak of energy spectrum (s)
sigWaveHeight	Significant wave height (m)
time	Unix time of each observation (seconds since 1970-01-01 00:00:00 UTC)

All wave buoy data were acquired in September and October. The earliest data are from WB207 on 2 September 2014. The latest are from WB202 on 11 October 2014.

1.5.4.2 Instruments and Parameters Measured

This description of wave buoy data is drawn from the NetCDF files themselves, and directly from correspondence with MIZ investigator Martin Doble. Note that the Experiment Plan (Lee et al., 2012) describes combined ice mass balance (IMB) and wave buoy instruments. The IMB data were of poor quality. Only the wave buoy (WB) data are included here.

> *Wave characteristics will be obtained through the incorporation [on ice mass balance buoys] of a vertical accelerometer (heave) and tiltmeters to give surface slope. For waves in ice (as opposed to open ocean waves), this configuration is more sensitive than a three-dimensional accelerometer, because the relatively constrained ice cover is not able to respond to orbital motion in the x/y plane. The sensors will collect data at 1-s intervals, transmitting full timeseries data on demand (e.g., during the most interesting breakup period, where the evolution of wave energy and period can be better tracked) […] The IMB/WB will be a float, and thus will continue to obtain important data on the evolution of the upper ocean heat and the ocean wave spectra. The background open ocean spectra will be used in conjunction with buoys that are still in the ice to quantify wave attenuation rate.* --From Lee et al. (2012, pg. 25)

Buoys were deployed in arrays west of Banks Island, in March 2014 by aircraft- and helicopter-supported ice camps. The buoys drifted in the ice for several months until transmissions ceased (last transmission was in November 2014). Buoys reported their GPS-derived positions at hourly intervals. Buoys also transmitted the 1 Hz timeseries of heave, roll, and pitch, as measured by the onboard inertial motion unit (IMU). Motion was generally beneath the sensitivity floor of the IMUs until the buoys melted out of the ice in late Fall.

Nine of 19 deployments provided good wave spectral energy data. Investigators processed the data to obtain directional wave spectra, but are not confident of the magnetic heading for the buoys and so those results are not included here. The buoys tended to spin down the wave fronts, resulting in unusable direction information.

Wave data were derived from buoy motions measured by SBG Systems Ellipse-A IMU instruments.

Wave buoy data provided these parameters:

- Wave energy spectral density
- Significant wave height
- Peak wave period

1.5.4.3 Data Acquisition and Processing

Wave spectral processing was identical to the scheme used for Sea State SWIFT data (Thomson and Persson, 2021). Processing code is available on GitHub at https://github.com/jthomson-apluw/SWIFT-codes. Observations of surface waves occur in bursts of raw data collected. These were postprocessed into half-hour intervals for bulk statistical quantities (Smith et al., 2018). Smith and Thomson (2019) and Smith et al. (2018) describe aspects of SWIFT data processing that were used with Sea State data. More fundamental aspects of SWIFT data are described in Thomson (2012).

M. Doble provided post-processed 30-minute interval data in NetCDF files to NSIDC in June 2021.

The figures below illustrate aspects of the wave buoy data. Figure 8 and Figure 9 show significant wave height values. Figure 10 plots wave energy spectral density for the first samples (r = 1) taken by two wave buoys.

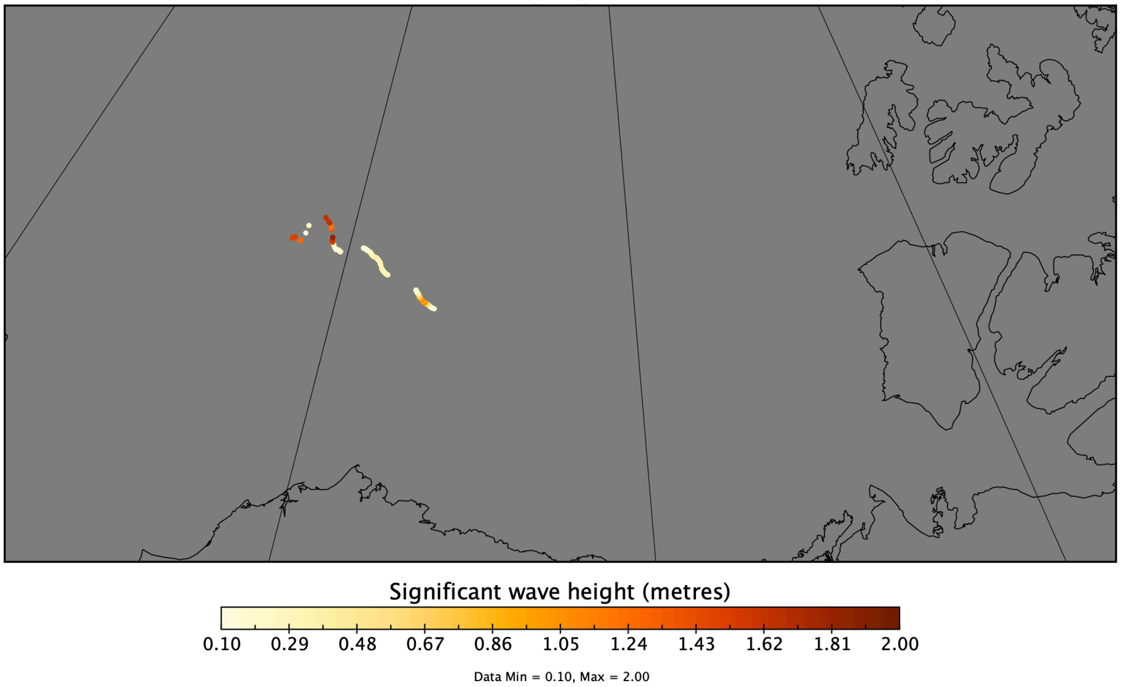

Figure 8. Significant wave height from `WB202_wavedata.nc` plotted using the NASA Panoply NetCDF viewer

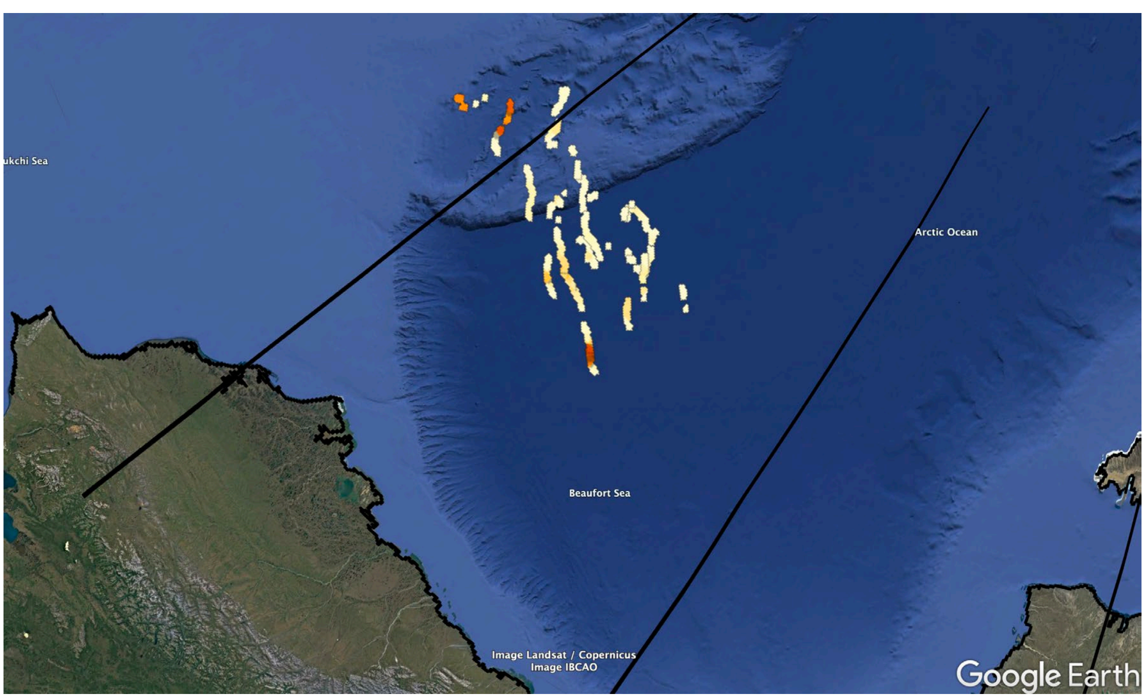

Figure 9. Significant wave height from all nine wave buoy trajectories plotted using the NASA Panoply NetCDF viewer and Google Earth.

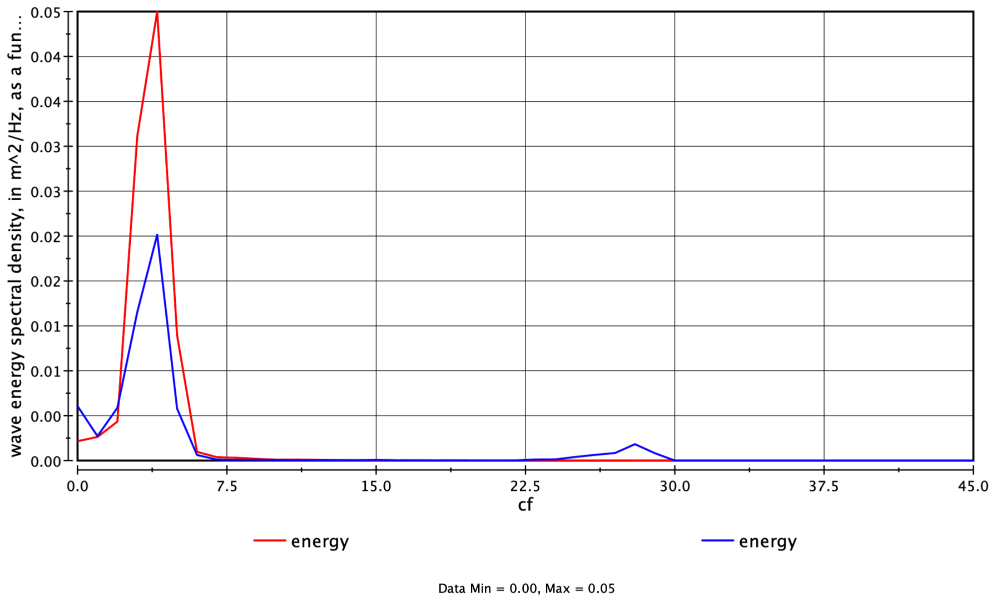

Figure 10. Wave energy spectral density as a function of frequency from WB 201 (red line) and WB 202 (blue line). These are from the first sample (r = 1) in `WB201_wavedata.nc` and `WB202_wavedata.nc` plotted using the NASA Panoply NetCDF viewer.

1.5.5 Waveglider Data

1.5.5.1 Format, Contents, and Naming Convention

The Waveglider instrument data are in a NetCDF-3 file called `WavegliderSV3-16_MIZ2014.nc`. It resides in the `Waveglider` directory. The naming convention is described in Table 8.

Table 8. Waveglider file naming convention

Variable	Description
WavegliderSV3-16	Waveglider instrument identifier SV3-16
MIZ2014	Indicates data acquired during the ONR DRI MIZ experiment in 2014
Jul14	Data acquired on 14 Jul 2014
.nc	Identifies this as a NetCDF file.

Table 9 describes the variables in the Waveglider file. Variable descriptions are taken from the NetCDF file.

Table 9. Variables in the Waveglider file

Variable Name	Variable Description
latitude	Latitude (decimal degrees)
longitude	Longitude (decimal degrees)

Variable Name	Variable Description
peakwavedirT	Wave direction (degrees from North)
peakwaveperiod	Peak of period orbital velocity spectra
sigwaveheight	Significant wave height (m)
time	Days since 1970-1-1 00:00:00
winddirT	True wind direction (degrees from North)
windspd	Wind speed at 1 m height above the wave-following surface (m/s)

Waveglider data begin on 28 July 2014 and end on 18 September 2014.

1.5.5.2 Instruments and Parameters Measured

> *Two Liquid Robotics Wavegliders will follow the northward sea ice retreat, maintaining position close to the ice-based instruments nearest the ice edge, to provide additional acoustic navigation signals, open water measurements, and boundary layer meteorological measurements within the open water south of the MIZ. Lastly, autonomous Seagliders will follow the retreating ice edge, occupying sections that span open water, the MIZ, and full ice cover to document upper ocean evolution as a function of distance from the ice edge throughout the entire northward retreat. These high-resolution sections will bridge the regions between observations collected by the ice-based and drifting platforms, provide spatial context, and bind the array together.* --From Lee et al. (2012, pg. 20)

This description of Waveglider data is drawn from the Experiment Plan (Lee et al., 2012) and from the Waveglider NetCDF data file. See the Wave Glider: How It Works web page on the Liquid Robotics site for more information on the Waveglider platform itself.

Waveglider data parameters are wave direction, wave period, significant wave height, wind direction, and wind speed. Data from only one instrument are available.

1.5.5.3 Data Acquisition and Processing

All processing took place prior to delivery to NSIDC. J. Thomson provided data files to NSIDC in July 2021. Data processing is described in detail in Thomson et al. (2018).

1.5.6 The MIZ Network in a KML File

Users may wish to use the miz_network.kml file to see the spatial relationship of instruments over time. NSIDC downloaded this file from the APL MIZ website in September 2021.

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3 RELATED DATA SETS

Thomson, J. and Persson, O. (2021). Arctic Sea State 2015 Field Campaign, Version 1. Boulder, Colorado USA. National Snow and Ice Data Center. https://doi.org/10.7265/qt2b-y743.

U.S. National Ice Center. (2020). U.S. National Ice Center Daily Marginal Ice Zone Products, Version 1. Boulder, Colorado USA. National Snow and Ice Data Center. https://doi.org/10.7265/ggcq-1m67.

4 RELATED WEB SITES

- Marginal Ice Zone Program: The APL-UW MIZ web site has material compiled when the experiment was being planned and some later information, including lists of investigators, project titles, and publications. The data in this data set, or portions of these data, may also be available from this site.
- Sea State Program: The APL-UW Sea State web site describing another ONR DRI field campaign that took place in the autumn of 2015 in the Beaufort Sea.

5 RELATED PUBLICATIONS

These publications, along with descriptions, may be found at the UW-APL *Marginal Ice Zone Program* website.

Brenner, S., Rainville, L., Thomson, J., and Lee, C. (2020). The evolution of a shallow front in the Arctic marginal ice zone. *Elementa Science of the Anthropocene*, 8. https://doi.org/10.1525/elementa.413.

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6 CONTACTS AND ACKNOWLEDGEMENTS

The Marginal Ice Zone Science Steering Team is: Craig Lee, Martin Doble, Wieslaw Maslowski, Tim Stanton, Jim Thomson, Mary-Louise Timmermans, and Jeremy Wilkinson

Other MIZ investigators are: Sylvia Cole, Lee Freitag, Hans Graber, Phil Hwang, Steve Jayne, Rick Krishfield, Ted Maksym, Breck Owens, Pam Posey, Luc Rainville, Andrew Roberts, Axel Schweiger, Bill Shaw, Mike Steele, John Toole, Peter Wadhams, and Jinlun Zhang

Craig Lee, Marginal Ice Zone Principal Investigator with the Applied Physics Laboratory at the University of Washington, assisted with identifying and collecting data to be archived and published by NSIDC. He reviewed this User Guide prior to its publication online.

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7 VERSION HISTORY

Table 10. Version History Summary

Version	Release Date	Description of Changes	Citation
1	June 2023	Initial release	Lee, C.M. and the Marginal Ice Zone Team. 2023. Marginal Ice Zone 2014 Field Campaign, Version 1. [data set]. Boulder, Colorado USA. NSIDC: National Snow and Ice Data Center. https://doi.org/10.7265/j769-hn64.

8 DOCUMENT INFORMATION

8.1 Author

Florence Fetterer wrote this User Guide in Spring 2023. It was edited and published online by Ann Windnagel.

8.2 Publication Date

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