Laboratoire d'Océanographie Physique et Spatiale

UMR6523 – CNRS-IFREMER-IRD-UBO

http://www.umr-lops.fr

Cruise Report : ARcticGO 2023

Ship : “Le Commandant Charcot” (Ponant)

10 to 27 July 2023

ref: 02.03.2023, 10.07.2023-27.07.2023,
Jnr. 23/3462

Nicolas Kolodziejczyk (LOPS, UBO)

Camille Lique (LOPS, Ifremer)

Claudie Marec (IUEM, CNRS)

LOPS - IUEM, Rue Dumont d'Urville, 29280 Plouzané

Campus Ifremer – ZI de la Pointe du Diable – CS10070 – 29280 Plouzané

Tél 33 (0)2 98 22 48 50 – Fax 33 (0)2 98 22 44 96

1. Abstract

The 15-days cruise (10 to 27 July 2023) purpose was to deploy autonomous platforms and perform expandable measurements in the Eurasian Arctic Basin from the touristic icebreaker of opportunity “Le Commandant Charcot” which is run by the French Ponant Company, operating between Svalbard and the North Pole.

More specifically, the ARcticGO 2023 cruise, supported by french funding program LEFE- GMMC INSU and Argo France, aimed at:

- deploying under-ice autonomous profiling Argo floats that measure hydrological profiles over the water column in the framework of the International Argo program (https://argo.ucsd.edu/);
- deploying surface drifters measuring hydrological properties in the Marginal Ice Zone in the framework of the Global Drifter Program https://www.aoml.noaa.gov/phod/gdp/;
- carrying out XBT/XCTD and CTD hydrological measurements of the water column along the transect ~34°E between 80°N-90°N.

This scientific program involves several scientists from LOPS (UMR6523, Brest, France), and is done in collaboration with scientists from the Norwegian Argo program.

2. Context

The ArcticGo project is funded by the French LEFE GMMC INSU/CNRS program for 3 years over 2021-2023.

The Arctic region is experiencing some of the most rapid transformations on the planet in response to the on-going climate change. In response to the changes that have affected the atmosphere and the cryosphere in the Arctic Basin, changes in the ocean are also logically expected, although it remains challenging to detect a clear emerging signal from the observations thus far.

The purpose of the research is to deploy autonomous profiling floats in the framework of the international Argo program in the Eurasian Basin, in order to collect hydrological profiles (temperature, salinity, pressure and oxygen) over the water column (typically 2000 m depth). As the Eurasian Basin is seasonally ice-covered and hardly accessible without an icebreaker, the data coverage in the region is very sparse, preventing the monitoring of the Eurasian Arctic ocean physical change. To circumvent this constraint, the deployed floats are equipped with ice capacity allowing sea ice detection when profiling under ice. The data are then transmitted when the floats have drifted away and reached an ice-free region. This is an opportunity to monitor the evolution of heat and salt, as well as dissolved oxygen content in the Eurasian Basin, and to contribute to the reinforcement of the Argo network within the Arctic Ocean.

During the season when the cruise takes place (summer), sea ice is melting and strong freshwater fluxes are released at the surface of the ocean in the Marginal Ice Zone (MIZ). These processes have a strong impact on the upper ocean stratification and air-sea heat flux exchanges. To complement the observation of the water column, surface drifters buoys have been deployed in the MIZ to collect sea surface temperature and salinity data and surface current drift measurements. Monitoring the process driving the evolution of the MIZ during the seasonal sea ice retreat is particularly relevant in the context of the ongoing Arctic sea ice decline. The ARcticGO experiment has been conducted during summer 2022, and repeated during summer 2023 to monitor year-to-year variability of the melting processes in the MIZ.

3. Embarking Team

In the context of a cruise of opportunity, the embarking team is restrained to only 2 scientists who are responsible for deploying the autonomous platforms and performing the CTD/XBT casts with the help from “Le Commandant Charcot” crew.

Table 1 : Embarking scientists and affiliation

Scientist	Affiliation	Country
Camille Lique	LOPS, Ifremer	France
Nicolas Kolodziejczyk	LOPS, UBO	France

4. Campaign plan

The ARcticGO 2023 cruise was operated along a radial between Svalbard (embarking at Longyearbyn, Svalbard) and North Pole (Eurasian Arctic Basin 77°N – 90°N / 0°E – 35° E). See Figure 1 for previsional campaign plan. For scientific reason, the deployments of Argo floats and surface drifters have been delayed in August (20/08/2023) on another cruises of "Le commandant Charcot" (see Section 6: "ZEE operation". The summary of deployment is as follows:

- deploying 3 under-ice autonomous profiling Argo floats, in the MIZ (~81.30'N), that measure hydrological profiles over the water column in the framework of the International Argo program (https://argo.ucsd.edu/);
- deploying surface 3 drifters in the MIZ (~81°30'N) measuring hydrological properties in the Marginal Ice Zone in the framework of Global Drifter Program (https://www.aoml.noaa.gov/phod/gdp/);
- performing XBTand CTD hydrological measurements of the water column along the transect xx°E between 80°N-90°N .

The planning of the scientific operations achieved during the cruise is given Table 2:

Table 2: Planning of the ARcticGO 2023 cruise

Day	Date	Operations	Remarks
1	10/07/2023	Embarking	Longyearbyen, Svalbard
2	11/07/2023	Departure 7:00 p.m. LT	Longyearbyen, Svalbard
3	12/07/2023	Transit & Station, CTD (2), XBT (12)	ice pack
4	13/07/2023	Transit, XBT (5)	Ice pack
5	14/07/2023	Transit & station	Ice Pack
6	15/07/2023	Transit & station	Ice Pack
7	16/07/2023	Station, CTD (1), XBT (1)	North Pole
8	17/07/2023	Transit	North Pole
9	18/07/2023	Transit, station, CTD (1)	ice pack
10	19/07/2023	Station, CTD (13)	MIZ, near Kvitoya
11	20/07/2023	Station, CTD (10)	MIZ, near Kvitoya
12	21/08/2023	Transit, end of Scientific operations	

13	22/07/2023	Transit	Ice Pack
14	23/07/2023	Transit	Ice Pack
15	24/07/2023	Transit	Ice Pack
16	25/07/2023	Transit	Ice Pack
17	26/07/2023	Transit	Ice Pack
18	27/07/2023	Arrival, disembarking ~7:00 a.m. LT	Longyearbyen, Svalbard
20	20/08/2023	Deployment of drifter (3)/Argo (3)	North Svalbard, isobath 1000 m isobath,

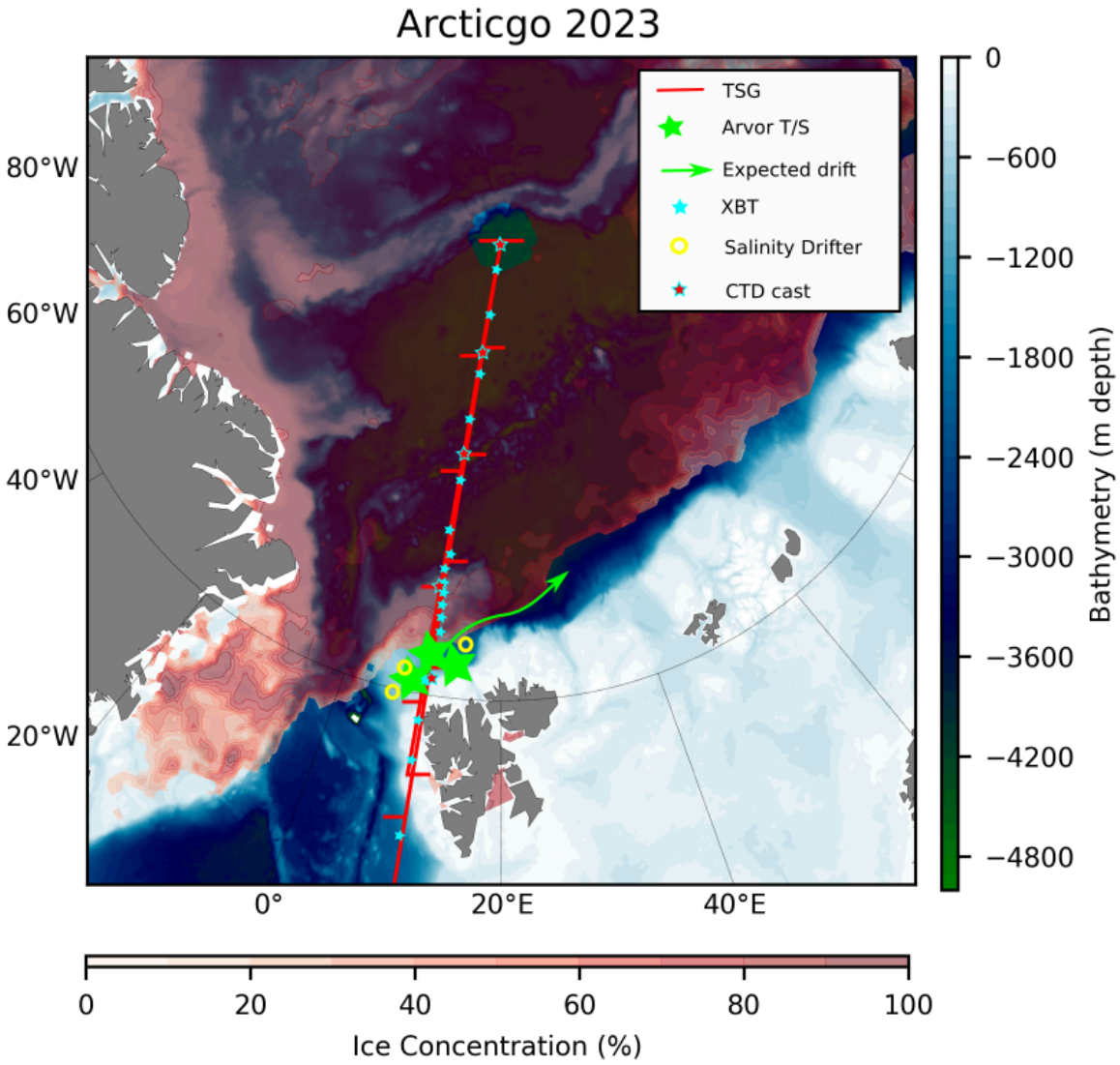

Figure 1: Summary of the deployments planned during the cruise ARcticGO 2023 actual track between Svalbard and the North Pole is plotted in Figure 8. Each symbol indicates a different instrument. The blue/green shading indicates bathymetry, while the red shading shows the extreme sea ice low extent for September 2012.

5. Details of the operations

a. Argo deployment

3 Argo profiling floats have been deployed along a transect between Svalbard and the North Pole in the MIZ around 82°30'N (Fig. 1 & Table 2). The profiling floats are NKE ARVOR T/S collecting profiles of temperature, salinity and pressure between 0-2000 m every 10 days and between 0-200 m every day. The floats are equipped with an Ice Sensing Algorithm. The data are collected in the framework of Argo France program (https://www.argo-france.fr/en), which is a contribution to the international Argo program and freely distributed for fundamental research and operational oceanography : https://argo.ucsd.edu/. The float positions are instantaneously notified through : https://www.ocean-ops.org/board?t=argo . Not that, during July 2023, due to too southward ice edge to deploy floats in the MIZ and in deep ocean, off the shelf, the deployments have been delayed in August during another cruises

Table 2 : Deployment position and set up of the Argo floats during ARcticGO2023.

Serial Number	WMO*	Type	Time (UTC)	Latitude	Longitude	CTD cast	Remarks
AI2600-23FR001	7901038	NKE Arvor Ice	20/08/2023 21h01	81°29.8310'N	20°43.5425'E	CTD cast1 800 m depth	MIZ
AI2600-23FR002	2903799	NKE Arvor Ice	20/08/2023 22h32	81°29.4984'N	20°38.6177'E	CTD cast3 800 m depth (x2+niskin at 800 m)	MIZ, lost, never surface after deployment
AI2600-22FR105	4903655	NKE Arvor Ice	20/08/2023 20h43	81°31.4043'N	20°57.6885'E	CTD cast3 800 m depth (x2+niskin at 800 m)	MIZ

*Click on the WMO number to access detailed information on the floats technical and scientific data, and visualize data and trajectory plot from : https://fleetmonitoring.euro-argo.eu/

b. Surface Drifter deployment

3 surface drifters have been deployed in the MIZ north of Svalbard (~81°30'N). These drifters are NKE SVP BSC SC40 drifters measuring the surface temperature, salinity and atmospheric pressure. They are equipped with a drogue at 15 m depth to drift with the actual surface currents. The geolocalization by GPS provides us with their trajectories to estimate surface currents. The data are gathered in the framework of the Global Drifter Program and are freely distributed for fundamental research, operational oceanography and weather forecast: https://www.aoml.noaa.gov/phod/gdp/. Table 3 shows the list of SVP drifter deployed during ARcticGO 2023. SVP Drifters trajectories since the deployments are shown on map in Figure 2. The temperature, salinity,surface current velocity and Sea Surface Atmospheric Pressure time series for each drifter are shown in Fig. 3 to 7.

Table 3: Deployment position and set up of the SVP drifting buoys during ARcticGO2023

drifter	WMO	SN	IEMI	Time (UTC)	Latitude	Longitude	Remarks
1	2802087	SC40 Y23 N0054	300534064102310	20/08/2023 20:25:00	81°31.4043'N	20°57.6885'E	MIZ
2	7801712	SC40 Y23 N0055	300534064106300	20/08/2023 21:01:00	81°29.8310'N	20°43.5425'E	MIZ
3	4804109	SC40 Y23 N0056	300534064109310	20/08/2023 22:32:00	81°29.4984'N	20°38.6177'E	MIZ

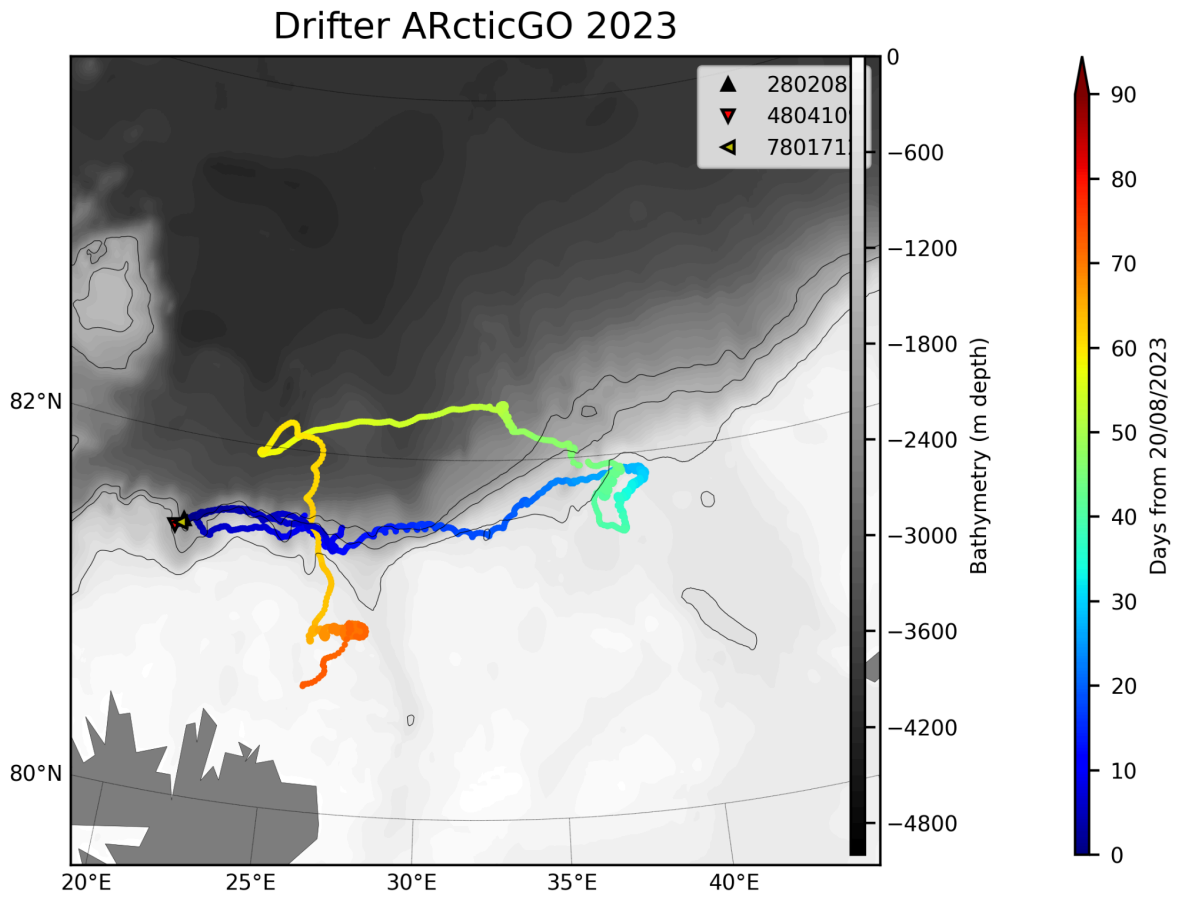

Figure 2: Trajectories (thick curves with color shading : day since 20 August 2023) of the 3 drifters deployed in the MIZ during the Arcticgo2023 cruise north of Svalbard.

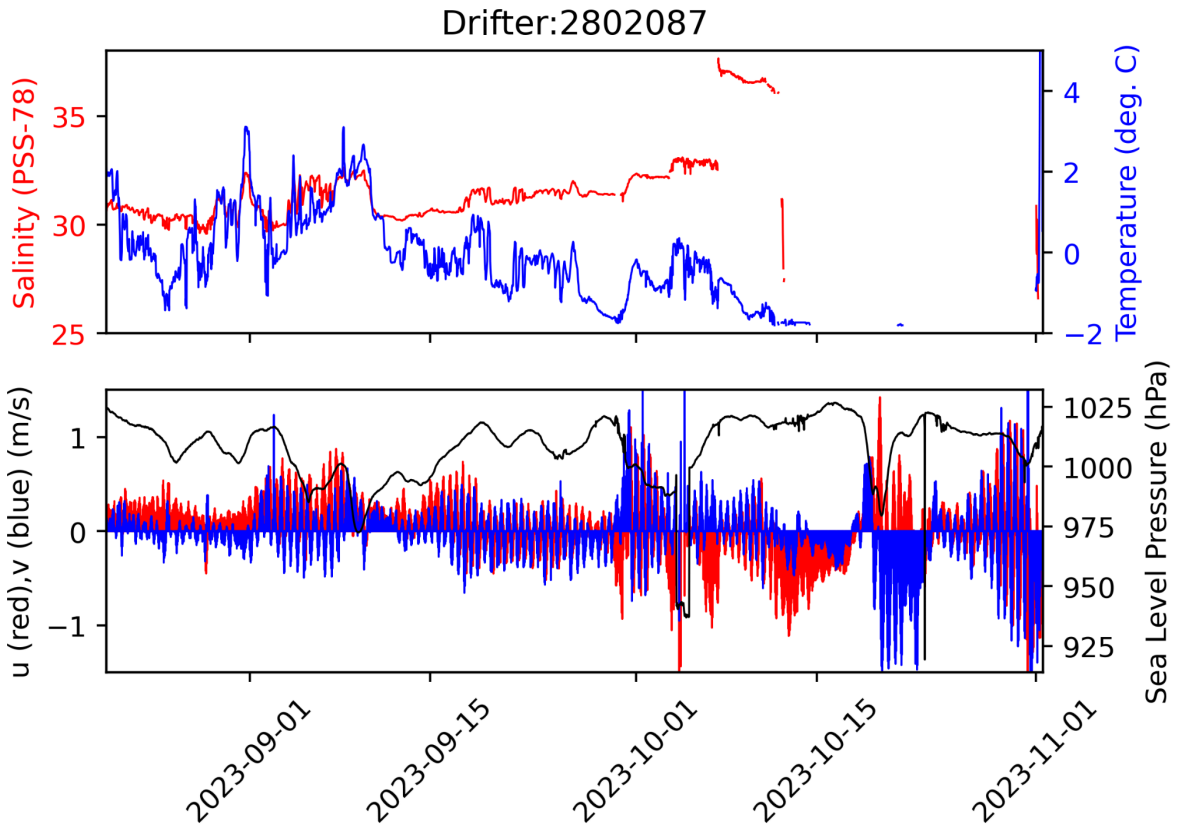

Figure 3 : Timeseries of temperature (blue, upper panel, in °C) , salinity (red, lower panel, in pss), surface (~15 m depth) zonal velocity (red, lower panel, in m/s), surface meridional velocity (blue, lower panel, in m/s), and Sea Level Atmospheric Pressure (black, lower panel, in hPa) along the drifter 2802087.

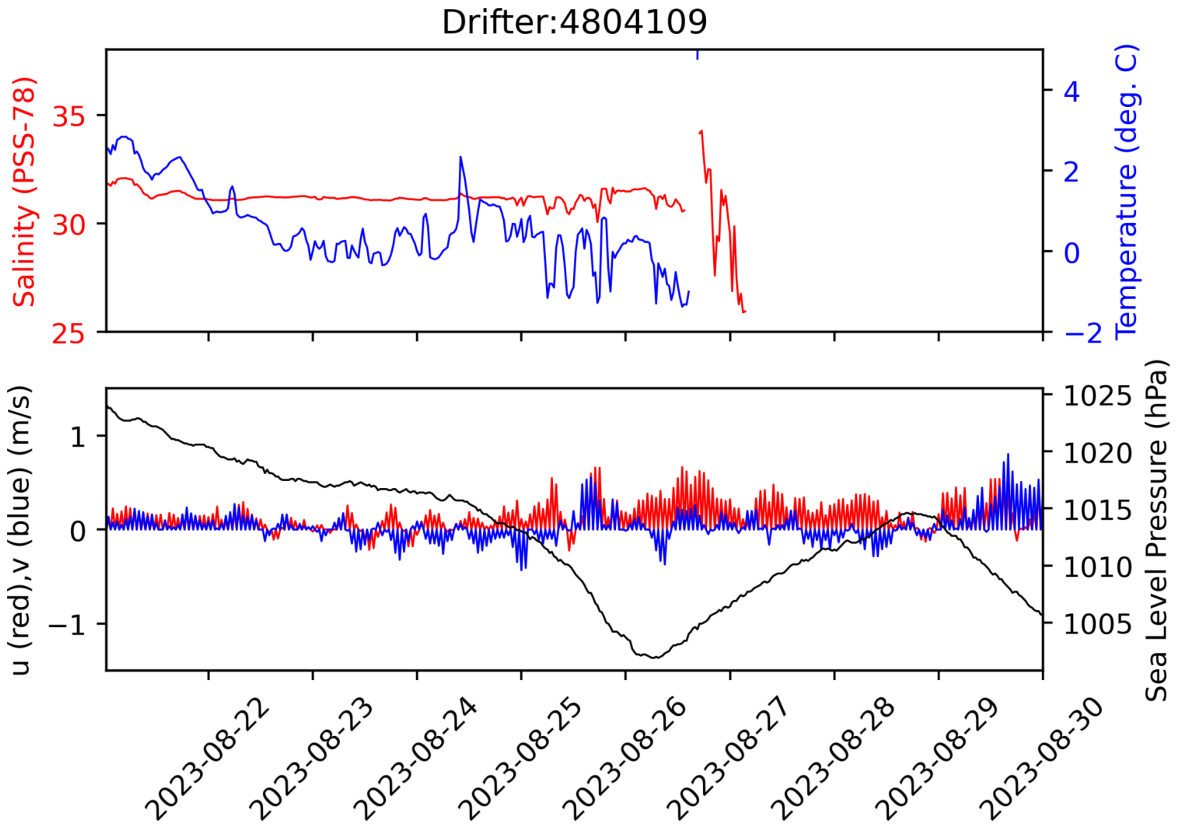

Figure 4: Same as Figure 2, but for drifter 4804109.

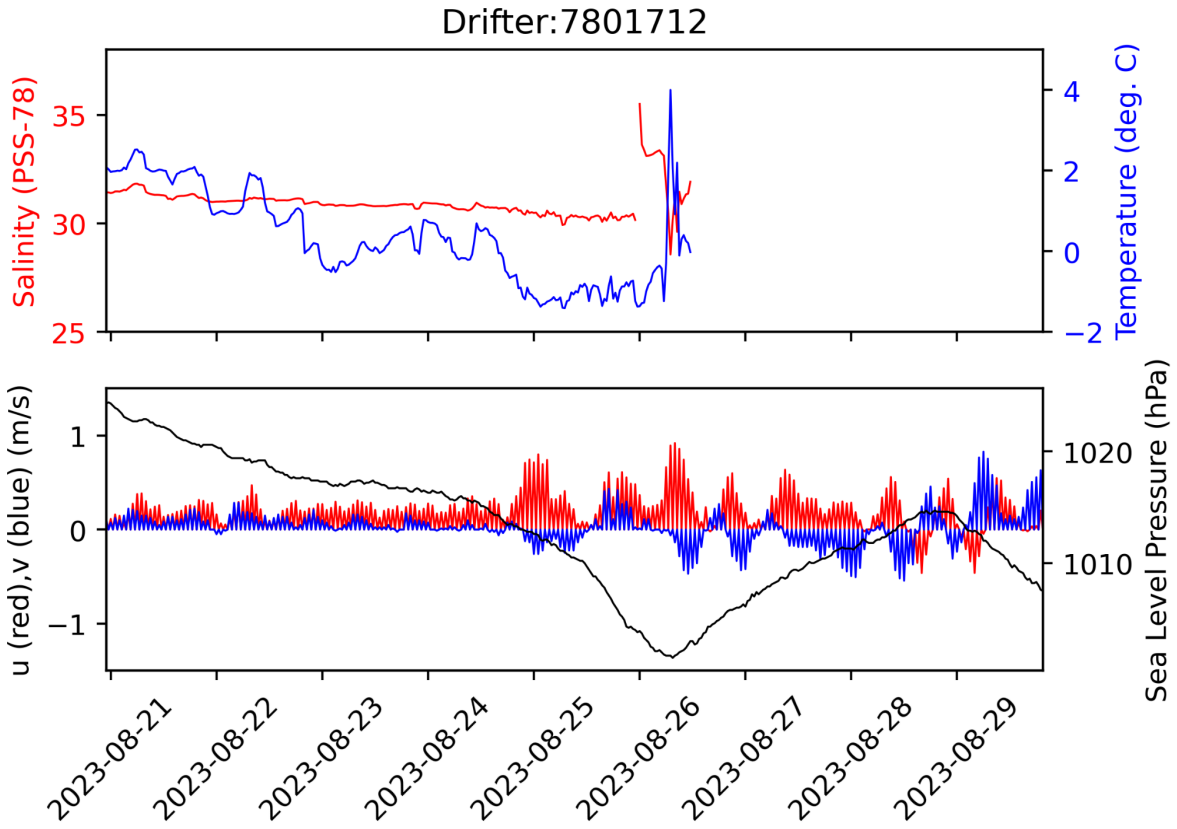

Figure 5: Same as Figure 2, but for drifter 7801712.

c. CTD stations

7 CTD stations including 30 casts have been carried out for the calibration of the CTD sensors of the autonomous platforms. An RBR Concerto3 750 m CTD inductive sensor has been deployed over the upper water column (800 m depth) and provide temperature, salinity and pressure measurements. After calibration and validation, the profiles will be freely distributed by the French Coriolis Data Center for fundamental research purposes and operational oceanography (http://www.coriolis.eu.org/). Below is the list of the CTD stations (Table 4) along with temperature and salinity plots of CTD positions (Fig. 6) and profiles casts (Fig. 7) during the ARcticGO 2023.

Table 4: List of CTD stations during ARcticGO2023

Station	Time (UTC)	Latitude	Longitude	Remarks
1	12/07/23 09:21	81.0902169444444	9,25279194444444	
2	16/07/23 09:30	90°00		North Pole
3	16/07/23 13:34	89°59’52’’N	89°15’37’’E	
4	18/07/23 09:42	87,4066666666667	45,0188888888889	
5.1	20/07/23 14:51	79°55’48’’N	32°29’54’’E	MIZ, shallow water near Kvitoya
5.2	20/07/23 14:58	79°55’36’’N	32°29’33.70’’E	MIZ, shallow water near Kvitoya
5.3	20/07/23 15:08	79°55’22’’N	32°29’14’’E	MIZ, shallow water near Kvitoya
5.4	20/07/23 15:12	79°55’17’’N	32°28’45’’E	MIZ, shallow water near Kvitoya
5.5	20/07/23 15:17	79°55’08’’N	32°28’24’’E	MIZ, shallow water near Kvitoya
5.6	20/07/23 15:23	79°55’00’’N	32°27’59’’E	MIZ, shallow water near Kvitoya
5.7	20/07/23 15:28	79°54’52’’N	32°28’40’’E	MIZ, shallow water near Kvitoya
5.8	20/07/23 15:34	79°54’50’’N	32°29’55’’E	MIZ, shallow water near Kvitoya
5.9	20/07/23 15:41	79°54’47’’N	32°31’28’’E	MIZ, shallow water near Kvitoya
5.10	20/07/23 15:49	79°54’25’’N	32°30’57’’E	MIZ, shallow water near Kvitoya
5.11	20/07/23 15:56	79°54’32’’N	32°31’15’’E	MIZ, shallow water near Kvitoya
5.12	20/07/23 16:02	79°54’36’’N	32°32’05’’E	MIZ, shallow water near Kvitoya
5.13	20/07/23 16:07	79°54’41’’N	32°33’26’’E	MIZ, shallow water near Kvitoya
6.1	21/07/23 08:45	80°02’14’’N	31°21’05’’E	MIZ, shallow water near Kvitoya
6.2	21/07/23 08:51	80°03’43’’N	31°19’09’’E	MIZ, shallow water near Kvitoya
6.3	21/07/23 08:55	80°03’37’’N	31°18’33’’E	MIZ, shallow water near Kvitoya
6.4	21/07/23 09:00	80°03’33’’N	31°17’50’’E	MIZ, shallow water near Kvitoya
6.5	21/07/23 09:04	80°03’31’’N	31°17’18’’E	MIZ, shallow water near Kvitoya

6.6	21/07/23 09:08	80°03’23’’N	31°17’35’’E	MIZ, shallow water near Kvitoya
6.7	21/07/23 09:12	80°03’08’’N	31°17’33’’E	MIZ, shallow water near Kvitoya
6.8	21/07/23 09:16	80°02’51’’N	31°17’57’’E	MIZ, shallow water near Kvitoya
6.9	21/07/23 09:19	80°02’43’’N	31°18’20’’E	MIZ, shallow water near Kvitoya
6.10	21/07/23 09:22	80°02’37’’N	31°18’49’’E	MIZ, shallow water near Kvitoya
7	20/08/23 20:43	81°31.4043’N	20°57.6885’E	Along with Argo deployments

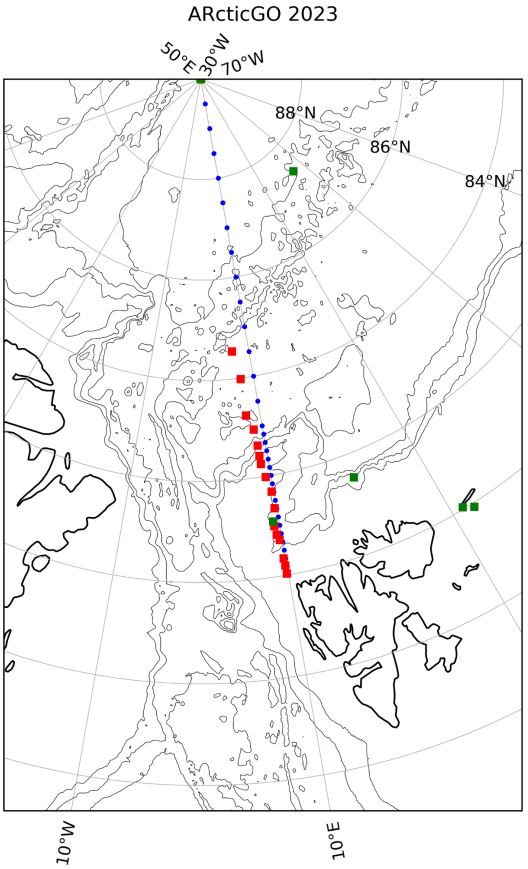

Figure 6: Position of planned XBT launch (blue squares) and performed (red dots) ; and CTD stations (green squares during the ARctiGO 2023 cruise.

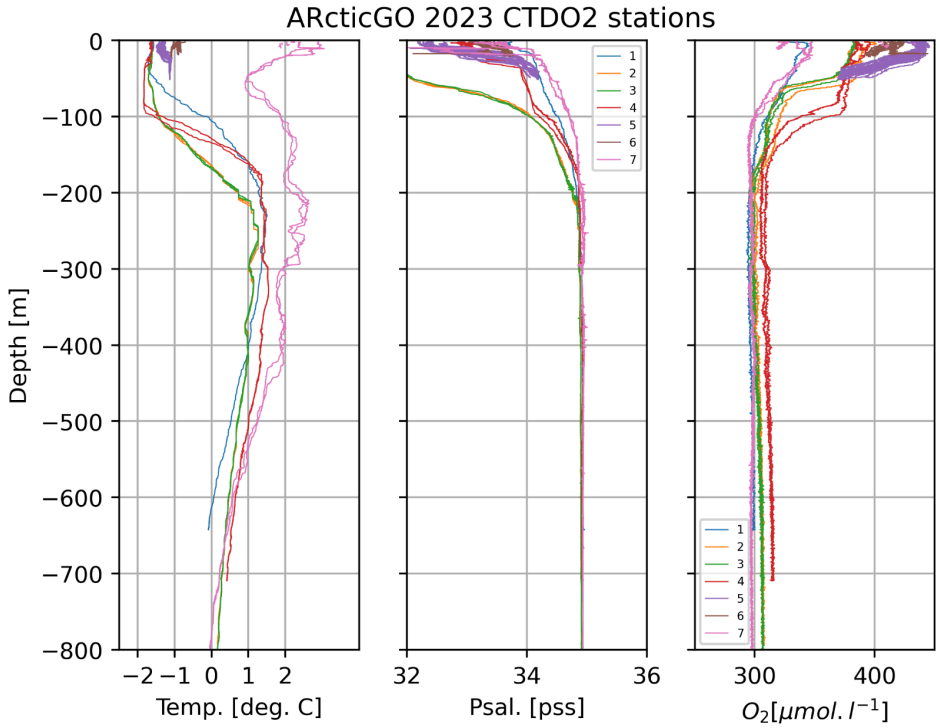

Figure 7: Temperature (in °C, left panel), Salinity (in pss, middle panel) and Dissolved Oxygen concentration (in µmol/l, right panel) from CTDO2 station carried out during ARcticGO2023 cruises. Station numbers corresponds to the stations listed in Table 3.

d. XBT launch

XBTs Lockheed-Martin Sippican T7/T5 are one-shot-probs measuring profile of temperature of the upper 700/1500 m depth of the water column (https://www.lockheedmartin.com/content/dam/lockheed-martin/rms/documents/oceanographic-instrumentation/20050054_XBT_XSV_reader_page.pdf).They have been launched during the transit of ship without stopping ship. After calibration and validation, the data will be freely distributed by the French Coriolis Data Center for fundamental research purposes and operational oceanography (http://www.coriolis.eu.org/). The position of XBT launch are reported in Table 5 and in map Fig. 6 and along the section from Svalbard to North Pole in Fig. 8 and 9.

Table 5: List of XBT launch during Arcticgo2023

Launch	Time (UTC)	Latitude	Longitude	Depth	data file	Probs type
1	12/07/23 02:44	80°01'59.90''N	9°50'52.13''E	~500 m	XBT T-7 20230712023655	T7
2	12/07/23 03:26	80°11'28.41''N	9°48'37.23''E	~520 m	XBT T-7 20230712032106	T7
3	12/07/23 03:49	80°20'16.434''N	9°46'31.751''E	~620 m	XBT T-7 20230712034900	T7

4	12/07/23 05:50	80°42’43.408’’N	9°40’12.229°E	~360 m	XBT T-7 20230712055018	T7
5	12/07/23 06:35	80°49’17.435’’N	9°25’00.358’’E	~760 m	XBT T-7 20230712063508	T7
6	12/07/23 08:06	81°00’06.110’’N	9°19’53.828’’E	~760 m	XBT T-7 20230712080632	T7
7	12/07/23 09:12	81°05’24.781’’N	9°15’10.051’’E	~280 m	XBT T-7 20230712091240	T7
8	12/07/23 12:37	81°20’43.661’’N	9°43’56.419’’E	~760 m	XBT T-7 20230712123741	T7
9	12/07/23 15:29	81°40’47.731’’N	9°43’05.250’’E	~700 m	XBT T-7 20230712152911	T7
10	12/07/23 17:21	81°59’09.088’’N	9°12’38.110’’E	~700 m	XBT T-7 20230712172150	T7
11	12/07/23 20:06	82°15’13.336’’N	8°50’44.632’’E	~760 m	XBT T-7 20230712200649	T7
12	12/07/23 22:52	82°25’10.886’’N	8°49’58.444’’E	~760 m	XBT T-7 20230712225201	T7
13	13/07/23 01:16	82°37’29.635’’N	8°46’36.379’’E	~760 m	XBT T-7 20230713011609	T5
14	13/07/23 04:21	82°57’04.983’’N	8°33’41.582’’E	~1820 m	XBT T-5 20230713042102	T5
15	13/07/23 08:09	83°14’46.628’’N	7°36’59.893’’E	~1830 m	XBT T-5 20230713080920	T5
16	13/07/23 17:45	83°58’55.859’’N	7°32’56.719’’E	~1830 m	XBT T-5 20230713174523	T5
17	13/07/23 23:22	84°32’47.417’’N	6°47’43.933’’E	~1235 m	XBT T-5 20230714004722	T5
18	16/07/23 10:00	89°59’53.930’’N	59°51’15.911’’W	~1850 m	XBT T-5 20230716100020	T5

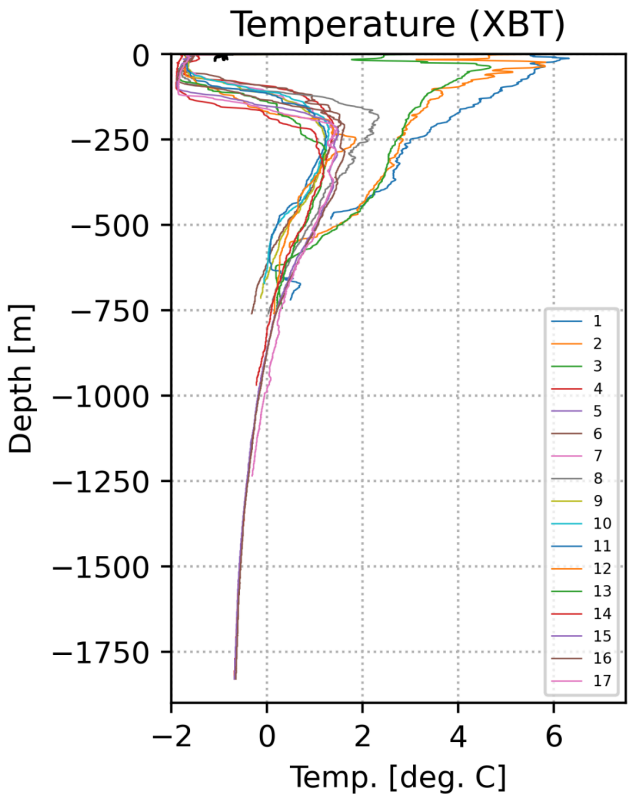

Figure 8: Temperature (left panel) and salinity (right panel) as function of depth from XBT/CTD profiles carried out during ARcticGO 2022 between Svalbard and North Pole (see Fig. 1). The profile number corresponds to the launch number in Table 4.

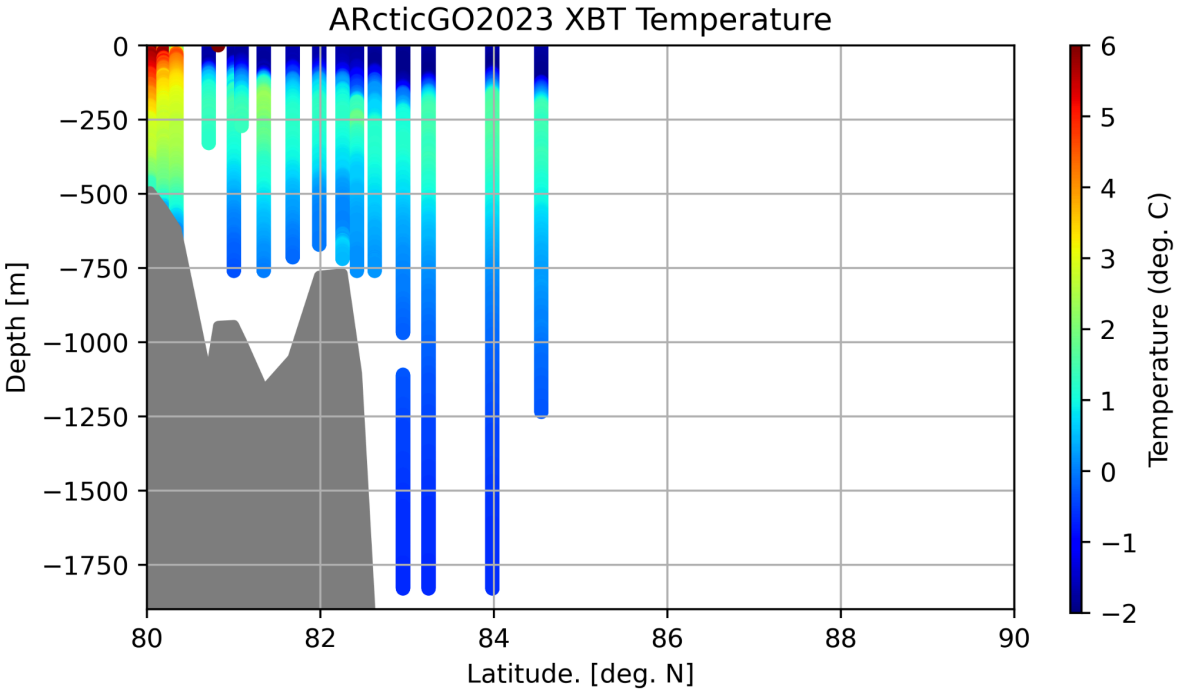

Figure 9: Latitude-depth temperature section between 81-90°N and between 20-40°E (see Fig. 1) from XBT/XCTD profiles carried out during ARcticGO 2023.

e. Underway TSG measurement

The vessel “Le Commandant Charcot is equipped with a Seabird SBE45 and SBE38 sensors (https://www.seabird.com/sbe45-microtsg-thermosalinograph/product?id=54627900541) measure conductivity [mS/cm] and temperature [°C]. The additional parameters of salinity [PSU] and sound velocity [m/s] are calculated internally and are also stored in the vessel's data management system. The data are collected for fundamental research and operational oceanography. Water samples are collected for validation and SBE45 conductivity cell drift correction. After post processing and validation, the data are archived on French National Services of Sea Surface Salinity and freely displayed and distributed at http://www.legos.obs-mip.fr/observations/sss/.

6. ZEE operation

ARcticGO 2023 cruise has been performed in July 2023 (07/07-27/07) on “Le Commandant Charcot” between Longyearbyen and the North Pole. Argo floats, XBT/XCTD, SVP-BSC drifters, CTDs have been deployed within the Norvegian/Svalbard ZEE in the Marginal Ice Zone with clearance: **ref. 23/3462. For scientific reasons, the deployments of Argo floats and drifting buoys have been delayed on 20/08/2023 on another cruises of “Le Commandant Charcot”. An extension of clearance until 10/09/2023 has been accepted by the Norwegian Directorate of Fisheries.**