SCIENCE AND TECHNOLOGY ORGANIZATION
CENTRE FOR MARITIME RESEARCH AND EXPERIMENTATION

Cruise Report **CMRE-CR-2023-06-COLD23**

COLD23 Post-Cruise Report

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April 2025

About CMRE

The Centre for Maritime Research and Experimentation (CMRE) is a world-class NATO scientific research and experimentation facility located in La Spezia, Italy.

The CMRE was established by the North Atlantic Council on 1 July 2012 as part of the NATO Science & Technology Organization. The CMRE and its predecessors have served NATO for over 50 years as the SACLANT Anti-Submarine Warfare Centre, SACLANT Undersea Research Centre, NATO Undersea Research Centre (NURC) and now as part of the Science & Technology Organization.

CMRE conducts state-of-the-art scientific research and experimentation ranging from concept development to prototype demonstration in an operational environment and has produced leaders in ocean science, modelling and simulation, acoustics and other disciplines, as well as producing critical results and understanding that have been built into the operational concepts of NATO and the nations.

CMRE conducts hands-on scientific and engineering research for the direct benefit of its NATO Customers. It operates two research vessels that enable science and technology solutions to be explored and exploited at sea. The largest of these vessels, the NRV Alliance, is a global class vessel that is acoustically extremely quiet.

CMRE is a leading example of enabling nations to work more effectively and efficiently together by prioritizing national needs, focusing on research and technology challenges, both in and out of the maritime environment, through the collective Power of its world-class scientists, engineers, and specialized laboratories in collaboration with the many partners in and out of the scientific domain.

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CMRE-CR-2023-06-COLD23

COLD23 Post-Cruise Report

R. Been, A. Tesei

This document, which describes work performed under the Maritime Unmanned Systems for ASW (E01) project of the 2023 STO-CMRE Programme of Work, has been approved by the Director.

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COLD23 Post-Cruise Report

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Executive Summary: During the COLD23 sea trial, the team deployed a cluster of sea bottom nodes in shallow waters. Three nodes were equipped with a suite of sonar sensors and magnetometers. The main objectives of the trial were to investigate the space and time coherence of signals received by the bottom nodes while source ranges and environmental conditions varied. More specifically, the goal was to study the effects of the Arctic environment on the performance of sensing nodes.

This report contains an overview of the trial plans, its objectives, and first impressions from the environmental data. The data collected during the execution phases of COLD23 was not processed in real time and has therefore been assessed in post-processing. A look at the data indicates that the environmental data is of high quality, and that, despite the fact that the sea trial was shortened due to bad weather, the experiments were successfully executed.

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Keywords: passive sonar, quantum magnetic sensing, underwater sensing networks, sea bottom characteristics, low power consumption, long endurance, interoperability

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Contents

1 Introduction

The Maritime Unmanned Systems (MUS) for ASW project is part of the Autonomy for ASW (AASW) Programme at NATO STO Centre for Maritime Experimentation (CMRE). The project aims at augmenting conventional ASW capabilities by means of unmanned platforms.

From 5 through 16 June 2023, the AASW Team of CMRE conducted a sea trial north of Tromsø: COLD23. During the COLD23 sea trial, the team deployed a cluster of sea bottom nodes in shallow waters. Three nodes were equipped with a suite of sonar sensors and magnetometers. The main objectives of the trial were to investigate the space and time coherence of signals received by the bottom nodes while ranges and environmental conditions varied. More specifically, the goal was to study the effects of the Arctic environment on the performance of sensing nodes.

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2
Trial Planning and Execution

2.1 Operational Area

The Operational Area "B" used during COLD23, was defined by the following coordinates, also see Figure 1. Area "S" was not used in the end, because of the (initially good) prevailing weather conditions. Also, the depth variation and the expected underwater environment (variability) played a decisive role in choosing the area of interest.

Bear Island OpArea ("B")

Point	*Latitude*	*Longitude*
B1	75° 00.00' N	16° 00.00' E
B2	75° 00.00' N	17° 55.00' E
B3	74° 7.300' N	17° 55.00' E
B4	74° 7.300'N	20° 46.40' E
B5	73° 27.73'N	20° 46.72' E
B6	73° 27.73'N	16° 00.00' E

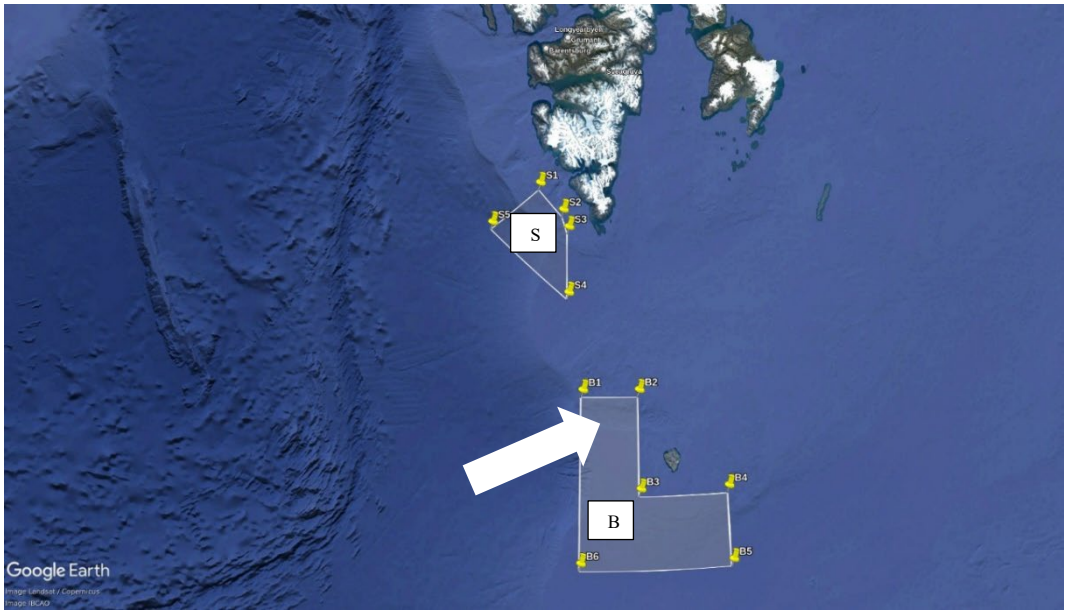

Figure 1. OpArea for COLD23

2.2 Time schedule

The trial was executed in the period from 5 through 16 June 2023. The planned trial activities were divided in 7 main phases:

- Phase 0: 3-4 June – pre-cruise port call NRV Alliance in Tromsø, NOR (alongside, loading of a container); CMRE personnel embarking NRV Alliance;
- Phase 1: 4-5 June – Transit to OpArea;
- Phase 2: 6-8 June – Deployment in OpArea;
- Phase 3: 8-13 June – Measurements in OpArea;
- Phase 4: 13-14 June – Recovery systems in OpArea;
- Phase 5: 15-16 June – Transit back to Tromsø;
- Phase 6: 17-19 June port call NRV Alliance in Tromsø, for personnel disembarking/embarking, and unloading of COLD23 container.

Due to the bad weather encountered, more detail will be given later, the executed plan was:

- Phase 0: 3-4 June – pre-cruise port call NRV Alliance in Tromsø (alongside, very minor loading/unloading); personnel embarking NRV Alliance;
- Phase 1: 4 June – Depart for OpArea
- Phase 2: 6-8 June – Deployment in OpArea;
- Phase 3: 8-9 June – Measurements in OpArea;
- Phase 4: 10+11 June – Recovery WireWalker, experimentation, recovery OBSs, experimentation;
- Phase 5: 11-14 June – Seek shelter;
- Phase 6: 15 June – Recovery remaining assets;
- Phase 7: 16 June –Arrival in Tromsø;
- Phase 8: 17-19 June port call NRV Alliance in Tromsø, CMRE personnel disembarking. Minor loading/unloading.

2.3 Daily reports

This section contains the SITREPS for all COLD23 experiment days.

2.3.1 Daily report 6 June

NRV Alliance arrived in the Ops Area in the morning of the 6th, around 5:30 local time. The main activities of the day were:

- Very limited multi-beam survey of the area where the Conductivity Temperature Depth (CTD) system is to be deployed, result: the sea bottom is sufficiently flat to proceed with its mooring;
- Moored CTD deployment;
- Transit to area for further system deployment;
- Deployment;
- Bottom grab at the location where the CMRE bottom nodes (BONOs) will be deployed.

Position: North Western part of the Bear Island 'B' Ops Area (see Figure 1);
Weather conditions: SS 2, light/medium breeze;
Effectiveness: All equipment working as intended.

2.3.2 Daily report 7 June

The main activities of the day were:

- Take a CTD;
- Bottom grab at the location where the Ocean Bottom Seismometers (OBSs) will be deployed (see Figure 2);
- Deploy OBS systems;
- Transit to other part of the area for other bottom node deployment;
- Deployment of bottom nodes; this step completes the bottom nodes deployment and the moored environmental sensors' deployment;
- Take a CTD;

Weather conditions: SS 3, medium breeze;
Effectiveness: All equipment working as intended.

Figure 2 Bottom grab

2.3.3 Daily report 8 June

The main activities of the day were:

- Take a CTD;
- Deploy sound source (the level of which was always maintained equal or below180 dB re 1µPa @ 1m) (see Figure 3);
- Ramp-up procedure for the transmitted sound level (apply marine mammal risk mitigation procedures [1], incl. visual and acoustic monitoring);
- Perform structured runs (in both zones in the area with bottom nodes);
- Recover bottom node;
- CTD.

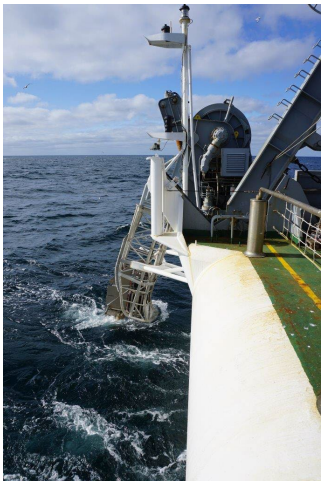

Figure 3 Source deployment

The glider was not deployed due to sea-state limitations.

A bottom node was recovered with the objective of downloading data (for data quality assessment and preliminary analysis on board NRV Alliance), recharging batteries, and deploying the node the morning of the 9th in a different position to alter the overall nodes' geometry (creating larger distances between nodes in terms of wavelengths).

Weather conditions: SS 3, medium breeze;
Effectiveness: All equipment working as intended.

2.3.4 Daily report 9 June

The main activities of the (productive) day were:

- Take a CTD;
- Deploy bottom node recovered on the 8th of June; activate all bottom nodes in order to record data;
- Ramp-up procedure for the transmitted sound level;
- Limited dynamic runs;
- Point measurements in the area around the bottom nodes;
- Recover bottom node for data recovery;
- CTD;
- Evening activities: further dynamic runs for inter-node underwater communications, runs with a focus on magnetic sensing observing environmental variation, and acoustic runs;

The glider was not deployed due to sea-state limitations and in the end was not deployed during COLD23.

A second bottom node was recovered with the objective of downloading data (for data quality assessment and preliminary analysis on board NRV Alliance).

The weather situation started deteriorating Sunday 11th around 16H local time. By then, sailing back to Tromsø was advised since that meant going straight into the storm with an expected sea-state 6.

It was therefore decided to do the maximum of possible measurements in the evening and early night of the 9th, and to continue with the following activities on the 10th, starting at 7H local time in the first bottom node zone (most southern part of the area):

- Recovery WireWalker;
- Recovery Vertical Line Array;
- Take a core close to the bottom nodes;
- Recover the bottom nodes;
- Sail to the other bottom node deployment zone in the area;
- Do point measurements close to the bottom nodes;
- Do limited dynamic runs in the evening, early night.

Weather conditions: SS 3, medium breeze;
Effectiveness: All equipment working as intended.

2.3.5 Daily report 10 June + 11 June

Re-scheduling of activities took place in order to deal with the upcoming bad weather.

The main activities of the 10th were:

- Recovery WireWalker;
- Recovery Vertical Line Array;
- Recover two bottom nodes;
- Sail to the other bottom node deployment zone in the area;
- Do point measurements close to the bottom nodes, take CTD;
- Afternoon and evening activities: further dynamic runs.

The main activity of the 11th was:

- Recovery of the remaining bottom nodes.

As expected, the weather situation started deteriorating Sunday 11th around 10H local time. Sailing to Tromsø was not an option since this meant going straight into the storm with an expected sea-state 6.

It was therefore been decided to seek shelter on the East side of Svalbard. It was hoped that, by the 14th, or 15th morning, the storm would have died down so that transit back to

Tromsø would be possible, where it was hoped, , weather permitting to take two cores underway. One at the first bottom node deployment zone and one at the other.

Weather conditions: SS 3/4, medium/strong winds.

2.3.6 Daily report 12 June + 13 June

The NRV Alliance sheltered from the storm on the 12th (see Figure 4) and as the sea state was expected to improve (see Figure 5), it was hoped to leave the area east of Svalbard and transit back to the trials area, and take cores (weather permitting) in the bottom nodes area on the 14th of June.

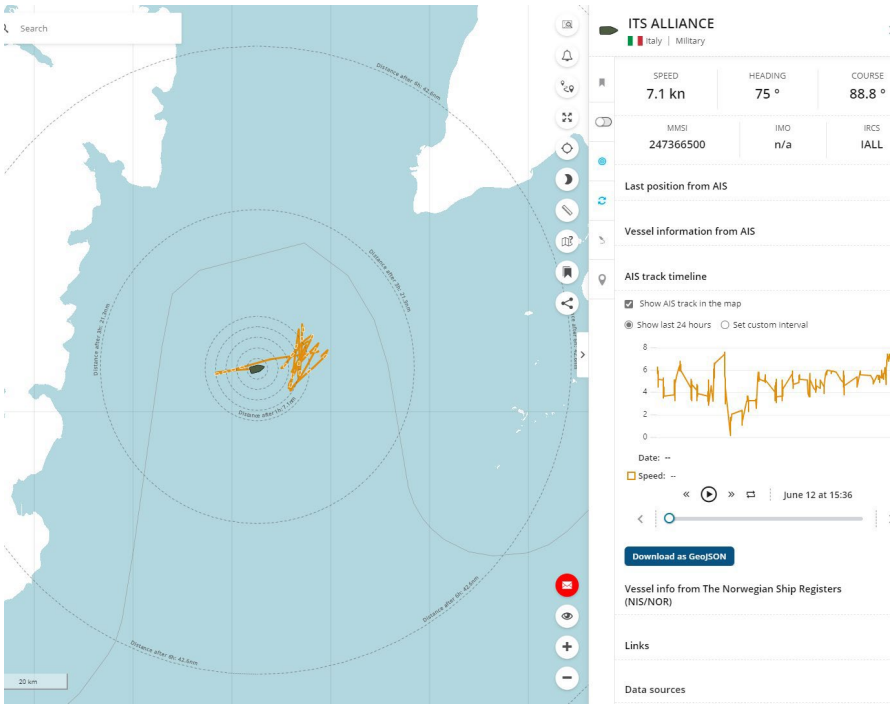

Figure 4 Shelter area east of Svalbard (Courtesy: ship AIS App)

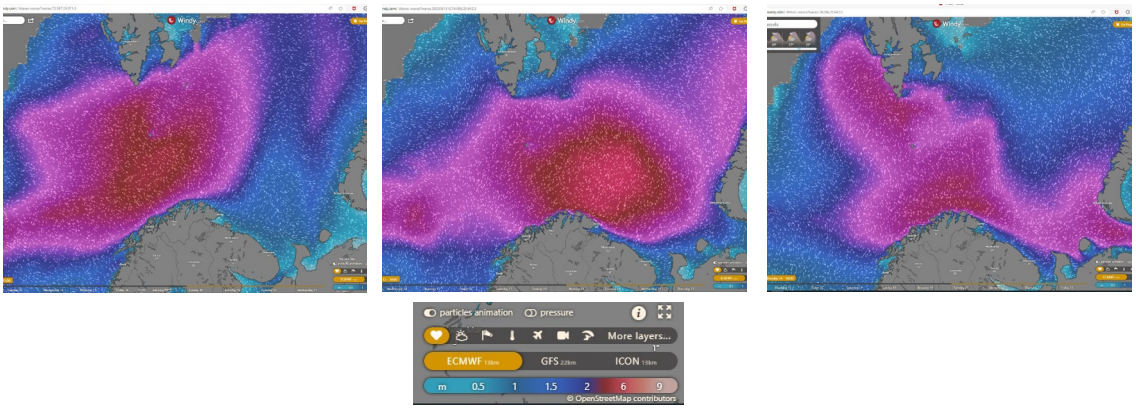

Figure 5 Windy screenshot for 13 June 2023 (left), 14 June 2023 (middle) and 15 June 2023 (right) (Courtesy: www.windy.com)

2.3.7 Daily report 14 June + 15 June

14th of June:
We left the shelter area east of Svalbard and transited back to the trials area, taking bottom grabs in the OBS area. Taking cores was not possible due to the weather so we set course to Tromsø.

15th of June:
Transit day, arrival in the fjords at 17:00, where we waited for the pilot to take us back to Tromsø. Arrival at Tromsø was foreseen at 10:30 on the 16th.

Despite adverse weather conditions, the CMRE team on board NRV Alliance managed to collect valuable data. Following the first on-board analysis, we believe this is a good data set to be further explored. Obtaining these results was made possible through a joint effort of all CMRE teams, on board and in La Spezia, and of course thanks to a very fruitful cooperation and engagement with the ITA Navy and in particular with the CO, officers and crew of NRV Alliance. Our thanks also go out to the Norwegian authorities who made this trial possible.

3 Preliminary results

This section shows some preliminary results of some of the data collected during COLD23. These results are mainly quality checks (partly) using the bottom nodes, the CTD tools, and bottom grab data.

3.1 COLD23 collected data

The data shown in this section comprises:

- Conductivity Temperature Depth (CTD) data collected from the 6th through the 10th of June, from the start of the experiments to the recovery phase (accelerated for reasons of bad weather);
- Bottom grab results for various positions inside the COLD23 area;
- Examples of the magnetometer data that exhibit the influence of the environment.

3.1.1 CTD data from 6 through 10 June

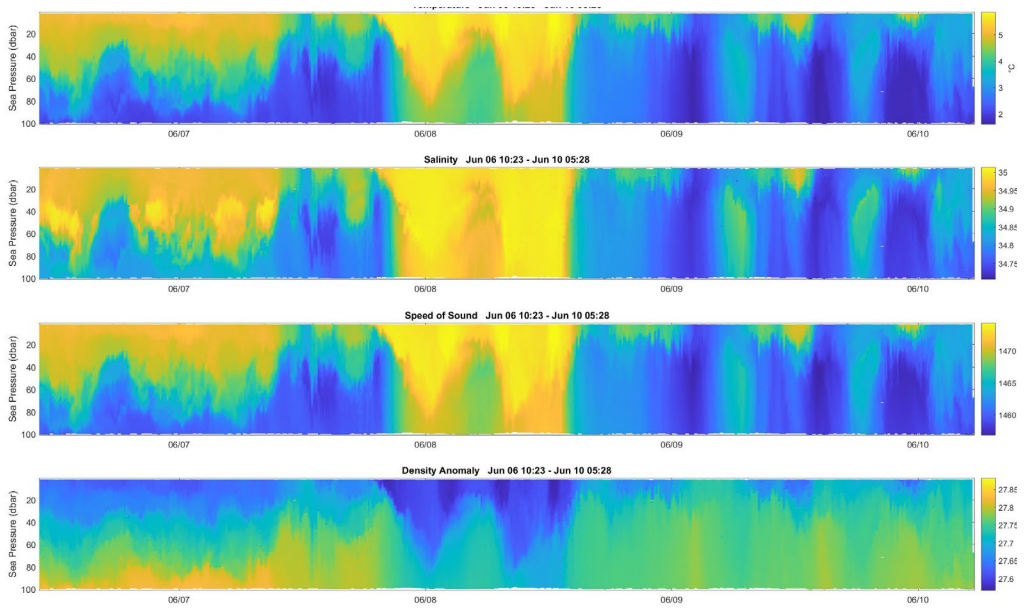

Figure 6 COLD23 CTD data recorded from the 6th through the 10th of June, clearly showing strong environmental variation

The CTD data in Figure 6 where recorded from the 6th through the 10th of June, and clearly show strong environmental variation during the operations.

3.1.2 Bottom grabs in the COLD23 operations area

The team on board NRV Alliance took bottom grabs in the area in order to verify the bottom type indications we had for the area (Figure 1), based on publically available information shown in Figure 7 (courtesy: www.mareano.no).

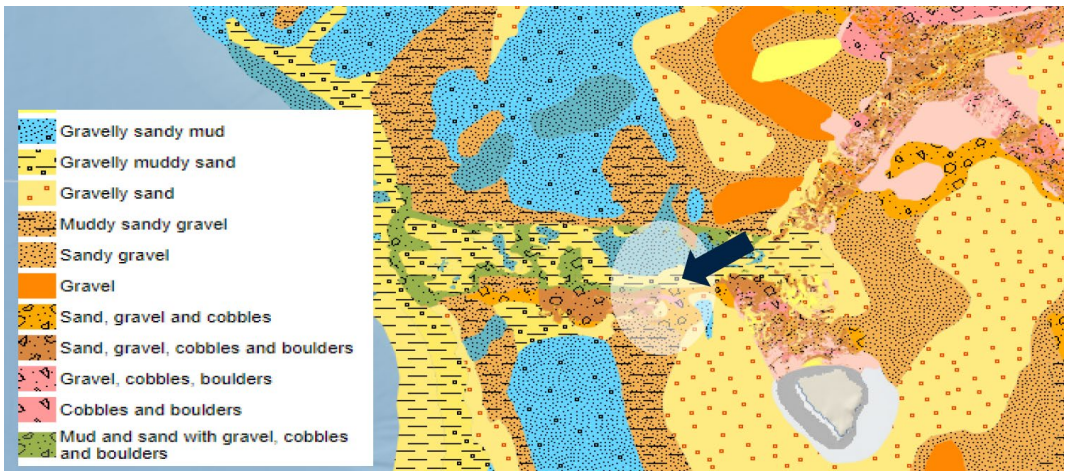

Figure 7 Publically available data for the bottom types in the area of interest (courtesy www.mareano.no)

A summary of the grabs carried out by CMRE is given in Table 1 below. Please note that no cores were taken.

Table 1. Bottom grab results

DATE	EVENT	POSITION		DEPTH	Quick-look on board	Lab results
06/06/2023						
	Grab#01	74 37.490 N	017 41.605 E	115 m	Sandy Silty Gravel	Sandy Silty Gravel
06/07/2023						
	Grab#02	74 44.338 N	017 43.823 E	220 m	Sandy Silty Gravel	Sandy Silty Gravel
14/06/2023						
	Grab#03	74 45.087 N	017 43.523 E	260 m	Gravelly Silty Sand	Gravelly Clayed Sand
	Grab#04	74 45.659 N	017 43.452 E	272 m	Silty Sand	Clayed Sand

3.1.3 Sample magnetic sensor data collected in the COLD23 operations area

The CMRE team also collected magnetic data during COLD23. Figure 8 shows a representative sample of long-term data collected in the area, showing strong environmental variation.

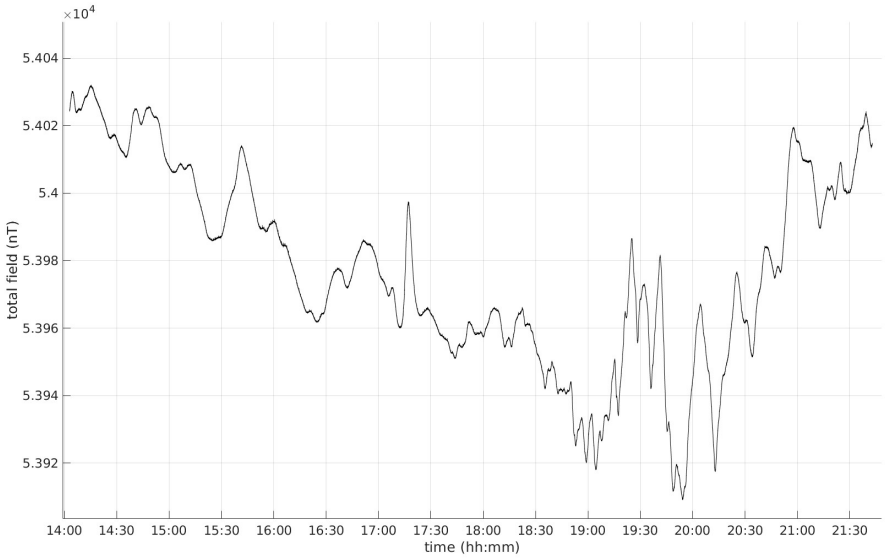

Figure 8 Representative sample of the magnetometer data collected on one of the bottom nodes during COLD23

4 Summary

This report describes the planning and execution phase, the collected data, and some results of the COLD23 experiments that took place in Northern Norwegian waters in June 2023. The objectives for COLD23 included an assessment of the performance of each of the sensors that are mounted on the CMRE sea bottom nodes. The key information that the CMRE team was looking for was environmental influences. The quality of the data was assessed on board NRV Alliance. Given the data quality checks on board, the team believes that the collected data is highly valuable.

Our heartfelt thanks goes out to all parties that have supported us and have made these experiments possible. The trials would not have been possible without this support.

References

[1] CMRE Staff Instruction 77 (V13.1 signed by Director CMRE 14/10/2013);

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Title

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Keywords

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