The Iceland-Greenland Seas Project

ALL0118 Cruise Report

Chief Scientist: Robert S. Pickart, Woods Hole Oceanographic Institution

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Section A: Overview

Contributing author: Robert Pickart (rpickart@whoi.edu)

The Iceland-Greenland Seas Project (IGP) is an international, multi-disciplinary program investigating wintertime ventilation in the western Nordic Seas and the associated atmospheric forcing. There are 12 participating institutions (Table A1) and over 50 researchers involved. The fieldwork consists of a wide array of components, including two winter cruises, an aircraft campaign, moorings, gliders, floats, and a meteorological buoy. This report documents the activities carried out on the NRV *Alliance* winter cruise in February-March 2018. A list of the shipboard programs/measurements is contained in Table A2, along with the associated personnel who participated on the cruise. A summary of each program is included below as part of this report.

Alliance departed Reykjavik, Iceland on 6 February for leg I of the cruise, which focused on the northwest Iceland Sea (Fig. A1). During this period we occupied 6 transects, some of them using *Alliance's* conductivity-temperature-depth (CTD) package, some with expendable CTDs (XCTDs), and some using a combination of the two. This was largely dictated by the sea state (XCTDs were used when it was too rough to deploy the CTD package) along with timing considerations (XCTD measurements require far less time than CTD casts). Most of the CTD casts were taken to the bottom, the exception being in the Iceland Sea gyre. Three of the sections extended into the East Greenland current (EGC). Unfortunately leg I was interrupted for an unscheduled port stop in Akureyri, Iceland resulting in a significant loss of science time. Leg I operations ended on 21 February at which time *Alliance* sailed to Isafjordur, Iceland for the mid-cruise port stop.

Institution	Cruises/aircraft campaign	Science contributions
Woods Hole Oceanographic Institution, USA	Cruises	Shipboard hydrography, mooring, ocean modeling
University of East Anglia, Norwich, UK	Aircraft campaign	Atmospheric measurements, shipboard meteorological measurements, atmospheric modeling
University of Bergen, Norway	Cruises	Gliders, floats, mooring, meteorological buoy, atmospheric measurements
Uni Research, Bergen, Norway	Cruises	Shipboard chemistry
Institute of Marine Research, Bergen, Norway	Cruises	Moorings
Marine and Freshwater Research Institute, Reykjavik, Iceland	Cruises	Moorings, shipboard hydropgraphy
University of Akureyri, Iceland	Cruises	
University of Toronto, Canada	Cruises and aircraft campaign	Ice imagery, reanalysis products
University of British Columbia, Vancouver, Canada	Cruises	Glider
Icelandic Met Office	Cruises and aircraft campaign	Meteorological support
British Antarctic Survey	Aircraft campaign	Aircraft support
UK Met Office	Cruises and aircraft campaign	Meteorological support

Table A1: IGP participating institutions

Leg II began on 26 February, roughly coincident with the start of the IGP aircraft campaign. Shortly after leaving port a cold-air outbreak (CAO) developed in the Iceland Sea, and over the next week we coordinated the shipboard sampling with the aircraft operations to sample the different stages of the event.

After a pre-CAO XCTD survey (lines s1-s3 in Fig. A2), we began repeat occupations of two "triangles" in the northwest Iceland Sea (see the legend in Fig. A2) to document the water column response to the enhanced heat fluxes. Part of the goal was to be able to calculate heat budgets in order better quantify the mixed layer evolution through the event, which lasted roughly 6 days. We also began occupying a timeseries station at the base of the southern triangle, which was visited 7 times over the course of the cruise. Unfortunately, science operations were interrupted a second time in order to give the crew a rest period in Akureyri (inexplicably, only 9 days after leaving port for leg II). This resulted in another significant loss of science days.

After the stay in Akureyri we steamed to the southwest Greenland Sea and occupied a series of sections (CTD, XCTD, XBT) concentrating on the western side of the Greenland Sea gyre (Fig. A1). The CTD casts were taken to 800m (far deeper than the mixed-layer depth) in order to save time. As time went on, the ship became more comfortable working in the marginal ice zone, and, consequently, we sampled well into the EGC on these sections. We also made an excursion into the central part of the Greenland Sea gyre. During our steam back south to the Iceland Sea we occupied two long XBT sections, as well as a CTD section along the western-most gap in the West Jan Mayen Ridge (section 11, Fig. A1). The final CTD transect was occupied across Denmark Strait, a re-occupation of the so-called Látrabjarg Section. This was done at high resolution (5 km station spacing) to accurately capture the structure of the overflow water passing through the strait. The cruise ended on 22 March when *Alliance* docked in Reykjavik.

Table A2: Shipboard programs and measurements

Shipboard measurement	Onboard contact	Institution
Shipboard CTD and ADCP	Leah McRaven (ltrafford@whoi.edu)	Woods Hole Oceanographic Institution, USA
Underway shipboard meteorological measurements	Leah McRaven (ltrafford@whoi.edu)	Woods Hole Oceanographic Institution, USA
XBT and XCTD survey	Leah McRaven (ltrafford@whoi.edu)	Woods Hole Oceanographic Institution, USA
Bottle salinity	Leah Houghton (lhoughton@whoi.edu)	Woods Hole Oceanographic Institution, USA
Meteorological measurements	Christopher Barrell, Annick Terpstra (C.Barrell@uea.ac.uk, annick.terpstra@UIB.NO)	University of East Anglia, Norwich, UK
Glider and Met buoy deployment	Kjetil Våge (kjetil.vage@uib.no)	University of Bergen, Norway
CFC-12, SF6, dissolved oxygen, and nutrients	Emil Jeansson, Kristin Jackson (Emil.Jeansson@uni.no, Kristin.Jackson@uib.no)	Uni Research and University of Bergen, Norway
Water Isotope Measurements	Yongbiao Weng (yongbiao.weng@uib.no)	University of Bergen, Norway
Glider	Chris Payne (cpayne@eoas.ubc.ca)	University of British Columbia, Vancouver, Canada

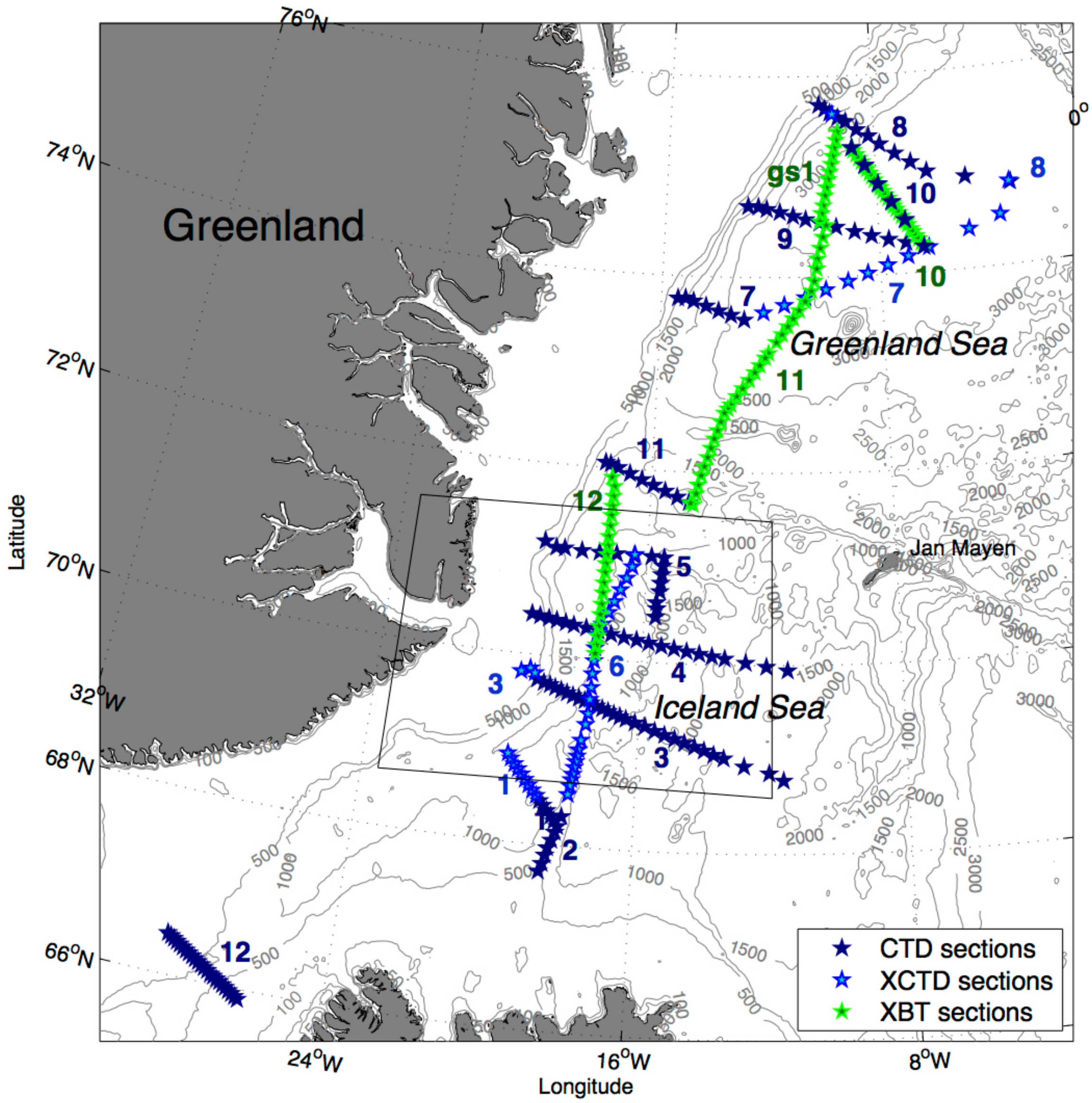


Figure A1: Large-scale basemap showing the locations of the shipboard transects occupied during ALL0118 (see the legend). The box outlines the zoomed-in region shown in Fig. A2.

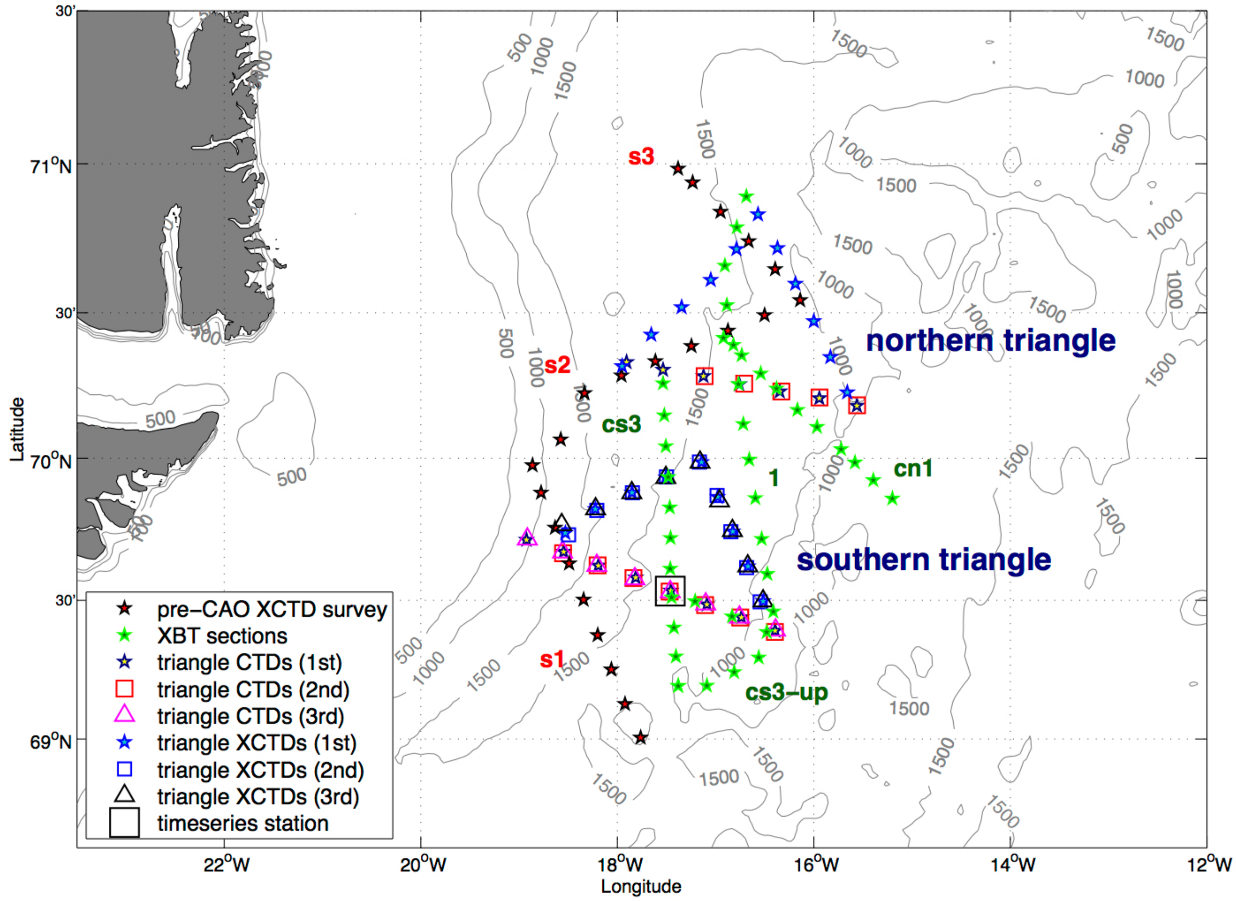


Figure A2: Detailed shipboard sampling done in the northwest Iceland Sea (within the boxed region of figure A1). See the legend for an explanation of the measurements.

Operations

Since the cruise was targeting inclement weather, and much of the operations were to take place in and near the marginal ice zone (MIZ), it was imperative to have accurate and timely weather forecasts and ice imagery. Furthermore, it was critical to have good communications between the ship and the aircraft team ashore to plan and carry out the overflights of the ship.

Each morning we received, via ftp, a variety of weather products from both the Icelandic Met Office and the UK Met Office who were running high-resolution models tailored for our study area. The Danish meteorological institute (DMI) also provided a detailed forecast via email. These products were incorporated into the daily operational briefings on the ship and proved to be invaluable for planning our science activities. DMI also provided a daily ice image from the Sentinel satellite, onto which we overlaid our planned stations. The University of Toronto emailed a high-resolution SAR image each day, also with the station positions on it, as well as a digital file of ice concentration from AMSR2. These three ice products allowed us to anticipate the conditions in the MIZ, giving us valuable context for maneuvering the ship. As a general rule we would aim to begin each approach into the MIZ at first light, maximizing the number of daylight hours for station work in and near the ice.

The primary oceanographic instrument used during the cruise was the CTD system, mounted on a small rosette. This was *Alliance's* "Inside CTD" which was deployed from a small Baltic room on the starboard side of the ship. *Alliance's* other system is their "outside CTD" which is staged from the port side of the foredeck (without a hanger). Due to the below-freezing air temperatures and high sea state experienced during much of the cruise, it was essential to use the Baltic room. We were able to carry out CTD casts in sustained 30-35 knot winds. The XCTDs and XBTs were launched from the fantail (either the port or starboard side, depending on the direction of the swell). The chemical analyses were carried out in the main lab and the CTD lab, and the salinometer measurements were done in a van on the fantail. The IGP meteorological instrumentation was located on the boat deck (one level up from the fantail), and the radiosondes were launched from there as well. A van was set up on the boat deck to house the met computers and electronics. *Alliance's* met systems were positioned on the bow mast.

Science operations were carried out 24 hours a day using three teams of CTD watchstanders. The two shipboard technicians also maintained a watch schedule that provided 24-hour coverage. The IT person worked during the day, but was continually on call. Each day at 1245 we held a science briefing to discuss upcoming plans, address any problems, and review the data being collected to help guide our sampling strategies. In total we occupied 189 CTD stations, 152 of them with chemical sampling, 120 XCTDs, and 144 XBTs. Lists of CTD, XCTD, and XBT stations, including time of occupation and station depths, are included in Appendix A1. This resulted in 453 realizations of the mixed layer. Radiosondes were launched daily, with more frequent sampling during interesting weather events. In total 100 sondes were launched. The met instruments, shipboard ADCP, and underway CTD recorded data continuously during the cruise. We also deployed a meteorological buoy during leg I, and launched gliders as well as an APEX float.

Brief Science Highlights

Overall, the winter of 2017-18 was milder than normal: air temperatures were 1-2 standard deviations warmer than the long-term average for the western Nordic Seas. Consequently, the measured mixed layers were not as dense or as deep as anticipated. Furthermore, because the ship arrived in Reykjavik late and had two unplanned port stops during the cruise, we lost a total of 13 science days – more than 25% of the planned operational time. Despite both of these factors, however, we collected a large and rich data set. Together with the aircraft data, and the data from other observational components of the IGP as well as the planned modeling work, we will be able to shed great light on the ventilation processes that result in the formation of Denmark Strait overflow water and how this dense water progresses to the sill.

One of the notable discoveries on the cruise was the highly variable spatial structure of the ventilation outside of the Iceland and Greenland Sea gyres. A revealing example of this can be seen in the vertical section of temperature and density for transect 8, which extended from the edge of the Greenland shelf into the Greenland Sea gyre (Fig. A3). The two seaward-most stations in the section are in the gyre, while the four inner-most stations are in the heart of the EGC. The boundary current is characterized by a fresh surface layer above the warm and salty Atlantic-origin water which extends to roughly 600m. The surface heat fluxes are strongest near the boundary, but the freshwater on the shelf/upper-slope freezes, prohibiting convection. Indeed, stations 134-137 were occupied in the MIZ. However, seaward of the MIZ the Atlantic water is being ventilated. We suspect that any freshwater in the outer part of the boundary current was vertically mixed by wind, thereby removing the stratified surface cap and allowing convective overturning to greater than 300m.

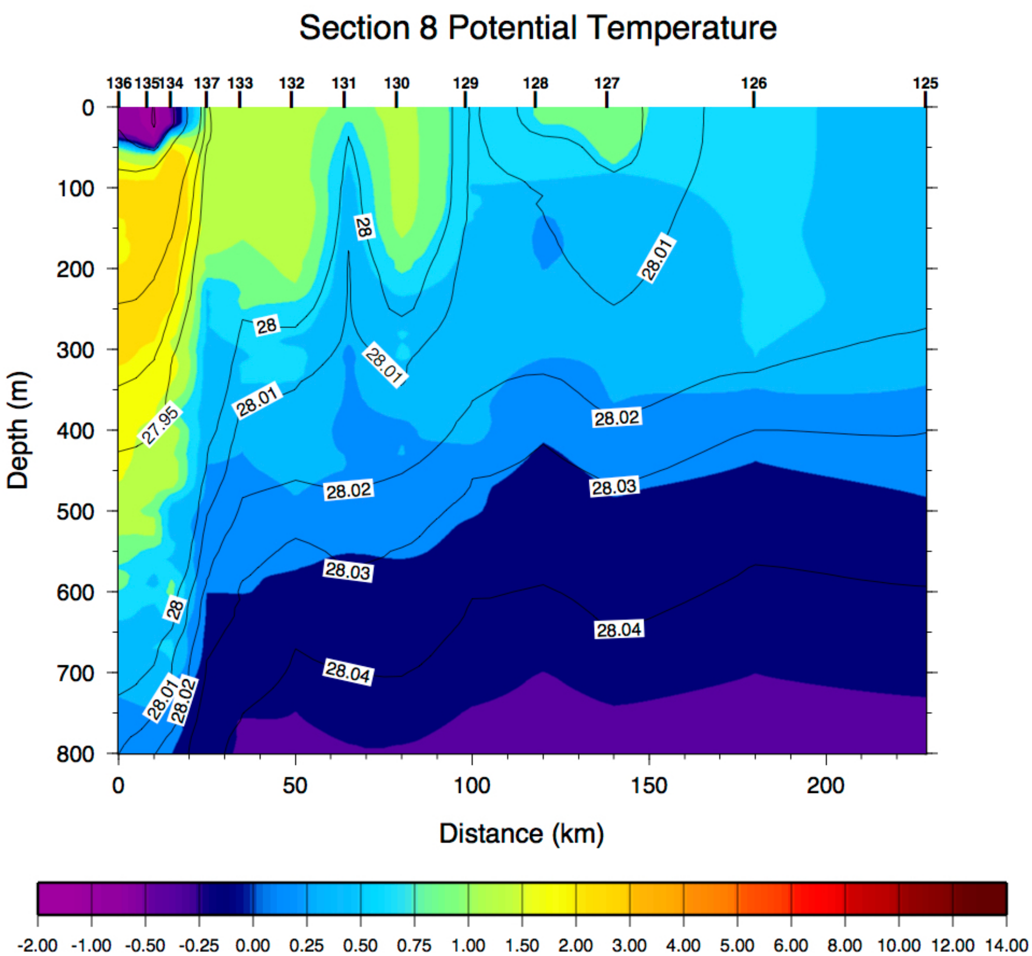


Figure A3: Vertical section of potential temperature (^{o}C, color) and potential density (kg m^{-3}, contours) for transect 8 in the western Greenland Sea (see Fig. A1 for the location of the transect). The viewer is looking north. The station locations are indicated along the top of the plot.

A striking aspect of the section is that, where there are interruptions in the boundary current water, the isopycnals rise sharply towards the sea surface (note stations 131 and 129). In these regions denser water is being ventilated. One of the early conclusions from the cruise is that there is not a well-defined transition from no convection in the boundary current to dense ventilation in the interior. We observed significant amounts of cold, fresh surface polar water and warm, salty Atlantic-origin water away from the boundary throughout our study region. This implies that the EGC is highly unstable at this time of year, and that the water fluxed from the current dictates to first-order the location and degree of dense water ventilation outside of the Iceland and Greenland Sea gyres. Another example of this variability can be seen in XBT section 11 which extends from the Greenland Sea to the West Jan Mayen Ridge (Fig. A4). We also sampled well-defined anti-cyclonic eddies that had been spawned from the EGC (not shown). This emphasizes the importance of the boundary current water and the pre-existing eddy field in modulating the ventilation of Denmark Strait overflow water. This and many more aspects of our exciting data sets will be explored in the coming months and years.

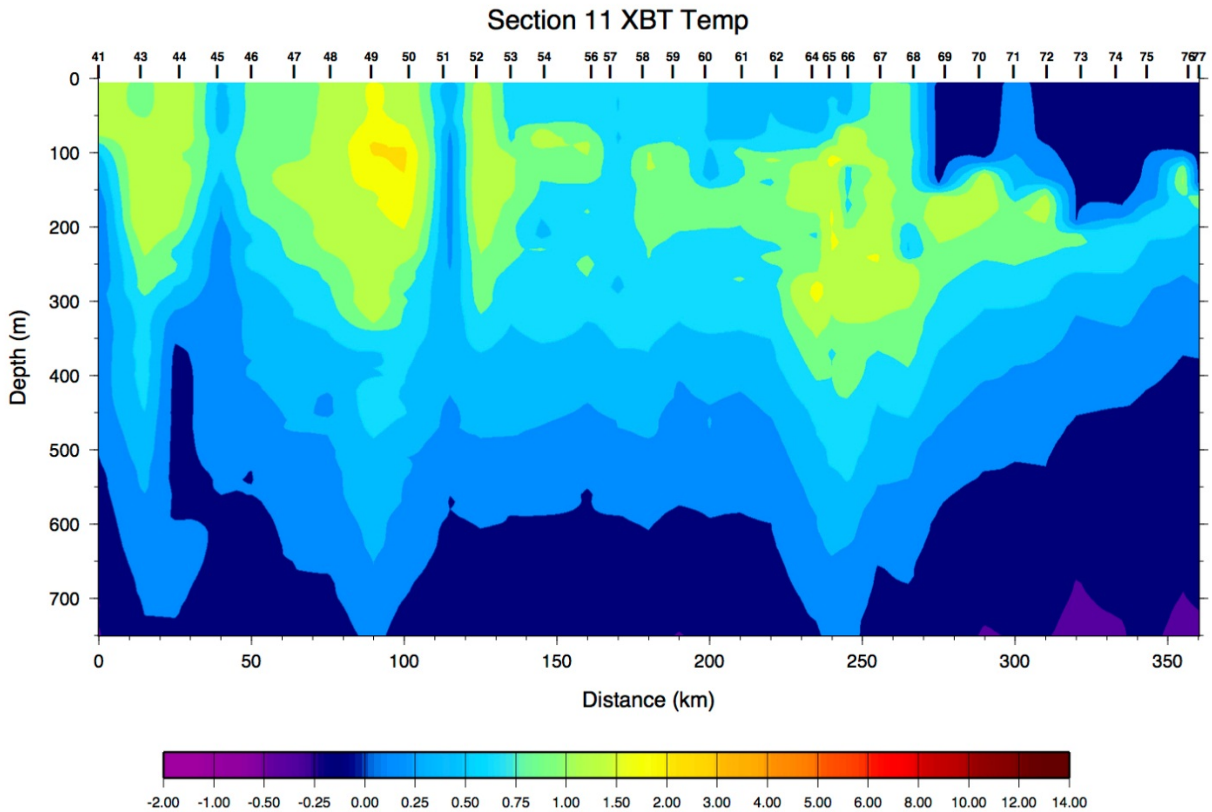


Figure A4: Vertical section of temperature (^oC) for XBT transect 11 (see Fig. A1 for the location of the transect). The viewer is looking to the east. The station locations are indicated along the top of the plot.

Section B: Shipboard CTD report

Contributing author: Leah McRaven (ltrafford@whoi.edu)

CTD configuration and operation

A total of 189 casts were performed using a SeaBird 911plus CTD and deck unit configured to measure pressure, temperature, conductivity, and oxygen current. The CTD data were acquired by an SBE Model 11 plus V2 CTD Deck Unit providing demodulated data to a personal computer running SEASAVE (SeaBird). Bottom approach was controlled by real time altimeter data and ship provided ocean depth information. For each cast, water samples were collected at up to 12 discrete intervals and analyzed for salinity and oxygen. A rosette frame holding 12 5-L Niskin bottles was used for collecting water samples.

Given the very cold and rough working conditions, there were multiple issues with the CTD sensors, as well as the autosal that was used for measuring bottle salinity. In particular, below-freezing temperatures caused sensor freezing, which resulted in the replacement of one sensor and sensor drift throughout the cruise. Cold temperatures also caused considerable difficulty in maintaining consistent temperatures in the van containing the autosal. A retermination of the CTD connection was required part way through the cruise, most likely due to the rough sea state during casts. A detailed outline of important events and problems encountered can be found in the ALL0118_CTD_Calibration_Report.pdf document.

CTD calibrations

Calibrations of the CTD sensors were performed by the Centre for Marine Research and Experimentation (CMRE) before the cruise. As per manufacturer recommendations, CTD data were processed using SeaBird data processing software (ver. 7.22.0). The raw CTD data were converted from HEX to ASCII, lag corrected, edited for large spikes, smoothed according to sensor, and pressure averaged into 2 dB bins for final data quality control and analysis. CTD salinity and oxygen data were then further calibrated by utilizing Niskin water measurements.

Despite the problems associated with cold weather and rough sea state, an overall well-calibrated dataset was obtainable. Once calibrated, the overall standard deviation of the primary CTD conductivity measurements (s/n 3991) and water sample differences is 0.0092 psu. The overall standard deviation of the secondary CTD conductivity measurements (s/n 2946 and s/n 3934) and water sample differences is 0.0085 psu. Details regarding all data processing methods and calibration results are outlined in the ALL0118_CTD_Calibration_Report.pdf document.

Section C: Shipboard ADCP report

Contributing author: Leah McRaven (ltrafford@whoi.edu)

Shipboard ADCP configuration

Underway hull-mounted ADCP data were collected throughout the cruise using two systems: a 75 kHz Ocean Surveyor (OS75) and a 300 kHz Ocean Surveyor (OS300) ADCP (both from Teledyne RD Instruments). Only data from the former instrument was processed. VMDAS data acquisition software was used to collect raw ADCP data from the 75 kHz ADCP. Throughout the cruse, the OS75 was set up to collect 8-meter bins of data for every ping in narrowband mode.

Shipboard ADCP processing

Raw single ping data were processed on board using the CODAS shipboard ADCP processing software developed at University of Hawaii's School of Earth Science and Technology. Single ping data were averaged and edited to remove ship heading and motion from the measured velocity. Five minute processed data were available as absolute velocity profiles throughout the cruise. Barotropic tidal velocities were then removed using Matlab OTIS tidal predictions, kindly provided by Laurie Padman, Earth Systems Research.

Shipboard ADCP sections

The OS75 system recorded data throughout the entire cruise. Special care was taken to steam at a slower speed (10 kts or less) during hydrographic sections to ensure higher data quality and greater data return. Due to the limited data return of the SADCP (primarily due to rough weather conditions), more intensive editing of the data is required before distribution of a final product. Figure 1 shows the latitude and longitude of the SADCP coverage for legs 1 and 2.

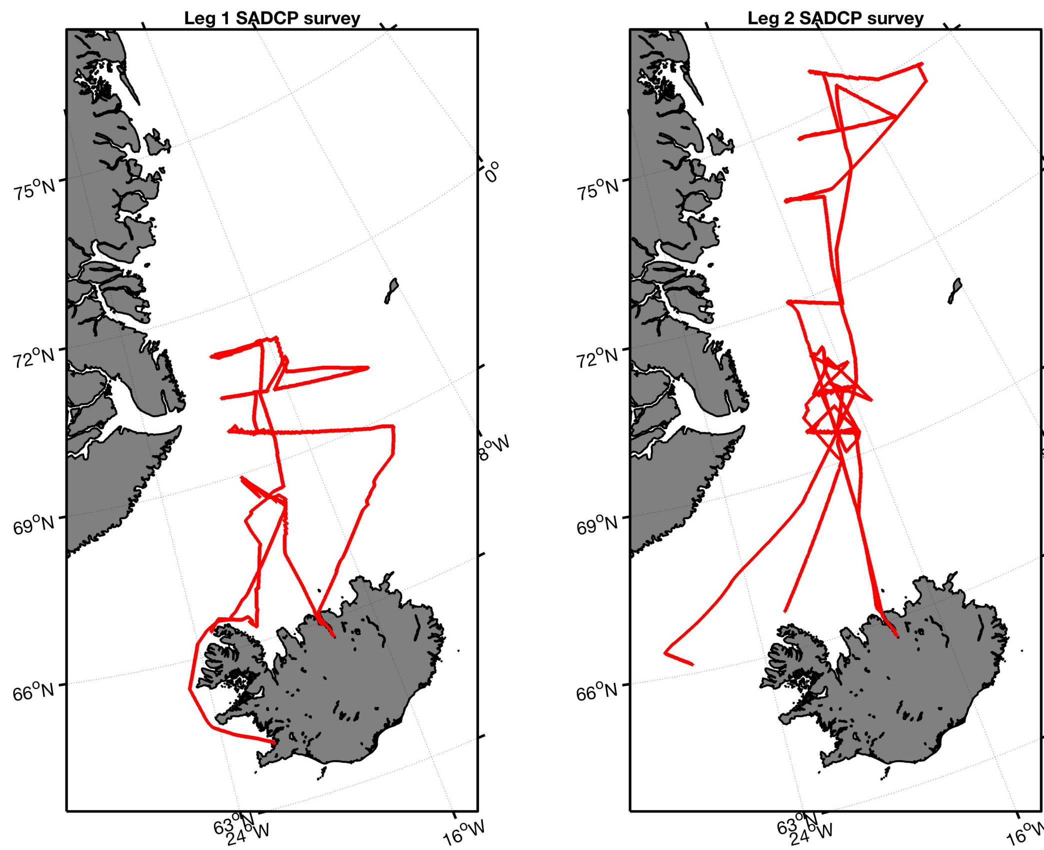


Figure 1: ALL0118 ship track for Legs 1 and 2

Section D: Underway shipboard data report

Contributing author: Leah McRaven (ltrafford@whoi.edu)

Shipboard underway CTD data were collected for the majority of ALL0118. A shipboard dedicated computer running SeaSave (Seabird Electronics software) recorded ocean temperature and salinity through a water intake located at 2.5 m depth on the bow of the ship. An SBE38 temperature sensor measured water temperature close to the seawater intake. Further down the seawater intake line an SBE45 Micro TSG Thermosalinograph measured conductivity and temperature. Throughout the cruise, the SBE45 temperature consistently measured ~0.7 °C warmer than the SBE38 temperature sensor closer to the bow intake. As indicated in the SBE XML configuration files saved with the raw data, no calibration coefficients were applied to the sensors. As such, a post-cruise calibration of the underway CTD temperature and salinity using the calibrated CTD station data will be assessed.

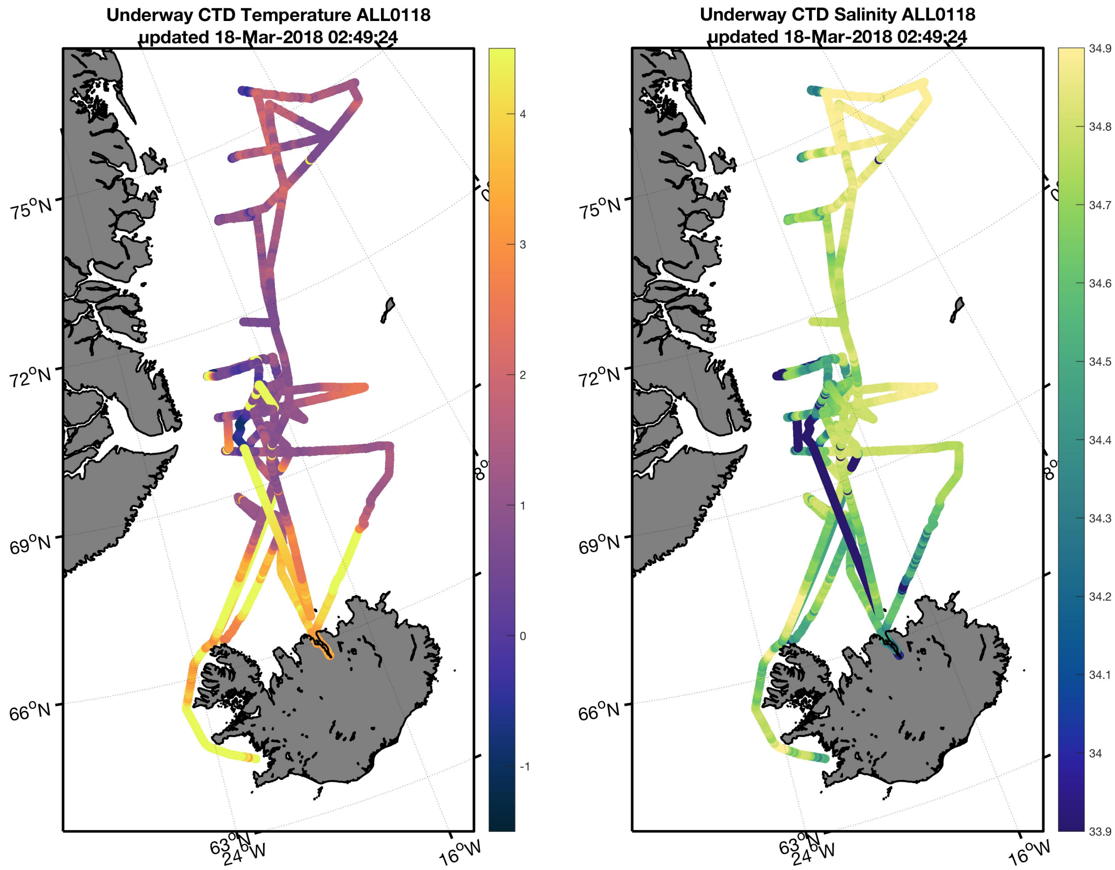


Figure 1: Underway CTD temperature and salinity along the ALL0118 cruise track

Section E: Meteorological data report

Contributing authors: Christopher Barrell (C.Barrell@uea.ac.uk) and Ian Renfrew (I.Renfrew@uea.ac.uk)

Team Members

- Ian Renfrew (PI, UEA, not on board) – i.renfrew@uea.ac.uk
- Chris Barrell (UEA, leg 1 & 2) – c.barrell@uea.ac.uk
- Annick Terpstra (UiB & UEA, leg 1) - annick.terpstra@uib.no
- Daniel Smith (UEA, leg 2) – d.smith5@uea.ac.uk
- Shenjie Zhou (UEA, leg 1) - shenjie.zhou@uea.ac.uk
- Denis Sergeev (UEA, not on board) – d.sergeev@uea.ac.uk
- Andy Elvidge (UEA, not on board) – a.elvidge@uea.ac.uk

Overview

The key goals were to observe the onset and development of cold-air outbreaks (CAOs) and boundary layer evolution. This was achieved through measurement of surface conditions and atmospheric profiles. Observations were made using radiosondes, a wind LIDAR, a radiometer, and a rain radar; the locations of the sensors can be seen in Figure 1. These data are also important for the IGP oceanographic team to analyze the atmospheric forcing of densification and convection within the oceanic mixed layer. The meteorological team also aided with forecast provision for ship operations. Following are details of the instruments on the *Alliance*, their operational schedule and specifications.

Radiosonde Program

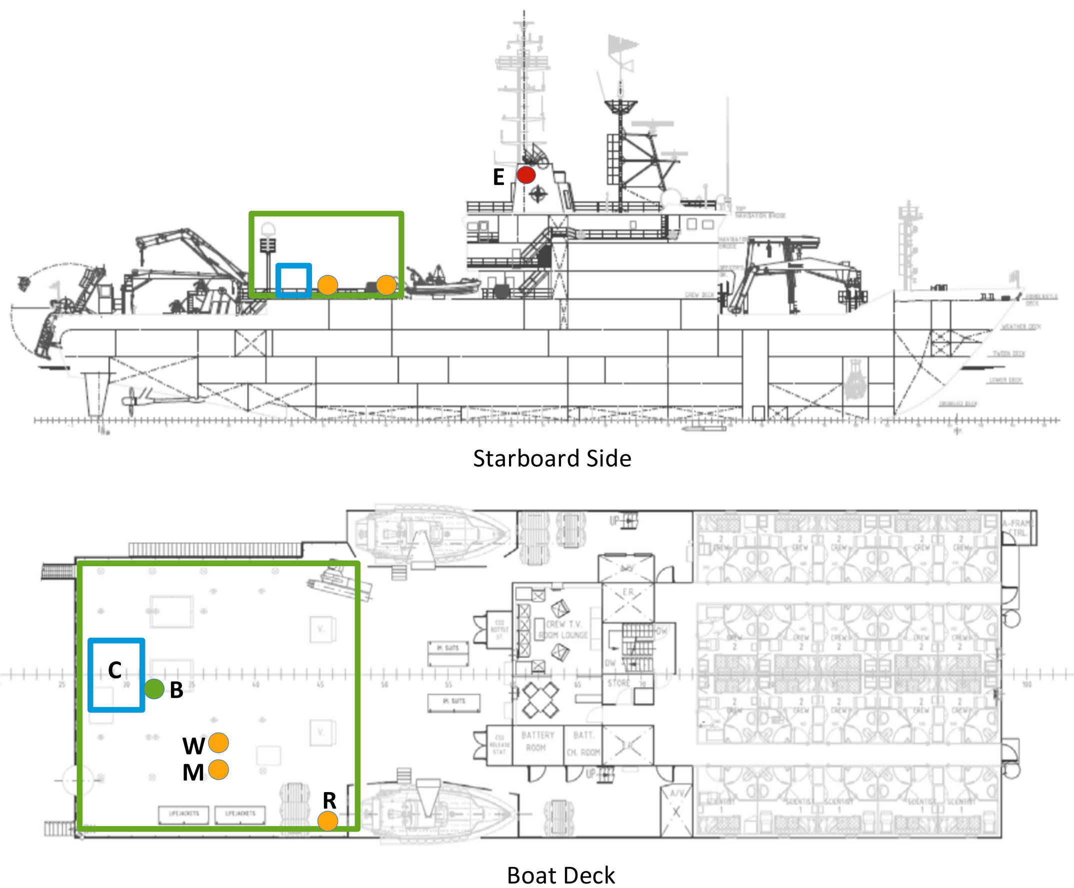


Figure 1. Locations of instruments: **C**: Container, **B**: Balloon Basket, **R**: HATPRO Radiometer, **W**: Windcube, **M**: Micro Rain Radar, **E**: Exhaust Stack.

Summary

They key component of the meteorological observations performed on the *Alliance* is the radiosonde program. Radiosondes provide reliable high-resolution profiles of the atmosphere and are long proven to be effective tools for operational forecasting and assessment of numerical weather prediction reanalyzes. The radiosondes nominally reach an altitude of around 20-25km.

A stock of 100 radiosondes were brought for the cruise, accompanied with 105 Totex 300g weather balloons and 10 50L cylinders of Helium at 300bar. This provided a minimum of 1 balloon per day for general observations and over 50 balloons for intensive observation periods. The particular periods of interest were the transition to CAO conditions and during high ocean-atmosphere heat fluxes. For example, during the onset of a CAO, radiosondes were launched every 3 hours for 48 hours. A quick look at the sounding locations is shown in Figures 2 and 3. Details of the soundings are provided in Appendix 1.

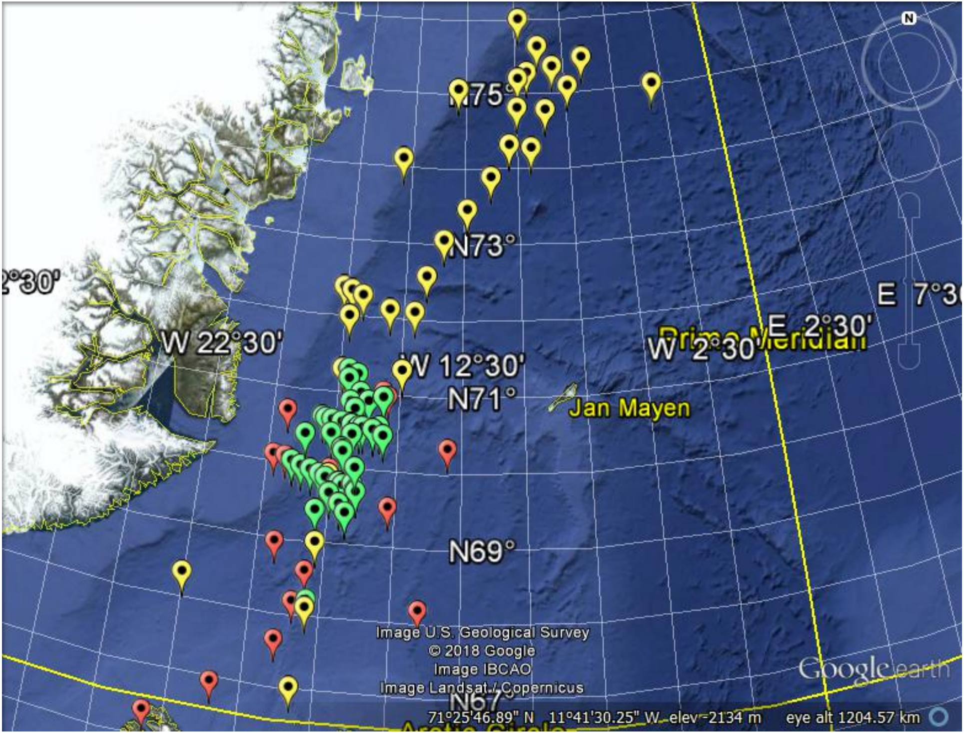
The Vaisala RS41-SG radiosondes collect high-resolution humidity, temperature, pressure, and wind measurements. The temperature sensor utilizes linear resistive platinum technology. The small size of the sensor results in low solar radiation error and fast response. Wind, height and pressure data are resolved from the radiosonde's GPS data combined with differential corrected GPS data from the Vaisala MW41 ground station aboard the ship. The ground station was located in the meteorological team's container on the boat deck. The GPS and UHF antennae were fixed high on the side of the container with ample viewing angle for telemetry. The system's height above mean sea level and its height difference with the antennae, launch position, and barometer are all adjusted parameters for the operational set up.

Preparation of each radiosonde for launch included automatic physical zero humidity check and in-built functional temperature check. For each sounding initial surface values were entered using other instruments on the ship; the origin of these observations changed several times between the ship's weather packs, full details will be provided with the data. Balloon filling was aided by the use of a filling basket located just outside of the container, which held the balloon in place during preparations. Helium was supplied from inside the container where a gas meter allowed precise fill volumes. Volumes were adjusted in the initial stages of the cruise to ensure a suitable ascent rate. Balloons were tied off with basic cotton string. Much care was taken to wrap any sharp edges in the vicinity of the balloon filling and moving area. The launches took place from the boat deck from the port or starboard side depending on wind direction. At times it was necessary to turn the ship to guarantee a safe launch. Occasionally the radiosonde would pass through the ship's exhaust fumes causing a brief excursion in measurements.

Data availability

The radiosonde data were submitted on a daily basis in 'bufr' format to the World Meteorological Organisation's (WMO) Global Telecommunication System (GTS) for operational forecasting. A repository of this data is held at the UK Meteorological Office.

Further quality control of the radiosonde data will take place at the University of East Anglia, UK. The resulting dataset will be available online through the Centre for Environmental Data Archive (CEDA).



N75°
N73°
2°30'
W 22°30'
W 12°30'
N71°
Jan Mayen
N69°
N67°
E 7°30
E 2°30'
W 2°30'
Prime Meridian
Image U.S. Geological Survey
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Image Landsat / Copernicus
71°25'46.89" N 11°41'30.25" W elev -2134 m eye alt 1204.57 km
Arctic Circle
Google earth

Vaisala RS41-SG Radiosonde Specifications	
Measurement cycle	1 s
Temperature Sensor	Type: Platinum Resistor
Measurement range	+60 °C to -90 °C
Resolution	0.01 °C
Response time (63.2%, 6 m/s flow, 1000 hPa) (1)	0.5 s
Stability (1 year / 3 years)	< 0.05 °C / < 0.1 °C
Repeatability in calibration	0.1 °C
Combined uncertainty after ground preparation	0.2 °C
Combined uncertainty in sounding < 16 km	0.3 °C
Combined uncertainty in sounding > 16 km	0.4 °C
Reproducibility in sounding (2)	
> 100 hPa	0.15 °C
< 100 hPa	0.30 °C
Humidity Sensor	Type: Thin-Film Capacitor
Measurement range	0 to 100 %RH
Resolution	0.1 %RH
Response time:	
6 m/s, 1000 hPa, +20 °C	< 0.3 s
6 m/s, 1000 hPa, -40 °C	< 10 s
Repeatability in calibration	2 %RH
Combined uncertainty after ground preparation	3 %RH
Combined uncertainty in sounding	4 %RH
Reproducibility in sounding (2)	2 %RH
Pressure	Type: Calculated from GPS
Measurement range	From surface pressure to 3 hPa
Resolution	0.01 hPa
Combined uncertainty / Reproducibility in sounding (2)	
> 100 hPa	1.0 hPa / 0.5 hPa
100 - 10 hPa	0.3 hPa / 0.2 hPa
< 10 hPa	0.04 hPa / 0.04 hPa
Geopotential Height	Type: Calculated from GPS
Measurement range (3)	From surface to 40 000 m
Resolution	0.1 gpm
Combined uncertainty in sounding	10.0 gpm
Reproducibility in sounding (2)	6.0 gpm
Wind Speed	
Velocity measurement uncertainty (4)	0.15 m/s
Resolution	0.1 m/s
Maximum reported wind speed (3)	160 m/s
Wind Direction	
Directional measurement uncertainty (4)	2 deg

Resolution	0.1 deg
Wind direction range	0 to 360 deg
(1) After applying time-lag correction, the effect to measurement uncertainty is negligible.	
(2) Standard deviation of differences in twin soundings, ascent rate above 3 m/s	
(3) In practice unlimited	
(4) Standard deviation of differences in twin soundings. Wind speed above 3 m/s for directional measurement uncertainty.	
Telemetry	
Transmitter type	Synthesized
Frequency band	400.15 – 406 mHz
Tuning range	400.16 – 405.99 mHz
Maximum transmitting range	Up to 350 km
Frequency stability, 90 % probability	±2 kHz
Deviation, peak-to-peak	4.8 kHz
Emission bandwidth	According to EN 302 054
Output power (high-power mode)	Min. 60 mW
Sideband radiation	According to EN 302 054
Modulation	GFSK
Data downlink	4800 bit/s
Frequency setting	Wireless with ground check device
GPS Receiver (SA Off, PDOP<4)	
Number of channels	≥ 48
Frequency	1575.42 mHz, L1 C/A code
Cold start Acquisition Time	35 s (nominal)
Reacquisition Time	1 s (nominal)
Correction	Differential
Reporting resolution of lat, lon position values	1e-8°
Operational Data	
Power-up	Wireless with ground check device or with switch
Factory calibration	Stored on Flash memory
Battery	2 pcs AA-size Lithium cells
Operating time	> 240 min
Weight EPS / plastic covers	80 g / 109 g
Dimensions (1)	Body (L × W × H): 155 × 63 × 46 mm Sensor boom bent (L × W × H): 282 × 63 × 104 mm
(1) For EPS cover; without wire antenna	
Add-On Sensor Support	
Protocol support	Xdata to connect several sensors in the same chain, data transferred either directly or via OIF411 to RS41
Transfer rate	Max. 200 bytes/s
Unwinder	
Material of the string	Non-UV treated polypropylene

Tenacity	<115 N
Length of the string	55 m
Unwinding speed	0.35 m/s
Weight	25 g
The performance data is expressed with 2-sigma confidence level (k=2), unless otherwise explicitly specified.	
For humidity, the performance data is valid T > -60 °C.	

RPG Hatpro Radiometer (Radiometer Physics Gmbh)

Summary

The Hatpro radiometer instrument provides continuous measurements of humidity and temperature profiles of the atmosphere. Essentially, the Hatpro provides a proven alternative tool to radiosondes and remote sensing by satellites for atmospheric profiling at high temporal resolution. Profiling is achieved by measuring the atmospheric microwave emission of different pressure levels, using two frequency bands where atmospheric opacity is high. Atmospheric water vapor information is derived from 7 frequency channels in the range of 22-28GHz, while temperature distribution is resolved from 7 channels within the oxygen absorption complex in the range of 51-58GHz. The Hatpro also features a basic surface meteorological package recording barometric pressure, relative humidity and temperature. Atmospheric profiles are derived for:

- Vertical profiles of atmospheric temperature
- Vertical profiles of atmospheric humidity (relative and absolute)
- Liquid Water Path (LWP)
- Integrated Water Vapor (IWV)

To enable the Hatpro to reliably make measurements of different pressure levels aboard a moving ship the unit was seated on a single axis motion correction cradle. Known as the Stable Table, this detects the roll of the ship and produces movement in the opposite direction to maintain a horizontal planning for atmospheric scanning. Using accelerometers and gyroscopic sensors it is able to sample and correct for the roll of the ship at 10Hz. Occasionally during the cruise, the Stable Table software crashed resulting in the table being locked in one position.

The Hatpro was located on the boat deck, near the starboard rail. This provided a clear view for the instrument's selected operational scanning angle between 5° and zenith. The Hatpro features a scanning window, the radome, through which the background radiation is received. This is covered by a hydrophobic cover to minimize disruption by precipitation settling. A rain sensor provides further information for data quality control; however, it is important to note that during leg 2 it became clear that the rain sensor was increasingly flagging rain conditions falsely. To remove salt from sea spray and greasy soot that originated from the ship's exhaust stack just forward of the boat deck, this was cleaned with a light spray of fresh water roughly weekly on leg 1 then roughly twice a week on leg 2. The increase in frequency was due to noticeable gradual degradation of the cover's cleanliness and hydrophobic properties.

Data Availability

Quality control will take place at the UK National Centre for Atmospheric Science (NCAS). The resulting dataset will be made available online through CEDA.

RPG Hatpro Radiometer Specifications	
Optical Resolution	3.5° (2.5°) HPBW at 22 (51) GHz
Radiometric resolution	0.3 – 0.4 K RMS at 1.0 s integration time
Absolute system stability	1.0 K
Receiver and antenna thermal stabilization	< 0.02 K
Repetition rate	Filter bank receiver produces one atmospheric profile per second
Humidity profile performance	Vertical resolution:
	200 m (range 0-2000 m)
	400 m (range 2000-5000 m)
	800 m (range 5000-10000 m)
	Accuracy:
	0.4 g/m3 RMS (absolute hum.)
	5% RMS (rel. humidity)
Temperature profile performance	Vertical resolution:
	BL-Mode:
	30 m -50 m (range 0-1200 m)
	Z-Mode:
	200 m (range 1200-5000 m)
	400 m (range 5000-10000 m)
	Accuracy:
	0.25 K RMS (range 0-500 m)
	0.50 K RMS (range 500-1200 m)
	0.75 K RMS (range 1200-4000 m)
	1.00 K RMS (range 4000-10000 m)
LWP	Accuracy: +/- 20 g/m2
	Noise: 2 g/m2 RMS
IWV	Accuracy: +/-0.2 kg/m2 RMS
	Noise: 0.05 kg/m2 RMS

Micro Rain Radar (METEK Gmbh)

Summary

The Micro Rain Radar (MRR) is a compact FM-CW radar for the measurement of profiles of drop size distributions. Derived from this information are rain rates, liquid water content, and characteristic falling velocity resolved into 30 range gates. This high sensitivity instrument is able to detect very small amounts of precipitation below the threshold of conventional rain gauges. The droplet number concentration in each drop-diameter bin is derived from the backscatter intensity in each corresponding frequency bin. In this procedure the relationship between terminal falling velocity and drop size is used.

The MRR was located on the boat deck with a clear view of the sky. Snow and ice build-up on the dish occurred relatively often and was cleared so as not to effect measurements. Initially the MRR experienced a reoccurring problem with interference. Troubleshooting led to the discovery that the Stable Table was generating high frequency interference that was being transmitted through the power system for the container; this was solved by routing a separate power supply and the problem was eliminated by 12/02/18. After that the MRR worked very reliably.

Data Availability

Quality control will take place at UEA, data will be available online through CEDA.

METEK Micro Rain Radar Specifications	
Operating Frequency:	24.230 GHz
Operating Mode:	FMCW
Modulation:	0.5 - 15 MHz
Output Power:	50 mW (+17 dBm) (antenna foot point)
OoB and Spurious Emission:	< -80 dBm/MHz (antenna foot point)
2nd Harmonic:	-37 dBm
ITU-Designation:	40M0F3N
Power Supply:	24 VDC / 1A
Antenna	
Type:	parabolic offset antenna
Diameter:	600 mm
3 dB Beamwidth:	approx. 1.5 °
Gain:	40.1 dBi
Junction Box / Power Supply	
Input Voltage:	115 or 230 VAC (50 .. 60 Hz)
Output Voltage	24 VAC / 1.5 A
Dimensions:	270 x 170 x 100 mm
Weight:	4 Kg
Antenna Heating (Option)	
Power Supply:	115 or 230 VAC (50 .. 60 Hz)
Power Output:	approx. 500 W
Complete System	
Weight:	17.5 Kg
Dimensions:	800 x 600 x 850 mm

WINDCUBE v2 Offshore 8.66

Summary

The Windcube is a LIDAR (Light Detection And Ranging) device used for wind profile measurement from 40 m to 200 m. The LIDAR sends infrared laser pulses into the atmosphere. Four beams are sent successively in four cardinal directions within a 28° scanning cone angle, followed by a fifth vertical beam. Laser pulses are backscattered by aerosol particles in the air, such as dust and water droplets, that move at wind speed. The collected backscattered light allows for a calculation of wind speed and direction using Doppler induced wavelength shift. Simultaneous measurement of the wind speed at 12 different heights is made possible by the use of 12 different range gates for the laser pulse time of flight. The backscattered light is converted into an electronic signal and digitized. From this data a signal processing algorithm computes wind vector components from five consecutive line of sight measurements.

The user can interact with the Windcube through a graphical user interface that can be displayed on any browser. Real time and statistical wind data are stored on the Windcube's solid-state hard disk and can be downloaded via the interface. A LIDAR installation in a dynamic environment, such as on a ship, will likely result in measurement bias. In order to accurately retrieve the wind data, an inertial sensor was installed within the Windcube. Additional software then takes into account the pitch, roll and yaw movements.

The Windcube was situated on the boat deck. During the initial days of leg 1 there were frequent problems with blocking of the LIDAR beams. After several changes of position, this problem was eliminated by 14/02/18.

Data Availability

Quality control of the Windcube data will be managed by UEA and will be available alongside the other datasets online at CEDA.

WINDCUBE v2 Offshore 8.66 Specifications	
Operating principle	Pulsed LIDAR
Range	40m to 200m (exact range gate programmable depending on user requirements and sea conditions **)
Data sampling rate	1 Hz
Number of measurement heights	Between 10 and 12
Speed range	0 to +55 m/s (exact wind speed range depends on sea conditions**)
Wind Speed Absolute mean deviation	< 0.1 m/s
Wind direction Range	0° to 360°
Wind Direction absolute mean deviation	< 2°
Electrical	
Power Supply	18-32 V DC
Power Supply with the transformer provided with the WINDCUBE® v2 Offshore 8.66	90 ~ 264 VAC / 127 ~ 373 VDC
	47 ~ 63 Hz
Power consumption (after the 24V AC/DC converter)	**• 60W between -5°C and 32°C (nominal)**

	• 80W between -10°C and -5°C
	• 100 W between -25°C and -10°C
	• 120W between -32°C and -25°C
	• 73 W under -32°C or over 32°C
Environmental	
Operational Temperature range	• –20°C to +40°C (shadow temperatures)
	• up to +35°C under 1100W/m² solar irradiation
Operating humidity	0 to 100% RH (non-condensing)
Housing classification	IP66 for the external casing
	IP67 (internal module and power supply converter)
Shock & Vibration	ISTA/FEDEX 6A (Transportation)

Section F: Glider and Met buoy deployment report

Contributing author: Kjetil Våge (kjetil.vage@uib.no)

Glider deployment

Seaglider sg629 was deployed from the NRV *Alliance* in the western Iceland Sea. The glider operated from the ice edge east of Greenland westward into the northern Iceland Sea, between the West Jan Mayen Ridge and the locations of the UiB mooring and met buoy (Fig. 1). The glider will be recovered from R/V Kristine Bonnevie in June 2018.

Details of deployment:
Time: 13 February 2018, 16:00
Longitude: 15.53◦W
Latitude: 69.28◦W

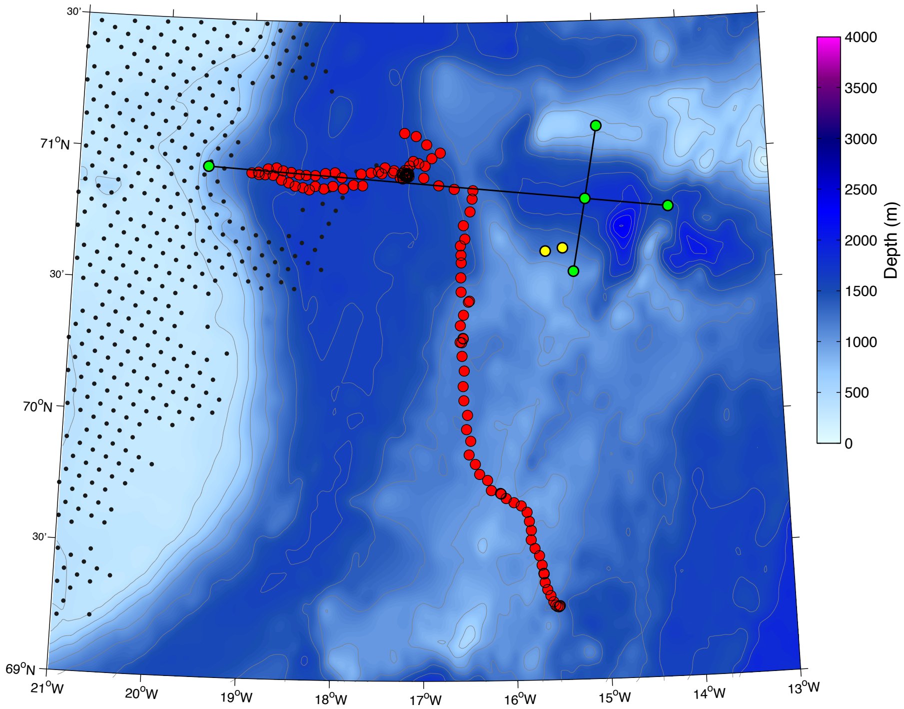

Figure 1: Glider track. The red circles mark the dives of the glider from 13 Feb to 18 March. The black lines are the nominal transects along which the glider operated. The yellow circles mark the UiB mooring and met buoy. The black dots indicate ice concentration in excess of 50% on 27 Feb.

Glider recovery

Seaglider sg561 was recovered in the central Greenland Sea. The glider was deployed west of Isfjorden, Svalbard in December 2017 and was supposed to be recovered from R/V Kristine Bonnevie in June 2018. Due to a malfunction that severely degraded communications with shore, the glider mission was aborted and an emergency recovery was carried out late in the cruise.

Details of recovery:
Time: 13 March 2018, 13:00
Longitude: 3.18◦W
Latitude: 74.85◦W

Met buoy deployment

A meteorological buoy was deployed in the northern Iceland Sea in the vicinity of the UiB subsurface mooring that was deployed in summer 2016. The buoy measures atmospheric temperature, wind velocity, humidity, and pressure as well as surface ocean temperature and velocity. The buoy will be recovered from RV Kristine Bonnevie in June 2018.

Details of deployment:
Time: 17 February 2018, 13:00
Longitude: 15.41◦W
Latitude: 70.64◦W

Section G: CFC-12, SF6, dissolved oxygen, and nutrients report

Contributing authors: Emil Jeansson (Emil.Jeansson@uni.no) and Kristin Jackson (Kristin.Jackson@uib.no)

During the ALL0118 cruise, samples were collected for the transient tracers chlorofluorocarbon-12 (CFC-12) and sulphur hexafluoride (SF_6), dissolved oxygen, and nutrients, at a large number of the CTD stations. In total, 149 stations contain some of the parameters. The transient tracers and oxygen were analyzed on board, while the nutrient samples will be analyzed post-cruise at a facility in Iceland. More details on the respective parameters are given below.

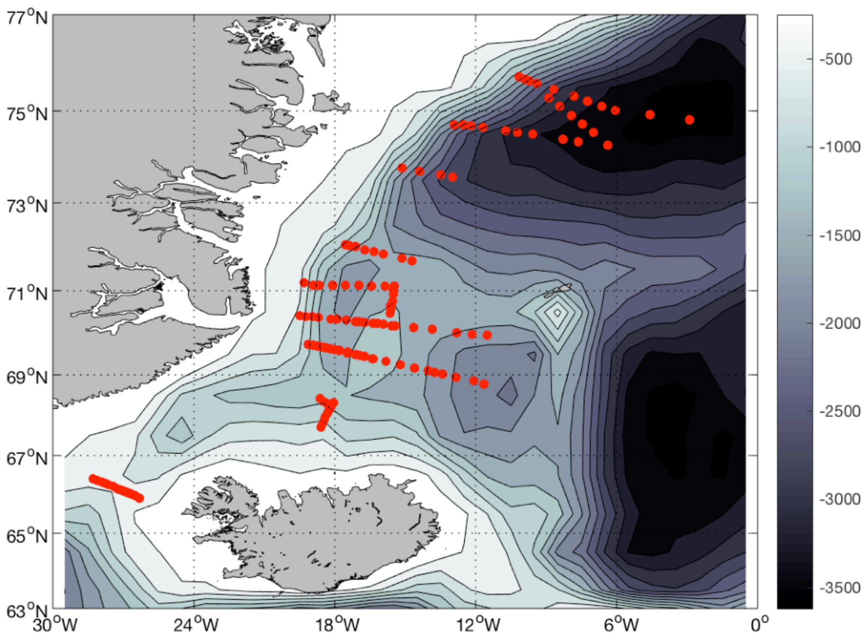

Figure. 1. Location of stations sampled for chemistry during the IGP cruise.

CFC-12 and SF_6 analyses

Samples for analysis of CFC-12 and SF_6 were taken from the Niskin bottles in 250-ml glass syringes, which were stored cold (on the deck outside the lab), and analysis took place within six hours after sampling. The analysis is based on purge-and-trap work-up of the water samples, followed by gas chromatographic separation and electron capture detection of the different compounds; the analytical technique is described by Bullister et al. (2008) and Stöven and Tanhua (2014).

The standardization was achieved by calibration gas prepared at Deuste Steininger GmbH, Mühlhausen, Germany, and cross-calibrated against gas prepared at Scripps Institute of Oceanography. The standard gases were calibrated against the SIO-05 scale.

Except for some minor issues, the instrument worked very well during the entire cruise, especially for SF_6. This tracer is most valuable for the recently ventilated water masses in the upper ocean, and thus is of great interest for the IGP. The data for CFC-12 have some issues, especially during the first part of the cruise when the response of the detector was very unstable, resulting in some questionable data. This improved during the cruise, and for the entire second leg, and last part of the first leg, the CFC-12 data are good. Nevertheless, due to the change in the atmospheric evolution of CFC-12 since the early 2000s, with first a slowdown followed by a decline, the usefulness of this tracer for recently ventilated water masses is limited, such as the mixed layer values.

Winkler oxygen

Dissolved oxygen concentration samples were taken from each Niskin into 125 ml glass flasks with stoppers and pickled using 1 ml doses of manganese chloride and sodium hydroxide/sodium iodide. Samples were stored in a dark environment for up to 15 hours before analysis. Oxygen concentrations were determined using Winkler titration on an instrument designed and built at Scripps Institution of Oceanography, in which the pickled sample was reacted with 1 ml of sulphuric acid and titrated with sodium thiosulfate until the spectrophotometric endpoint was reached. Before the instrument was started each day, four blanks and four potassium iodate standards were measured. One duplicate sample was taken at most stations. From these duplicates, the precision of the measurements was determined to be ± 0.007 ml/l. Chemical solutions were prepared in December, in the lab in Bergen. Sodium thiosulfate pentahydrate was pre-weighed in the lab and solutions were prepared aboard the ship. The instrument functioned very well throughout the cruise.

Nutrients

During the cruise approximately 500 samples were collected for nutrients (phosphate, nitrate and silicate) to be analyzed post-cruise. At these stations, samples were drawn from each Niskin into 24 ml scintillation vials and preserved with 0.2 ml chloroform. These samples are presently being analyzed on shore by collaborators at the Marine and Freshwater Research Institute, using an auto analyzer. While on the ship the samples were stored cold and in the dark.

Some preliminary results

As an example we show some preliminary results of the section in the Denmark Strait (Fig. 2). Here 16 stations were sampled for chemistry, resulting in a very well covered section compared to most previous surveys with chemical tracers in the area.

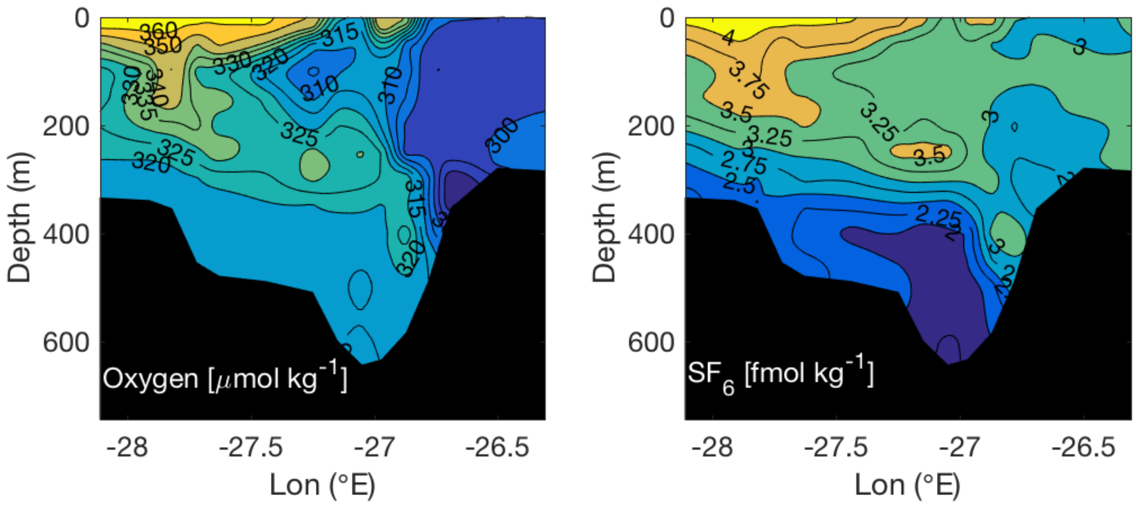

Figure. 2. Oxygen and SF_6 in the Denmark Strait during the IGP cruise.

There are clear gradients for both oxygen and SF_6, illustrating the different water masses present in the section. The highest concentrations are associated with the Polar Water in the East Greenland Current (seen in the upper layers in the western part of the section), since the lower temperature of this water mass increases the solubility of the gasses in seawater, thereby resulting in higher concentrations. The lower concentrations of oxygen to the east (in the upper 300 m) are connected to the warmer Atlantic Water in the North Icelandic Irminger Current. The deepest part of the section contains the dense overflow water. Here the concentrations of oxygen are very homogenous, while the gradient in SF_6, is significant, suggesting a clear contribution of older water.

References

Bullister, J. L., and D. P. Wisegarver (2008), The shipboard analysis of trace levels of sulphur hexafluoride, chlorofluorocarbon-11 and chlorofluorocarbon-12 in seawater, *Deep-Sea Res. I*, *55*(8), 1063-1074.

Stöven, T., and T. Tanhua (2014), Ventilation of the Mediterranean Sea constrained by multiple transient tracer measurements, *Ocean Sci.*, *10*(3), 439-457.

Section H: Water Isotope Measurements report

Contributing authors: Yongbiao Weng (yongbiao.weng@uib.no) and Harald Sodemann (harald.sodemann@uib.no)

Geophysical Institute, University of Bergen

Water vapor isotopes can provide information about the evaporation conditions at the ocean surface. The parameter *d*-excess has the potential to serve as a recorder of the source conditions, thereby providing evidence of the origin of water vapor. This opens up for possibilities for validating the water cycle in weather prediction and climate models.

During the IGP campaign, measurements of the isotope composition of water vapor and precipitation from R/V *Alliance* and aircraft MASIN provided a dataset during Cold-Air Outbreaks (CAOs). The CAO events provide a distinct initialization of the atmospheric vapor with an intense-evaporation signal. Given sufficiently coherent flow, measurements at the source on board R/V *Alliance* and the aircraft MASIN will provide evidence on the conservation of the *d*-excess during atmospheric transport.

Measurements onboard R/V *Alliance* mainly consisted of two parts. One part is the water vapor isotopes; the other part is monitoring of weather conditions. Water vapor measurements are performed with a laser spectrometer, Picarro L2140-*i*, placed inside a container on the boat deck. The inlet is mounted at 4 m above the boat deck on a ladder and heated to 50°C by a heating wire. Weather conditions were monitored by several instruments, such as radiometer and micro rain radar, accompanied by daily or more frequent radiosonde launches. Proper calibration should be performed before using these datasets.

Numerous water samples were taken as well for post-cruise isotopic composition analysis in the lab. These consist of 53 precipitation (rain and snow) samples and 272 ocean water samples. Precipitation samples were taken on the boat deck or aft deck with the rain sampler, or, for snow, directly on the surface. Ocean water was sampled at 29 selected CTD stations, 10 of which were from the section across the Denmark Strait. This may be of interest to add a piece of information to the origin and complex mixing happening in the study region. During the cruise, 1 sample from sea ice and 1 sample from fog condensate was also taken. All water samples were transferred to 1.5 ml vials, sealed with parafilm, and stored in the ship garage at the environment temperature (typically below 15°C).

Three significant CAO events were sampled during the cruise. Preliminarily calibrated data show that, during one CAO on March 16th, the humidity dropped from 6000 ppmv to 2000 ppmv within 2 hours and at the same time *d*-excess increased dramatically from ~0‰ to ~25‰, which is an indication of a strong evaporation triggered by the cold and dry air over the warm ocean surface. We are looking forward to using these valuable observations, together with the measurements of flow downstream (water vapor and precipitation in Iceland and Norway), to gain information about the extent to which the signal from the moisture source origin can be conserved during the atmospheric transport.

Appendix A1: CTD, XCTD, and XBT station lists

ALL 0118 CTD Sections

Station Number	Time Occupied (UTC)	Latitude (deg/min N)	Longitude (deg/min W)	Corrected Depth (m)	Chemistry taken (yes=y)
ALL0118 CTD SECTION 1					
6	Feb 08 2018 14:43:03	68 27.77	18 44.49	897.1	
5	Feb 08 2018 11:52:21	68 25.00	18 37.84	1227.3	Y
4	Feb 08 2018 08:46:52	68 21.85	18 30.55	1087	Y
3	Feb 08 2018 06:14:48	68 18.63	18 22.36	1102.2	Y
2	Feb 08 2018 03:49:15	68 15.58	18 16.39	902.1	Y
1	Feb 08 2018 01:55:48	68 12.39	18 9.83	520.7	Y
ALL0118 CTD SECTION 2					
7	Feb 09 2018 17:27:53	68 18.84	18 4.01	675.8	Y
8	Feb 09 2018 19:21:03	68 8.56	18 13.16	569.8	Y
9	Feb 09 2018 20:41:44	68 3.34	18 18.03	656.6	Y
10	Feb 09 2018 22:15:50	67 58.28	18 23.90	452.4	Y
11	Feb 10 2018 00:00:58	67 53.47	18 26.82	429.1	Y
12	Feb 10 2018 01:25:39	67 47.96	18 30.64	441.2	Y
13	Feb 10 2018 02:44:52	67 42.88	18 36.12	561	Y
ALL0118 CTD SECTION 3					
33	Feb 14 2018 18:29:36	69 44.50	19 7.97	558.5	Y
34	Feb 14 2018 20:24:15	69 42.74	18 55.59	938	Y
35	Feb 14 2018 22:04:35	69 41.73	18 44.27	1206.9	Y
36	Feb 15 2018 00:14:11	69 40.18	18 34.07	1402.6	
37	Feb 15 2018 02:41:26	69 38.80	18 23.10	1575.5	Y
42	Feb 15 2018 18:37:54	69 37.43	18 12.01	1618.2	
41	Feb 15 2018 16:14:38	69 36.02	18 0.84	1599	Y
40	Feb 15 2018 14:14:53	69 34.72	17 49.74	1572.7	
39	Feb 15 2018 12:02:17	69 33.42	17 38.89	1500.7	
38	Feb 15 2018 09:29:34	69 32.20	17 27.48	1449.3	Y
32	Feb 14 2018 07:34:46	69 30.56	17 17.35	1350	
31	Feb 14 2018 05:55:53	69 29.12	17 6.39	1290	
30	Feb 14 2018 03:43:18	69 27.62	16 55.54	1085	Y
29	Feb 14 2018 02:20:58	69 26.16	16 44.89	925	
28	Feb 14 2018 00:31:35	69 24.75	16 33.95	935	
27	Feb 13 2018 22:44:28	69 23.44	16 22.97	800	Y
26	Feb 13 2018 21:05:24	69 21.35	16 6.36	1053	
25	Feb 13 2018 19:01:22	69 19.32	15 48.35	1160	Y
24	Feb 13 2018 16:40:14	69 16.84	15 30.31	1345	
23	Feb 13 2018 12:46:33	69 14.59	15 12.57	1558	Y
22	Feb 13 2018 09:54:05	69 12.35	14 54.05	1478.5	
21	Feb 13 2018 08:06:52	69 10.07	14 36.36	1345.5	Y
20	Feb 13 2018 06:33:55	69 7.69	14 18.17	1619.5	
19	Feb 13 2018 04:55:59	69 5.52	14 1.14	1576.5	Y
18	Feb 13 2018 03:08:21	69 2.87	13 43.91	1441.2	Y
17	Feb 13 2018 01:21:40	69 0.72	13 25.76	1839.6	Y

16	Feb 12 2018 23:08:05	68 55.84	12 49.65	1833.4	Y
15	Feb 12 2018 20:26:27	68 51.54	12 4.72	1879.8	Y
14	Feb 12 2018 18:30:50	68 46.99	11 39.56	1751.7	Y
ALL0118 CTD SECTION 4					
43	Feb 16 2018 10:34:29	70 25.24	19 29.19	335.5	Y
44	Feb 16 2018 11:54:35	70 24.29	19 14.13	419.9	Y
45	Feb 16 2018 13:26:08	70 23.44	18 57.08	668.9	Y
46	Feb 16 2018 15:10:05	70 22.44	18 42.31	1145	Y
47	Feb 16 2018 17:19:40	70 21.41	18 25.30	1475	
48	Feb 16 2018 20:00:02	70 20.31	18 10.12	1637.5	Y
49	Feb 16 2018 22:32:54	70 19.19	17 46.52	1631.1	
50	Feb 17 2018 00:51:03	70 17.80	17 23.68	1596	
51	Feb 17 2018 03:42:12	70 16.29	16 59.47	1389	Y
52	Feb 17 2018 16:22:20	70 14.88	16 35.45	1266.4	
53	Feb 17 2018 18:33:56	70 13.59	16 11.69	1221.1	Y
54	Feb 17 2018 20:43:54	70 12.19	15 48.91	1128.3	
55	Feb 17 2018 22:43:01	70 10.63	15 25.17	1274.7	Y
56	Feb 18 2018 00:49:21	70 9.30	15 1.62	1020.4	
57	Feb 18 2018 02:55:27	70 7.86	14 38.27	1136.6	Y
58	Feb 18 2018 05:00:46	70 6.56	14 14.53	1218.5	
59	Feb 18 2018 07:10:57	70 5.20	13 51.08	1511.6	Y
60	Feb 18 2018 09:37:52	70 3.83	13 27.50	1403.2	
61	Feb 18 2018 12:03:07	70 1.44	12 48.73	1578.6	Y
62	Feb 18 2018 14:45:02	69 59.01	12 10.31	1765.4	Y
63	Feb 18 2018 17:33:09	69 56.74	11 31.33	1777.9	Y
ALL0118 CTD SECTION 5					
73	Feb 20 2018 12:00:22	71 11.28	19 17.82	455.9	Y
74	Feb 20 2018 13:43:33	71 8.02	18 56.07	1133.7	Y
75	Feb 20 2018 15:52:53	71 7.92	18 39.44	1480	Y
76	Feb 20 2018 18:30:50	71 7.29	18 6.08	1661.6	Y
77	Feb 20 2018 20:45:50	71 7.18	17 32.34	1675.1	Y
78	Feb 20 2018 22:49:15	71 6.90	16 59.21	1157.7	Y
79	Feb 21 2018 00:51:08	71 6.31	16 25.64	1462.5	Y
72	Feb 19 2018 21:17:17	71 6.55	15 51.70	1684.5	Y
71	Feb 19 2018 19:09:36	71 6.06	15 27.15	868.9	Y
70	Feb 19 2018 16:38:12	71 0.96	15 29.18	1481.8	Y
69	Feb 19 2018 14:36:52	70 55.45	15 30.17	1542.8	Y
68	Feb 19 2018 12:28:02	70 50.17	15 31.90	1471.7	
67	Feb 19 2018 10:19:48	70 44.83	15 32.76	1412.9	Y
66	Feb 19 2018 08:04:49	70 37.81	15 38.45	1306.1	Y
65	Feb 19 2018 06:23:02	70 34.00	15 37.14	1000.8	Y
64	Feb 19 2018 04:30:31	70 28.71	15 38.92	896.3	Y
ALL0118 CTD SECTION 7					
118	Mar 11 2018 23:46:29	73 34.10	12 59.93	2615.4	Y
119	Mar 12 2018 01:54:20	73 36.90	13 28.57	2500	Y
120	Mar 12 2018 03:58:45	73 39.38	13 55.62	2374.5	
121	Mar 12 2018 05:50:46	73 42.08	14 22.73	2166.7	Y
122	Mar 12 2018 07:44:55	73 44.86	14 50.12	1789.9	

123	Mar 12 2018 09:24:06	73 46.53	15 7.66	1445.5	Y
124	Mar 12 2018 11:54:13	73 46.34	15 24.00	1092.4	
ALL0118 CTD SECTION 8					
136	Mar 14 2018 14:18:24	75 42.91	10 8.76	1201.1	Y
135	Mar 14 2018 12:09:32	75 40.52	9 54.36	1468.6	Y
134	Mar 14 2018 10:18:56	75 38.09	9 42.88	1727	Y
137	Mar 14 2018 17:58:23	75 35.17	9 24.01	2090.1	Y
133	Mar 14 2018 08:11:53	75 32.71	9 6.01	2425.9	
132	Mar 14 2018 06:12:46	75 27.76	8 40.91	2817.1	Y
131	Mar 14 2018 04:43:11	75 23.72	8 13.27	3114.5	
130	Mar 14 2018 03:02:20	75 18.62	7 48.19	3280.4	Y
129	Mar 14 2018 01:03:30	75 12.57	7 13.71	3349.9	Y
128	Mar 13 2018 23:07:38	75 6.72	6 38.61	3389.6	Y
127	Mar 13 2018 21:04:52	75 0.56	6 3.31	3418.1	Y
126	Mar 13 2018 17:53:08	74 55.50	4 35.53	3502.1	Y
125	Mar 13 2018 14:25:15	74 49.45	2 53.85	3568.3	Y
ALL0118 CTD SECTION 9					
143	Mar 15 2018 11:42:47	74 42.70	12 53.94	1747.8	Y
144	Mar 15 2018 14:12:50	74 42.42	12 30.78	2050.4	Y
142	Mar 15 2018 09:20:57	74 41.05	12 12.11	2329.8	Y
141	Mar 15 2018 07:34:21	74 39.20	11 42.39	2756.8	Y
140	Mar 15 2018 05:53:12	74 36.93	11 12.47	2981.5	
139	Mar 15 2018 04:13:29	74 34.77	10 44.29	3071.2	Y
138	Mar 15 2018 01:39:00	74 32.59	10 12.86	3106.6	Y
145	Mar 15 2018 20:16:15	74 29.84	9 35.59	3135	Y
146	Mar 15 2018 22:17:10	74 26.84	8 54.14	3200.9	
147	Mar 16 2018 00:17:46	74 23.91	8 16.78	3243.1	Y
148	Mar 16 2018 02:13:13	74 21.14	7 38.83	3269.2	Y
149	Mar 16 2018 04:12:06	74 18.55	7 0.16	3293.7	
150	Mar 16 2018 06:04:49	74 15.68	6 21.52	3345.4	Y
ALL0118 CTD SECTION 10					
155	Mar 16 2018 17:35:48	75 17.07	8 53.51	3035.5	Y
154	Mar 16 2018 15:18:04	75 6.26	8 25.22	3252.4	Y
153	Mar 16 2018 13:07:46	74 54.81	7 56.52	3280.3	Y
152	Mar 16 2018 11:00:30	74 43.57	7 28.10	3326.5	Y
151	Mar 16 2018 08:54:07	74 32.29	7 0.19	3337	Y
150	Mar 16 2018 06:04:49	74 15.68	6 21.52	3345.2	Y
ALL0118 CTD SECTION cn1					
97	Mar 03 2018 23:56:46	70 10.93	15 33.71	975	Y
98	Mar 04 2018 01:42:09	70 12.49	15 56.66	1150	Y
99	Mar 04 2018 04:22:12	70 13.86	16 20.84	1193	Y
100	Mar 04 2018 08:29:31	70 15.35	16 45.53	1183	Y
101	Mar 04 2018 11:10:41	70 17.04	17 7.33	1556	Y
102	Mar 04 2018 14:51:40	70 18.33	17 32.03	1596	Y
103	Mar 04 2018 17:16:11	70 19.90	17 54.36	1624	Y
ALL0118 CTD SECTION cn2					
104	Mar 05 2018 09:13:51	70 11.01	15 33.60	950	Y
105	Mar 05 2018 11:34:23	70 12.65	15 56.57	1170	Y

106	Mar 05 2018 13:57:14	70 13.86	16 19.91	1170	Y
107	Mar 05 2018 16:57:14	70 15.50	16 42.53	1707	Y
108	Mar 05 2018 19:22:54	70 17.03	17 6.68	1555	Y
ALL0118 CTD SECTION cs1					
81	Mar 01 2018 02:06:20	69 23.47	16 23.62	793	Y
82	Mar 01 2018 03:58:24	69 26.35	16 44.20	1000	Y
83	Mar 01 2018 05:37:09	69 29.10	17 5.30	1282	Y
84	Mar 01 2018 07:33:52	69 32.07	17 27.30	1427	Y
85	Mar 01 2018 09:33:33	69 34.85	17 48.70	1551	Y
86	Mar 01 2018 11:33:55	69 37.38	18 11.62	1608	Y
87	Mar 01 2018 13:34:52	69 40.33	18 32.76	1425	Y
88	Mar 01 2018 15:17:09	69 42.87	18 55.43	946	Y
ALL0118 CTD SECTION cs2					
89	Mar 02 2018 04:04:38	69 23.24	16 23.82	799	Y
90	Mar 02 2018 05:51:59	69 26.32	16 44.97	890	Y
91	Mar 02 2018 07:53:53	69 28.97	17 6.39	1287	Y
92	Mar 02 2018 09:31:16	69 31.88	17 28.08	1440	Y
93	Mar 02 2018 11:01:08	69 34.76	17 50.18	1555	Y
94	Mar 02 2018 12:35:45	69 37.46	18 12.03	1605	Y
95	Mar 02 2018 14:22:07	69 40.03	18 33.12	1420	Y
ALL0118 CTD SECTION cs3					
109	Mar 06 2018 10:29:44	69 23.61	16 23.45	796	Y
110	Mar 06 2018 13:34:33	69 26.38	16 45.47	870	Y
111	Mar 06 2018 15:03:52	69 29.21	17 6.00	1293	Y
112	Mar 06 2018 16:30:49	69 31.83	17 27.69	1452	Y
113	Mar 06 2018 17:59:31	69 34.58	17 49.32	1551	Y
114	Mar 06 2018 20:04:43	69 37.42	18 12.49	1600	Y
115	Mar 06 2018 21:33:53	69 40.28	18 33.41	1415	Y
116	Mar 06 2018 23:09:25	69 43.00	18 55.01	947	Y

ALL0118 XCTD Sections

Station Number	Time Occupied (UTC)	Latitude (deg/min N)	Longitude (deg/min W)	Corrected Depth (m)
ALL0118 XCTD section s1				
17078283	Feb 27 2018 10:29:44	69 0.32	17 45.71	1005.5
17078284	Feb 27 2018 11:27:12	69 7.64	17 55.27	776.6
17078285	Feb 27 2018 12:10:36	69 15.12	18 3.65	996.1
17078286	Feb 27 2018 12:52:33	69 22.52	18 11.97	1452.4
17078287	Feb 27 2018 13:33:44	69 30.14	18 20.60	1604.6
17078288	Feb 27 2018 14:14:55	69 37.85	18 29.39	1499.8
17078289	Feb 27 2018 14:59:36	69 45.41	18 38.06	1283.5
17078290	Feb 27 2018 15:40:29	69 52.80	18 46.57	1054.3
17078291	Feb 27 2018 16:07:23	69 58.53	18 51.75	920.2
ALL0118 XCTD section s2				
17078291	Feb 27 2018 16:07:23	69 58.53	18 51.75	920.2
17078293	Feb 27 2018 17:26:13	70 3.92	18 34.57	1262.8
17078292	Feb 27 2018 19:00:44	70 13.51	18 20.00	1514.1

17078294	Feb 27 2018 19:59:59	70 17.17	17 57.42	1624.6
17078295	Feb 27 2018 20:53:38	70 20.10	17 36.74	1609.6
17078296	Feb 27 2018 21:52:29	70 23.21	17 14.74	1493.0
17078213	Feb 27 2018 22:53:18	70 26.34	16 52.46	1434.2
17078214	Feb 27 2018 23:53:06	70 29.50	16 30.05	1148.5
17078215	Feb 28 2018 00:44:52	70 32.59	16 8.39	1106.1
ALL0118 XCTD section s3				
17078215	Feb 28 2018 00:44:52	70 32.59	16 8.39	1106.1
17078216	Feb 28 2018 04:55:44	70 38.86	16 23.58	1358.6
17078217	Feb 28 2018 06:38:09	70 44.50	16 39.84	1288.6
17078218	Feb 28 2018 08:17:13	70 50.41	16 56.93	1475.3
17078219	Feb 28 2018 09:19:08	70 56.27	17 14.00	1661.7
17078220	Feb 28 2018 10:01:30	70 59.03	17 22.86	1658.0
ALL0118 XCTD section 1				
17078203	Feb 08 2018 16:26:59	68 30.92	18 50.89	1295.5
17078202	Feb 08 2018 17:25:49	68 34.12	18 58.48	1245
17078201	Feb 08 2018 18:18:03	68 37.21	19 5.50	1231.9
17078204	Feb 08 2018 19:26:20	68 40.43	19 12.78	1251.1
17078205	Feb 08 2018 20:47:19	68 43.58	19 19.92	1261.1
17078206	Feb 08 2018 22:00:43	68 46.69	19 26.97	1243.3
17078207	Feb 08 2018 22:58:23	68 49.70	19 33.86	1302
17078208	Feb 09 2018 00:25:03	68 52.93	19 41.21	1398.7
17078212	Feb 09 2018 11:29:39	68 56.04	19 47.03	1292.7
ALL0118 XCTD section 3				
17078211	Feb 14 2018 14:38:57	69 48.80	19 38.70	300.3
17078249	Feb 14 2018 16:16:59	69 50.99	19 22.55	365.4
17078250	Feb 14 2018 17:16:36	69 48.32	19 13.47	407.7
ALL0118 XCTD section 6				
17078255	Feb 21 2018 01:48:00	71 7.19	16 23.96	1509.9
17078256	Feb 21 2018 02:51:12	70 59.47	16 27.60	1251.6
17078257	Feb 21 2018 03:41:35	70 52.15	16 37.19	1180.1
17078258	Feb 21 2018 04:31:21	70 44.61	16 47.35	1396.4
17078259	Feb 21 2018 05:27:24	70 37.01	16 57.52	1467.6
17078260	Feb 21 2018 06:15:33	70 29.97	17 6.88	1489.3
17078261	Feb 21 2018 07:08:53	70 22.36	17 16.96	1523.9
17078262	Feb 21 2018 07:53:58	70 15.35	17 26.16	1583.8
17078263	Feb 21 2018 08:44:55	70 7.22	17 27.36	1572.7
17078264	Feb 21 2018 09:37:36	69 58.94	17 27.56	1513.2
17078265	Feb 21 2018 10:27:29	69 50.77	17 28.73	1454.9
17078266	Feb 21 2018 11:22:02	69 42.09	17 29.15	1120.2
17078267	Feb 21 2018 12:10:53	69 34.50	17 30.23	1549.3
17078269	Feb 21 2018 13:13:20	69 25.45	17 31.09	1400
17078270	Feb 21 2018 13:57:11	69 18.41	17 34.11	1243.9
17078272	Feb 21 2018 15:18:17	69 8.27	17 40.32	1074.5
17078273	Feb 21 2018 16:01:58	69 2.08	17 43.44	1092.1
17078274	Feb 21 2018 16:30:57	68 58.06	17 44.96	703.7
17078275	Feb 21 2018 16:58:24	68 54.47	17 46.80	1845.9

17078276	Feb 21 2018 17:28:39	68 50.69	17 48.87	1799.1
17078277	Feb 21 2018 18:04:06	68 46.35	17 50.07	1424.6
17078278	Feb 21 2018 18:29:54	68 42.82	17 52.05	1136.5
17078279	Feb 21 2018 19:03:02	68 38.87	17 53.86	1170.9
17078282	Feb 21 2018 19:53:48	68 33.21	17 55.81	878.9
ALL0118 XCTD section 7				
17099315	Mar 12 2018 17:47:39	73 38.54	12 18.25	2729.2
17099316	Mar 12 2018 19:08:25	73 43.04	11 33.49	2834.3
17099317	Mar 12 2018 20:37:12	73 47.63	10 47.65	2937.5
17099318	Mar 12 2018 22:09:06	73 52.15	10 2.42	3029.8
17099320	Mar 12 2018 23:43:11	73 57.02	9 13.29	3098.2
17099321	Mar 13 2018 01:05:35	74 1.40	8 28.96	3150.6
17099322	Mar 13 2018 02:29:01	74 5.81	7 44.11	3218.8
17099323	Mar 13 2018 03:50:21	74 10.38	6 57.42	3285
17099324	Mar 13 2018 05:16:39	74 14.97	6 10.31	3338.2
17099337	Mar 13 2018 08:09:38	74 23.94	4 37.55	3470.4
17099338	Mar 13 2018 10:31:33	74 30.92	3 24.58	3519.9
ALL0118 XCTD section 8				
17099339	Mar 13 2018 15:15:17	74 50.09	2 57.17	1831
17099340	Mar 14 2018 09:50:59	75 37.44	9 37.18	1860
ALL0118 XCTD section cn1				
17078241	Mar 04 2018 18:13:04	70 19.10	17 57.06	1625.9
17078242	Mar 04 2018 19:45:39	70 25.54	17 39.29	1612.2
17078243	Mar 04 2018 21:21:15	70 31.14	17 20.75	1591.9
17078244	Mar 04 2018 23:37:40	70 36.68	17 2.93	1469.2
17078245	Mar 05 2018 01:32:34	70 42.93	16 47.18	1347.4
17078246	Mar 05 2018 03:08:10	70 49.89	16 34.08	1337.5
17078247	Mar 05 2018 04:18:20	70 43.11	16 22.16	1543.2
17078248	Mar 05 2018 05:23:22	70 35.90	16 11.20	1050.5
17099301	Mar 05 2018 06:31:04	70 28.31	16 0.02	1098.3
17099302	Mar 05 2018 07:33:39	70 20.95	15 49.88	1162.0
17099303	Mar 05 2018 08:33:23	70 13.69	15 39.59	911.8
ALL0118 XCTD section cs1				
17078223	Mar 01 2018 18:39:38	69 44.29	18 31.77	1409.1
17078224	Mar 01 2018 19:40:09	69 49.34	18 13.37	1568.3
17078225	Mar 01 2018 20:47:02	69 52.82	17 50.98	1615.0
17078226	Mar 01 2018 21:43:13	69 56.00	17 30.25	1538.5
17078227	Mar 01 2018 22:39:33	69 59.19	17 8.52	1314.3
17078228	Mar 01 2018 23:39:16	69 51.91	16 58.73	1141.2
17078229	Mar 02 2018 00:45:08	69 44.59	16 49.48	1120.2
17078230	Mar 02 2018 01:49:34	69 37.21	16 40.21	1049.3
17078231	Mar 02 2018 02:51:35	69 29.80	16 30.94	1106.7
ALL0118 XCTD section cs2				
17078232	Mar 02 2018 15:43:10	69 43.93	18 29.78	1432.3
17078233	Mar 02 2018 16:42:01	69 49.07	18 12.55	1565.7
17078234	Mar 02 2018 17:44:07	69 52.79	17 50.83	1615.7
17078235	Mar 02 2018 18:41:17	69 56.09	17 29.97	1539.8
17078236	Mar 02 2018 19:36:21	69 59.20	17 9.89	1314.3

17078237	Mar 02 2018 20:35:21	69 52.22	16 59.12	1135.1
17078238	Mar 02 2018 21:23:18	69 44.57	16 50.72	1105.8
17078239	Mar 02 2018 22:16:14	69 36.97	16 41.06	989.1
17078240	Mar 02 2018 23:06:28	69 29.68	16 32.77	972.8
ALL0118 XCTD section cs3				
17099306	Mar 07 2018 00:56:19	69 46.07	18 34.01	1261.8
17099307	Mar 07 2018 01:59:43	69 49.39	18 13.24	1569.2
17099308	Mar 07 2018 03:04:42	69 52.79	17 51.21	1614.7
17099309	Mar 07 2018 04:07:34	69 55.97	17 30.43	1537.8
17099310	Mar 07 2018 05:09:24	69 59.17	17 9.46	1314.2
17099311	Mar 07 2018 06:17:51	69 51.05	16 57.64	1162.8
17099312	Mar 07 2018 07:04:27	69 44.79	16 49.74	1156.5
17099313	Mar 07 2018 08:01:28	69 37.33	16 40.37	1015.9
17099314	Mar 07 2018 08:57:57	69 29.87	16 31.04	1604.5

ALL0118 XBT Sections

Station Number	Time Occupied (UTC)	Latitude (deg/min N)	Longitude (deg/min W)	Approx Depth (m)
ALL0118 XBT SECTION 1				
1225257	Feb 28 2018 14:54:24	70 53.49	16 41.19	1266.5
1225258	Feb 28 2018 15:40:01	70 47.30	16 47.04	1401.7
1225259	Feb 28 2018 16:34:12	70 39.58	16 54.34	1448.8
1225260	Feb 28 2018 17:33:31	70 31.56	16 53.12	1366.3
1225261	Feb 28 2018 18:35:46	70 23.44	16 49.05	1341.5
1225262	Feb 28 2018 19:35:19	70 15.40	16 46.02	1205
1225263	Feb 28 2018 20:35:55	70 7.15	16 43.12	1084.2
1225264	Feb 28 2018 21:33:14	69 59.72	16 39.42	1204.6
1225265	Feb 28 2018 22:31:40	69 51.64	16 35.66	1089.8
1225268	Feb 28 2018 23:34:22	69 43.04	16 31.85	1088
1225269	Mar 01 2018 00:24:00	69 35.61	16 28.40	875.0
1225270	Mar 01 2018 01:17:52	69 27.60	16 24.77	1282.9
ALL0118 XBT SECTION cn1				
1225274	Mar 03 2018 3:12:24	70 24.89	16 55.15	1459.4
1225273	Mar 03 2018 2:38:36	70 21.32	16 44.02	1199.7
1225272	Mar 03 2018 2:02:18	70 17.58	16 32.41	1298.3
1225271	Mar 03 2018 1:33:41	70 14.46	16 22.75	1156.2
1225275	Mar 03 2018 6:16:58	70 10.06	16 10.00	1070.3
1225276	Mar 03 2018 6:52:28	70 6.53	15 58.06	965.8
1225278	Mar 03 2018 7:34:05	70 1.89	15 43.37	987.9
1225279	Mar 03 2018 07:56:07	69 59.12	15 34.93	1337.5
1225280	Mar 03 2018 08:31:30	69 55.42	15 23.62	1050.7
1225281	Mar 03 2018 09:06:29	69 51.55	15 12.02	1084.3
ALL0118 XBT SECTION cs3				
1225282	Mar 05 2018 22:35:44	70 15.56	17 32.06	1589.4
1225283	Mar 05 2018 23:29:54	70 8.92	17 31.33	1581.8
1225284	Mar 06 2018 00:18:55	70 2.50	17 30.42	1568.8
1225285	Mar 06 2018 01:12:55	69 56.05	17 28.93	1528.1

1225286	Mar 06 2018 02:12:22	69 49.68	17 27.92	1423.2
1225287	Mar 06 2018 03:04:22	69 43.24	17 27.52	1113.5
1225288	Mar 06 2018 04:08:30	69 36.74	17 27.68	1277.6
1225289	Mar 06 2018 04:53:02	69 30.62	17 26.84	1414.9
1225290	Mar 06 2018 05:34:01	69 24.14	17 25.43	1274.3
1225291	Mar 06 2018 06:13:53	69 17.93	17 24.19	908.3
1225292	Mar 06 2018 06:52:43	69 11.57	17 22.77	887.1
ALL0118 XBT SECTION cs3_up				
1225292	Mar 06 2018 06:52:43	69 11.57	17 22.77	887.1
1225293	Mar 06 2018 08:13:55	69 11.62	17 5.26	657.8
1225294	Mar 06 2018 09:04:56	69 14.56	16 48.58	1006.3
1225295	Mar 06 2018 09:41:43	69 17.69	16 33.59	848.4
1225296	Mar 06 2018 11:51:47	69 23.20	16 28.72	870.8
1225297	Mar 06 2018 14:13:43	69 26.55	16 49.91	924.9
1225298	Mar 06 2018 15:45:43	69 29.81	17 12.51	1395.1
ALL0118 XBT SECTION gs1				
1225300	Mar 14 2018 19:37:10	75 26.80	9 26.10	2600.1
1225299	Mar 14 2018 20:06:54	75 21.92	9 29.73	2762.9
1225301	Mar 14 2018 20:40:07	75 17.17	9 34.75	2908.8
1225302	Mar 14 2018 21:12:51	75 12.35	9 38.69	3002.4
1225303	Mar 14 2018 21:44:50	75 7.69	9 42.48	3081.4
1225304	Mar 14 2018 22:15:14	75 3.07	9 46.80	3129.8
1225305	Mar 14 2018 22:41:36	74 58.67	9 50.71	3164.7
1225306	Mar 14 2018 23:13:55	74 53.75	9 54.90	3180.6
1225307	Mar 14 2018 23:46:05	74 48.90	9 58.85	3178.1
1225309	Mar 15 2018 00:23:22	74 43.01	10 3.31	3168
1225310	Mar 15 2018 00:48:20	74 38.34	10 7.45	3135.7
1225311	Mar 15 2018 01:19:54	74 33.38	10 11.71	3044.9
ALL0118 XBT SECTION 10				
1225340	Mar 16 2018 17:20:27	75 16.70	8 53.78	2921.8
1225339	Mar 16 2018 17:10:10	75 15.40	8 50.25	2947.2
1225338	Mar 16 2018 16:53:39	75 12.91	8 43.17	2988.8
1225337	Mar 16 2018 16:37:03	75 10.55	8 37.33	3032.0
1225336	Mar 16 2018 16:13:24	75 8.38	8 31.74	3071.1
1225335	Mar 16 2018 15:02:01	75 5.31	8 23.78	3124.5
1225334	Mar 16 2018 14:50:22	75 3.79	8 20.11	3130.7
1225333	Mar 16 2018 14:36:08	75 1.49	8 14.46	3142.0
1225332	Mar 16 2018 14:21:50	74 59.46	8 9.43	3160.9
1225331	Mar 16 2018 14:09:10	74 57.32	8 3.96	3170.0
1225330	Mar 16 2018 12:53:39	74 53.96	7 55.14	3181.3
1225329	Mar 16 2018 12:38:10	74 52.51	7 51.83	3182.9
1225328	Mar 16 2018 12:27:38	74 50.21	7 46.01	3179.7
1225327	Mar 16 2018 12:13:39	74 47.96	7 40.33	3181.2
1225326	Mar 16 2018 11:59:15	74 45.82	7 34.58	3176.6
1225325	Mar 16 2018 10:45:26	74 42.52	7 26.50	3168.6
1225324	Mar 16 2018 10:36:18	74 41.02	7 23.07	3170.4
1225323	Mar 16 2018 10:22:04	74 39.02	7 18.02	3154.7
1225322	Mar 16 2018 10:07:12	74 36.82	7 12.44	3154.1

1225321	Mar 16 2018 09:52:52	74 34.55	7 6.78	3108.2
1225320	Mar 16 2018 08:39:05	74 31.19	6 58.40	3119.3
1225319	Mar 16 2018 08:26:09	74 29.33	6 54.08	3132.3
1225317	Mar 16 2018 08:06:57	74 26.68	6 47.75	3068.8
1225318	Mar 16 2018 07:55:37	74 24.95	6 43.64	3061.9
1225315	Mar 16 2018 07:34:36	74 22.28	6 37.26	3042.8
1225314	Mar 16 2018 07:17:47	74 20.23	6 32.37	3047.0
1225313	Mar 16 2018 07:02:20	74 17.82	6 26.37	3042.3
1225312	Mar 16 2018 06:51:35	74 16.58	6 21.67	3024.2

Appendix E1: Radiosonde Details

Appendix 1
Radiosonde Details

sounding_no	date	lat	lon	sounding_time	serial_no	surf_temp_degC	surf_pres_hPa	surf_RH_%	surf_wd_deg	surf_ws_m/s	Note 1	Note 2
1	04/02/2018	64.151785	-21.937844	12:00:00	N4820388	7.5	1000.0	95	179	10	Test	
2	09/02/2018	68.587144	-19.131661	14:00:00	N4840227	-7.2	986.8	80	342	22.7	Success	
3	09/02/2018	68.310426	-18.078807	18:00:00	N4820382	-6.7	985.8	89	112	19.2	Success	
4	10/02/2018	NaN	NaN	00:00:00	N4820396	NaN	NaN	NaN	NaN	NaN	Failed	
5	10/02/2018	67.890148	-18.450769	00:00:00	N4840205	-4.5	984.7	92	359	21.3	Success	
6	10/02/2018	67.311261	-18.910379	06:00:00	N4820395	-1.6	982.8	95	359	25	Success	
7	12/02/2018	67.905051	-13.920849	12:00:00	N4820389	0.0	979.8	64	177	12.5	Success	
8	13/02/2018	69.242782	-15.213494	12:00:00	N4820383	-0.1	989.9	75	80	6.5	Success	
9	14/02/2018	69.678466	-18.719752	12:00:00	N4820394	0.0	979.0	86	117	15	Success	
10	14/02/2018	69.812359	-19.63167	15:00:00	N4820387	-2.4	979.0	87	5	25	Success	
11	14/02/2018	69.760656	-19.196845	18:00:00	N4820381	-1.1	980.0	93	5	15	Success	
12	14/02/2018	69.703601	-18.946491	21:00:00	N4840223	-2.7	980.5	94	353	8.5	Success	
13	15/02/2018	69.556494	-17.636927	12:00:00	N4840246	2.0	977.0	98	68	13	Success	
14	16/02/2018	70.40451	-19.298079	12:00:00	N4820385	0.2	983.2	97	60	14.5	Success	
15	17/02/2018	70.683057	-15.413422	12:00:00	N4820390	0.1	1004.7	95	150	3	Success	
16	18/02/2018	70.025694	-12.956548	12:00:00	N4820380	2.0	1011.0	88	35	12	Success	
17	19/02/2018	70.757309	-15.62425	12:00:00	N4840225	0.0	1014.0	85	95	10	Success	
18	20/02/2018	71.190836	-19.330695	12:00:00	N4840224	0.6	996.0	80	130	7	Success	
19	21/02/2018	69.659658	-17.493599	12:00:00	N4820379	3.6	1010.0	71	138	9	Success	
20	22/02/2018	66.606528	-20.975428	12:00:00	N4830400	5.0	982.0	70	150	15	Success	
21	23/02/2018	66.067163	-23.117698	12:00:00	N4830398	4.8	993.0	48	20	1.8	Success	Only to 1km
22	27/02/2018	69.146185	-17.941466	12:00:00	N4830397	4.5	1032.0	72	181	6.6	Success	
23	27/02/2018	70.114132	-18.533686	18:00:00	N4840708	2.6	1030.0	73	205	10	Success	
24	27/02/2018	70.325794	-17.678071	21:00:00	N4840706	2.3	1031.0	80	210	5	Success	
25	28/02/2018	70.474921	-16.620207	00:00:00	N4840732	0.0	1032.0	96	180	3.5	Success	
26	28/02/2018	70.644814	-15.593971	03:00:00	N4940682	1.2	1030.0	90	170	4.5	Success	
27	28/02/2018	70.695978	-16.522942	06:00:00	N4840617	3.3	1028.0	78	250	3	Success	
28	28/02/2018	70.880266	-17.06956	09:00:00	N4820404	1.7	1029.0	83	10	11.5	Success	Only to 12km
29	28/02/2018	70.982005	-16.995107	12:00:00	N4830405	-3.0	1034.0	94	350	12	Success	
30	28/02/2018	70.893099	-16.685232	15:00:00	N4830402	-2.9	1037.0	71	358	16	Success	
31	28/02/2018	70.53883	-16.886856	18:00:00	N4840616	-2.9	1039.0	66	356	9.5	Success	
32	28/02/2018	70.083379	-16.697789	21:00:00	N4840707	-3.2	1040.0	58	355	9	Success	
33	01/03/2018	69.669069	-16.508408	00:00:00	N4830399	-3.2	1040.0	66	5	14	Success	
34	01/03/2018	69.381595	-16.443629	03:00:00	N4830401	-3.5	1040.0	67	20	13	Success	
35	01/03/2018	69.482503	-17.102812	06:00:00	N4830403	-3.0	1040.0	69	30	15	Success	
36	01/03/2018	69.559397	-17.649829	09:00:00	N4820386	-3.5	1041.0	68	14	13	Success	
37	01/03/2018	69.618302	-18.209455	12:00:00	N4820403	-3.3	1042.0	61	15	10	Success	
38	01/03/2018	69.742029	-18.738516	18:00:00	N4830404	-5.1	1042.0	79	355	9	Success	
39	01/03/2018	69.876056	-17.875891	21:00:00	N4820405	-3.4	1041.6	57	0	10	Success	GPS gaps, EDT simulated
40	02/03/2018	69.872316	-16.988507	00:00:00	N4820534	-3.6	1043.0	64	30	10.5	Success	
41	02/03/2018	69.488468	-17.173944	09:00:00	N4820530	-3.5	1041.0	68	14	13.1	Success	
42	02/03/2018	69.569464	-17.8551	12:00:00	N4820391	-3.5	1042.0	60	46	9.4	Success	
43	02/03/2018	69.658651	-18.573053	15:00:00	N4820402	-3.9	1042.5	63	25	10	Success	
44	03/03/2018	69.487559	-16.669755	00:00:00	N4820815	-3.2	1037.7	63	35	9	Success	
45	03/03/2018	70.232983	-16.336656	12:00:00	N4840168	-4.4	1033.0	54	35	5.5	Success	
46	04/03/2018	70.167708	-15.557293	00:00:00	N4840167	-4.3	1030.0	78	40	15	Success	
47	04/03/2018	70.24188	-16.510192	06:00:00	N4840558	-5.7	1030.0	72	28	15	Success	
48	04/03/2018	70.25569	-16.779823	09:00:00	N4820401	-6.8	1032.6	71	10	17	Success	
49	04/03/2018	70.283747	-17.164673	12:00:00	N4840169	-8.3	1032.0	71	5	17	Success	
50	04/03/2018	70.301544	-17.530818	15:00:00	N4820533	-8.7	1033.0	75	0	15.5	Success	
51	04/03/2018	70.326229	-17.927164	18:00:00	N4840264	-9.5	1032.0	74	0	15	Success	
52	05/03/2018	70.554968	-16.130018	06:00:00	N4820392	-4.0	1024.0	86	30	14	Success	
53	05/03/2018	70.219366	-15.658111	09:00:00	N4820393	-2.4	1022.0	58	30	18.5	Success	
54	05/03/2018	70.20928	-15.949898	12:00:00	N4820529	-2.3	1022.0	56	30	16.5	Success	
55	05/03/2018	NaN	NaN	18:00:00	N4840556	NaN	NaN	NaN	NaN	NaN	Failed	Instrument error after launch
56	05/03/2018	70.279139	-16.80398	18:00:00	N4820837	-3.0	1022.0	84	25	13	Success	
57	06/03/2018	70.10287	-17.518892	00:00:00	N4820531	-4.0	1024.0	86	30	14	Success	

58	06/03/2018	NaN	NaN	06:00:00	N4829532	NaN	NaN	NaN	NaN	NaN	Failed	Instrument error after launch
59	06/03/2018	69.309709	-17.416058	06:00:00	N4840557	-1.4	1018.0	70	50	19	Success	
60	06/03/2018	69.215324	-16.971574	09:00:00	N4840166	-1.0	1018.0	62	60	13	Success	
61	06/03/2018	69.385889	-16.480087	12:00:00	N4840621	-1.5	1019.0	70	50	13	Success	
62	06/03/2018	69.465425	-17.010249	15:00:00	N4840201	-1.6	1019.0	71	55	12	Success	
63	06/03/2018	69.562658	-17.725915	18:00:00	N4840210	-1.5	1020.0	65	55	12	Success	
64	07/03/2018	69.70216	-18.9445	00:00:00	N4840634	-4.4	1021.0	90	5	17	Success	
65	07/03/2018	69.915568	-17.051044	06:00:00	N4840613	-2.5	1019.0	74	20	12	Success	
66	07/03/2018	69.055445	-16.804718	12:00:00	N4840615	-1.9	1018.0	77	15	8	Success	
67	07/03/2018	67.854467	-17.916417	18:00:00	N4840619	-1.5	1016.0	59	40	14	Success	
68	08/03/2018	66.83853	-18.279184	00:00:00	N4820384	-1.0	1015.0	64	40	11	Success	
69	10/03/2018	66.721744	-18.233018	00:00:00	N4890208	-1.2	1014.0	65	160	6.5	Success	
70	10/03/2018	67.819537	-17.930487	06:00:00	N4840207	-0.2	1015.0	68	70	13	Success	
71	10/03/2018	68.694526	-17.771183	12:00:00	N4840209	-1.6	1019.0	80	45	13	Success	
72	11/03/2018	71.047797	-14.884853	12:00:00	N4840614	-2.9	1023.0	59	25	4	Success	
73	12/03/2018	73.777382	-15.38898	12:00:00	N4840622	-9.6	1018.0	89	20	13.5	Success	
74	13/03/2018	73.94141	-9.310286	00:00:00	N4830516	-5.2	1019.0	80	17	9	Success	
75	13/03/2018	NaN	NaN	12:00:00	N4840624	NaN	NaN	NaN	NaN	NaN	Failed	RH sensor failed on initialisation
76	13/03/2018	74.69024	-3.25282	12:00:00	N4840200	-2.9	1019.0	53	60	10.5	Success	
77	14/03/2018	75.104634	-6.677108	00:00:00	N4840625	-3.1	1018.3	70	55	9	Success	
78	14/03/2018	75.655264	-9.851748	12:00:00	N4820839	-2.8	1009.0	90	122	9	Success	Only to 2km
79	15/03/2018	74.829782	-9.968092	00:00:00	N4830515	-12.9	1014.0	85	300	7	Success	
80	15/03/2018	74.711052	-12.901834	12:00:00	N4820840	-8.8	1018.0	72	175	4	Success	
81	16/03/2018	74.417513	-8.510521	00:00:00	N4840629	-0.4	1016.0	96	195	7	Success	GPS gaps, EDT simulated
82	16/03/2018	74.740185	-7.4827	12:00:00	N4940683	-0.6	1012.0	98	180	9.5	Success	GPS gaps, EDT simulated
83	16/03/2018	75.033917	-8.262771	15:00:00	N4840703	-0.3	1007.0	98	165	9.5	Success	GPS gaps, EDT simulated
84	16/03/2018	75.284912	-8.886991	18:00:00	N4940679	-0.5	1002.0	98	200	7	Success	
85	16/03/2018	74.901144	-9.529673	21:00:00	N4940684	-8.5	1003.0	90	340	22	Success	
86	17/03/2018	74.43414	-10.057379	00:00:00	N4840704	-9.5	1009.0	90	330	20	Success	
87	17/03/2018	73.940656	-10.471831	03:00:00	N4840633	-10.5	1014.0	85	325	14.5	Success	
88	17/03/2018	73.51472	-11.401559	06:00:00	N4940680	-10.2	1016.0	77	340	15	Success	
89	17/03/2018	73.089587	-12.466876	09:00:00	N4840623	-10.0	1018.0	77	330	7.3	Success	GPS gaps, EDT simulated
90	17/03/2018	72.68435	-13.46078	12:00:00	N4840632	-8.4	1018.0	65	300	5	Success	
91	17/03/2018	72.209847	-14.10481	15:00:00	N4830514	-7.1	1018.0	54	300	10.5	Success	
92	17/03/2018	71.751216	-14.522491	18:00:00	N4840628	-6.4	1018.0	63	275	9	Success	GPS gaps, EDT simulated
93	18/03/2018	71.806352	-15.633268	00:00:00	N4840605	-7.2	1020.0	55	320	6	Success	
94	18/03/2018	71.952027	-16.706595	06:00:00	N4840627	-6.8	1019.0	60	305	10	Success	
95	18/03/2018	72.021745	-17.301586	09:00:00	N4840620	-7.3	1020.0	61	285	10.8	Success	
96	18/03/2018	72.044564	-17.547125	12:00:00	N4840630	-7.8	1021.0	54	310	8	Success	
97	18/03/2018	71.627813	-17.226224	15:00:00	N4840630	-6.4	1022.0	58	315	8	Success	
98	18/03/2018	70.878277	-17.322325	18:00:00	N4840635	-5.7	1024.0	47	355	5	Success	
99	19/03/2018	69.541561	-17.478488	00:00:00	N4840705	-3.8	1025.0	71	120	2.5	Success	
100	19/03/2018	67.997734	-22.531586	12:00:00	N4840627	1.8	1017.0	97	220	10	Success	

Appendix E2: Instrument Operation Log

Appendix 2

Instrument Operation Log

	02-Feb	03-Feb	04-Feb	05-Feb	06-Feb	07-Feb	08-Feb	09-Feb	10-Feb	11-Feb	12-Feb	13-Feb	14-Feb	15-Feb	16-Feb	17-Feb	18-Feb	19-Feb	20-Feb	21-Feb	22-Feb	23-Feb	24-Feb	25-Feb
MRR																								
HATPRO																								
Windcube																								
Stable Table																								
Radiosondes																								

	26-Feb	27-Feb	28-Feb	01-Mar	02-Mar	03-Mar	04-Mar	05-Mar	06-Mar	07-Mar	08-Mar	09-Mar	10-Mar	11-Mar	12-Mar	13-Mar	14-Mar	15-Mar	16-Mar	17-Mar	18-Mar	19-Mar	20-Mar	21-Mar
MRR																								
HATPRO																								
Windcube																								
Stable Table																								
Radiosondes																								

In harbour
Leaving harbour
At sea

Instrument off	
Calibration, initial testing or moblisation	
Data issues while instrument on	
Instument functioning normally	
Instrument failure	

Further details are available by contacting Chris Barrell.