R/V YUNUS-S (Istanbul University) cruise report
November 28, 2020
Istanbul – Istanbul

Science party

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Summary

The objective of this cruise was to the final recovery, from Imrali Basin of an instrumented frame deployed during a previous Istanbul University R/V *Yunus-S* cruise, Nov 19-20, 2019. Because of COVID-19 restrictions, the recovery cruise, initially planned in May 2020 was delayed until November

The frame was successfully recovered, but instruments were out of battery power. The RBR/Paroscientific (Digiquartz) bottom pressure recorder functioned continuously for 4 months and 10 days, then suffered cyclic perturbations and interruptions due to battery problems until June 24, 2020 when it stopped. The other instrument, a Seaguard doppler recording current meter (RCM) equipped with additional sensors (conductivity, pressure, temperature) provided 4.5 month of hourly data, but with cyclically missing records (1/3) after 1.5 months.

1-Cruise context and objectives

Deployment of Bottom Pressure Recorders on the seafloor of the Sea of Marmara deep basins is required by MAREGAMI project in order to detect and measure resonant frequency oscillations in the Sea of Marmara. These resonant oscillations (also known as seiches) are thought to play an important role in tsunami generation and influence the characteristics of turbidite-homogenite deposition after earthquakes and landslides. In addition, monitoring of bottom water variations in pressure, temperature, salinity, and of bottom currents will help understand the causes of perturbations affecting acoustic ranging measurements performed in Kumburgaz Basin as part of a geodetic experiment (Nov 2014 – Jan 2018) and shall be taken into account for the planning of future geodetic monitoring on the North Anatolian Fault in the Sea of Marmara. This cruise is the fourth, and last, recovery performed within the framework of MAREGAMI with the Istanbul University R/V Yunus-S.

The cruise operations were jointly funded by MAREGAMI, a bilateral collaboration project between ANR and TÜBITAK and by EMSO-France Research Infrastructure. Instruments and technical support were provided by CNRS/DT-INSU.

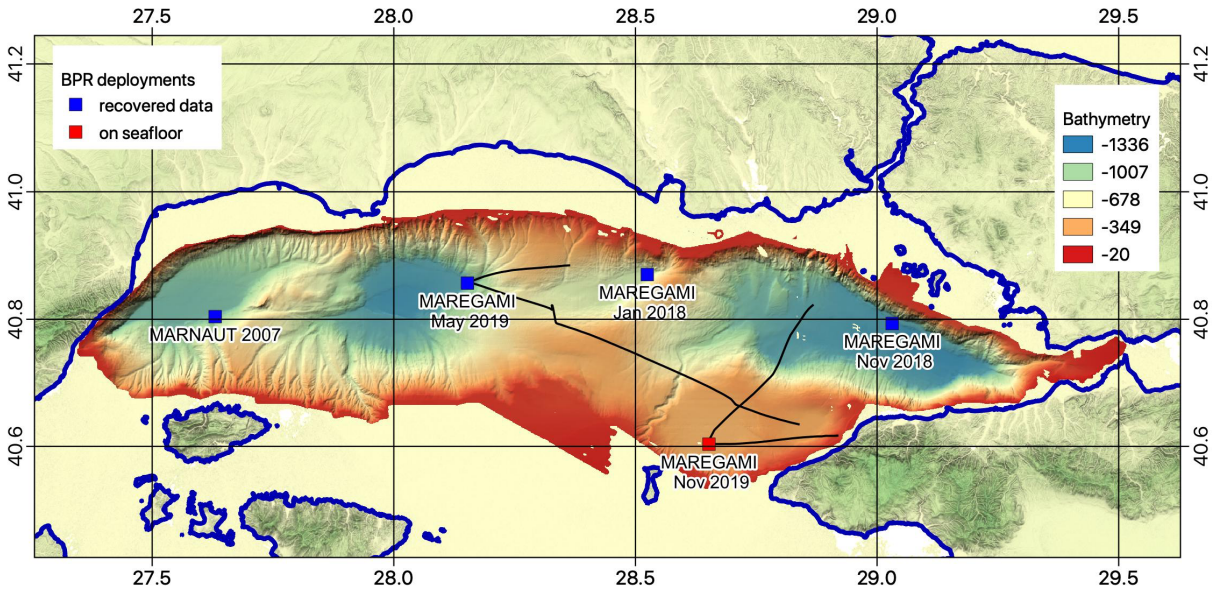


***Figure 1**: Ship tracks of YUNUS-S during November 19-20, 2019 cruise and location of BPR deployments. Pressure records were previously obtained in Tekirdağ Basin in 2007-2008 (Marnaut cruise of R/V L'Atalante), Kumburgaz Basin, Çınarcık Basin and Central Basin (R/V Yunus January 2018, November 2018 and May 2019 deployments). The November 28, 2020 cruise recovered instruments deployed in November 2019 in Imrali Basin.*

2-Instrumented frame and data recovery

Instrumentation on the frame (Figure 2 and 5) comprises (1) an RBR bottom pressure recorder (BPR) with a Paroscientific 0-2000 m Digiquartz sensor, (2) a Seaguard recording current meter (RCM) equipped with additional sensors: temperature, pressure (tide sensor Aandera 5217), conductivity, oxygen (Aandera optode). The tide sensor is a piezoresistive sensor of accuracy comparable to that of the Digiquartz sensors (0.02% vs 0.01% for Digiquartz), and 0.2 hPa (2 mm) resolution. The sampling interval was set to be compatible with a required minimum battery autonomy of at least a year. The RBR pressure sampling interval was thus set to 5s and the Seaguard RCM to one hour (for all sensors) after a battery failure occurred after only one month during the last deployment. The RBR system was acquired with MAREGAMI funding, the Seaguard RCM was loaned by DT-INSU, as well as the acoustic release systems, a flasher and an Argos beacon. The tide sensor fit on the Seaguard RCM was acquired with EMSO funding.

The frame was equipped with 2 acoustic releases (DT-INSU n° 394 and 853) attached to each end of the anchoring chain for redundancy. The frame was released at the first attempt and recovered without problem.

Figure 2: *Frame after recovery and removal of the isntruments*

Bottom Pressure Recorder data

Data exports are available in Ruskin (RBR software) format and in txt format (Table 1). The instrument set on the bottom at 2019-11-20 07:51:45.0. Power switching from external to internal battery packs occurred as expected 2020-03-10 13:19:05.0, 3.5 month into the deployment. However, the instrument switched back to the external battery 2020-03-31 03:39:00.0, only 20 days layer. This quickly led to low power and disturbed measurements until data acquisition failed at 2020-03-31 03:52:35.0. Data acquisition restarted at 2020-03-31 04:02:40.0 as the data logger switched back to internal power. This succession of events occurred again regularly over the next 2 months, with usually shorter interruptions of data recording, but also caused clock resets, detected at 2020-04-02 05:41:14.0 and 2020-04-03 08:22:14.0. Each of these interruptions is preceded by a few anomalous pressure and temperature measurements and is followed by a pressure and temperature transient. The polarity of the temperature transient is negative, its amplitude is typically a few mK and its duration about 20 minutes. Compared to natural variations, the temperature transient is relatively larger in amplitude than the pressure transient, which also appears shorter, lasting about 6 minutes. Reminding that the temperature sensor on this system is internal and that a temperature compensation is applied to the pressure sensor, it is possible that both pressure and temperature transients are indeed related to a small temperature variation within the data logger caused by the power interruption. After the 2020-05-31 00:39:55.0 time label the data logger remained stable on internal power and recorded continuously until 2020-06-23 00:32:45.0. After as reset, the instrument started recording again for 1.25 day between time labels 2020-06-23 05:52:25.0 and 2020-06-24 12:33:15.0. Because resets occurred, it is unclear whether these two records remained properly synchronized with UTC.

Table 1 - Time series acquired by RBR BPR

Data export	First record	Last record	Comments
052665_20201128_0458.rsk	2019-11-20 05:13:55.0	(2020-06-27 00:01:30.0)	From before deployment to after recovery First reset detected 2020-04-02 05:41:14.0
052665_20201128_0748.rsk	2020-11-28 13:36:25.0	2020-11-28 14:59:45.0	On board record. UTC

Seaguard RCM

The Seaguard RCM was found stopped. System parameter log indicate a rapid voltage drop 14/04/2020 from 6V to 4.79V at 18:30:20, date of the last record written down. The battery voltage (7.17 V) was close to nominal at the beginning of deployment, but seemingly random voltage fluctuations occurred. For instance, voltage dropped to about 6.9V 08/01/2020 at 15:30 but was back up to 7.126 V for the next record one hour later. This occurred again 09/01/2020 at 10:30. Cyclic malfunction of the data logger occurred from 09/01/2020 17:30:20. Conductivity, Doppler current sensor (DCS), oxygen sensors gave a reset warning (17) and the tide sensor a parameter warning (18). The conductivity sensor yielded slightly altered (by less that 1‰) conductivity and temperature values. Single readings of temperature and pressure from the Tide sensor were also slightly altered and the sensor could not calculate pressure averages. Oxygen sensor and DCS logged zero for all parameters (-80 dB for backscatter strength can be considered equivalent to a 0). Similar events repeated with remarkable regularity at 3 hours interval (and thus every 3 record), with only two exceptions. Meanwhile, the system parameters were recorded without warning. More small voltage perturbations were logged but their relationship with the faulty records is not obvious so that battery failure is probably not the primary cause of error. One clue could be with the dedicated temperature sensor (#119). This senor had anomalous drift during all the previous deployment and started this one about 1°C off. The temperature temporarily failed to respond from 14:30 to 17:30 on 08/01/2020, and then permanently after 9:30:20 on 08/01/2020. It is striking that these failures start just one hour before transient voltage drops are recorded, and that the permanent failure occur just a few hours before the first global malfunction of the RCM. One hypothesis is that the faulty sensor was the primary cause of failure by excessive power consumption during interrogation. This suggests an electric isolation fault may have occurred on the sensor. The last record with valid sensor data (Tide sensor only) has time label 2020-04-14 17:30:20. The next and final record only contains system parameters.

Table 2 – Time series acquired by SeaguardRCM

Data export	First record	Last record	Recorded sensors
YUNUS_nov_20_data.txt	2019-11-19 20:30:20	2020-04-14 18:30:20	Temperature #119, DCS #146, Conductivity #788, Tide #393, Oxygen Optode #3127

Vaisala Barometer

To test the possibility of calibrating the 0 of a Digiquartz sensor during a cruise, an atmospheric barometer (VAISALA PTB330TS) was brought on board the ship. The accuracy of the barometer is 0.1 hPa at lab temperature. The clock of the Vaisala was found to have been set approximately in local Istanbul time, in principle GMT+3, but the offset observed after the instrument was returned to Brest was 3 hours 11 minutes Pressure was recorded every minute from 2020-11-28 11:36:55 to 18:52:55, corresponding to 8:25:55 and 18:41:55 GMT. Data was exported in ascii files 2020-11-28_11_36.txt and 2020-11-28_11_36.m70 with the instrument time label. Time was corrected to UTC in the matlab export.

3-Navigation

Location of BPR deployment sites (Table 3) and location of instrument recovered during the November 28, 2020 cruise of RV Yunus-S (Figure 6).

Table 3 – BPR deployment sites

Point	Lat	Lon	Lat		Lon		Depth	Comment
MNT BPR	40.8042	27.6303	N 40°	48.253'	E 027°	37.816'	1110 m	marnaut (2007-2008)
MRG BPR1	40.8703	28.5244	N 40°	52.218'	E 028°	31.464'	805 m	recovered Nov 2018
MRG BPR2	40.7934	29.0312	N 40°	47.604'	E 029°	01.872'	1225 m	recovered May 2019
MRG BPR3	40.8568	28.1523	N 40°	51.408'	E 028°	09.138'	1184 m	recovered Nov 2019
MRG BPR4	40.6035	28.6521	N 40°	36.212'	E 028°	39.126'	406 m	recovered Nov 2020

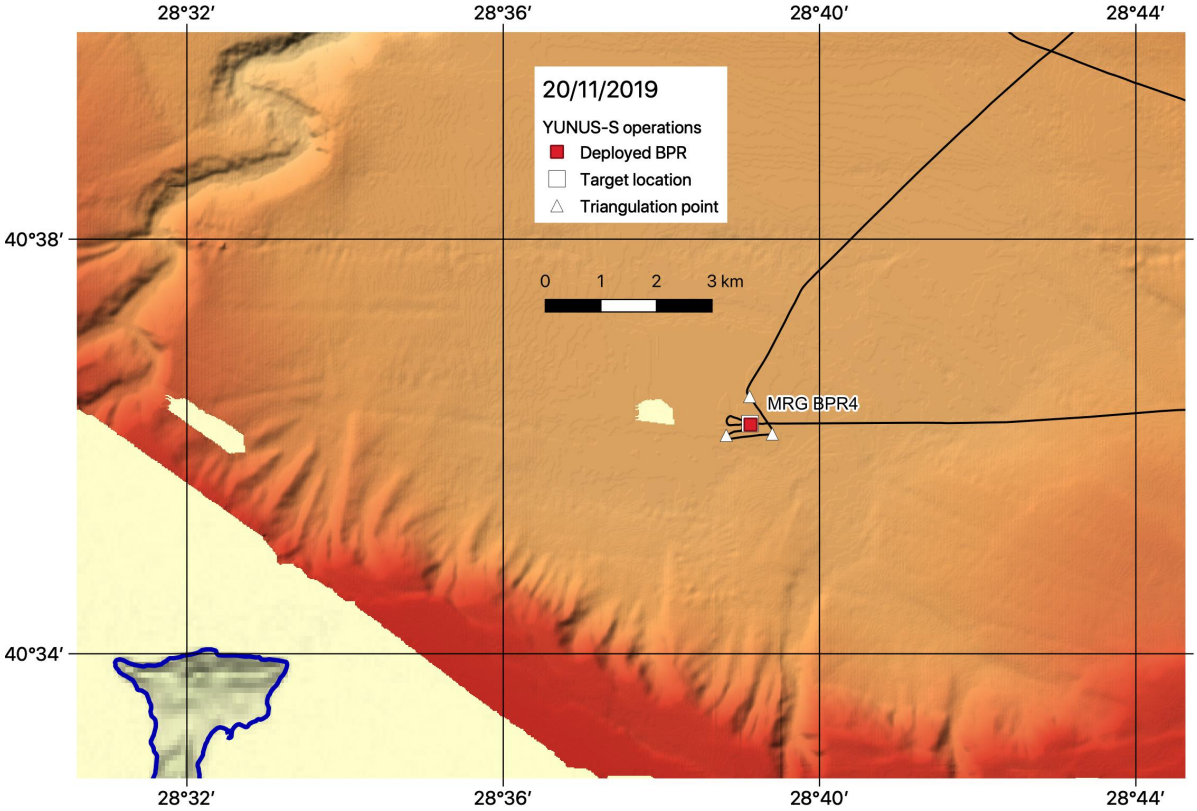


***Figure 6**: Location of BPR in Imrali Basin.*

4- Data distribution and initial assessment

Data from RBR BPR, Seaguard RCM, and Vaisala PTB are temporarily available at the OSU Pytheas Owncloud server[1] in ascii and in matlab binary format and explanation of variables in matlab files is given in Table 4, 5 and 6. Seafloor data will be distributed through the OSUPytheas ERDDAP server[2] as for the previous deployments.

4-1-RBR pressure and temperature records

The RBR deployment provided two intervals of continuous records with reliable bottom P, T data. The first one from immediately after touchdown at 2019-11-20 07:51:45.0 to the first battery-related disturbance at 2020-03-31 03:45, and is correctly dated, with a probable time error of less than 2 s considering the clock drift observed during previous deployment. The second one lasted from 2020-05-31 01:23 to 2020-06-23 22:29, but the accuracy of the time labels cannot be assessed. P and T data recorded in the interval between these two continuous time-series may still be usable after cleaning, but the cyclic interruptions will remain a problem for signal processing, notably by Fourier analysis.

The pressure record indicates that the device landed on the seafloor at 2019-11-20 07:51:45.0. Pressure stabilized in 20s and about 12 cm of seafloor subsidence under the weight of the instrument is inferred from the progressive pressure increase measured over the following 30 minutes. The amplitude of recorded pressure variations for the whole duration of the time series is 57 hPa crest to crest (equivalent to 57 cm of water) (Figure 7). Tidal amplitudes are about 10 cm and involve ≈12 hours and ≈24 hours dominant periods. Higher frequency oscillations have an amplitude of about 1 hPa (1 cm) and "white" noise level is ±0.1 mm (±1Pa). Bad P or T records occasionally occur and where automatically detected and removed using a 3-point median filter, setting a maximum difference of 5 hPa between raw signal and median-filtered pressure signals and a maximum difference of 0.1°C for the temperature record. Temperature variations are small at 14.6±0.02°C with an increasing trend of about 0.01°C from January to June.

Table 4 – Variables in BPR Matlab files

Name	Type	Comment
Time	datetime array	Time in datetime format Time.TimeZone='UTC' Time.Format='yyyy-MM-dd HH:mm:ss.S'
Timestring	cell array	Time as character string
elapsed_days *or* elapsed_hours	double array	time elapsed since first record in file days(Time-Time(1)) *or* hours(Time-Time(1))
Period	double array	Pressure sensor measured period in ps
Period1	double array	Temperature sensor measured period in ps
BPRpressure	double array	Pressure in dBar (10 kPa)
BPRtemperature	double array	Temperature in °C

[1] https://nuage.osupytheas.fr/s/wwPLNo4FeRG7rkB

[2] https://dataset.osupytheas.fr/geonetwork/srv/fre/catalog.search#/metadata/7175f88e-cde6-4a67-ada5-1e44a687156f

4-2-Seaguard data logger

The Seaguard RCM provided seafloor current, temperature, conductivity, pressure and oxygen data every hour without interruption from 2019-11-20 08:30:00 to 2020-01-09 16:30:20, and a cyclically interrupted record from 2020-01-09 18:30:20 to 2020-04-14 17:30:20 (1 data record missing every 3 hours).

The *pressure and temperature* time series acquired with the various sensors are compared in Figure 8. The average offset between the Digiquartz and the Aandera tide sensors is 124 hPa, hPa larger than the offset measured during the previous deployment, 116 hPa (Digiquartz values being higher), determined during the first month. In order to compare the records from both sensors the pressure measured by the RBR was averaged over 5 minutes every hour to match the Seaguard recording schedule. The rms of the difference between these two time-series (after removal of 124 hPa offset) is 0.72 hPa (Figure 9). However, there is a non-linear relative drift of the sensors. During the first month, the pressure measurements from the Digiquartz sensor increase by about 2hPa relative to the Tide sensor, and then stabilizes. Perturbations after January 11 may relate to Seaguard malfunction. More perturbations and faster drift after March 26 may be attributed to battery problems on both instruments. The Seaguard data logger recorded temperature variations with 4 different sensors: a specific temperature probe, and temperature sensors on the conductivity meter, on the tide sensor and on the oxygen optode. Like during the previous deployment, the dedicated temperature probe yields very poor results with random drifts and jumps. It eventually fails to work and apparently causes excessive power consumption leading to data logger malfunction and eventual battery failure after 4.5 months. The CTD temperature is stable, but with a noise amplitude of ± 0.01 °C, appears too noisy to resolve short term natural variations. The tide and optode sensors provide the best temperature records, with variations consistent with that recorded by the temperature sensor of the RBR BPR, but with static offsets between instruments. Data up to January 8 are undisturbed on both RBR and Seaguard instruments. During this time interval the average temperature measured are 14.5377°C for the tide sensor 14.5360°C (-0.0017°C) for the CTD sensor, 14.5454°C (+0.0094°C) for the oxygen sensor, 14.5548°C (+0.0171°C) for the Digiquartz sensor. Thus, the temperature sensors displayed very little relative drift compared with the previous deployment. Other parameters are shown on Figure 10.

The *current meter*, set 1.5 m above seafloor, recorded small currents up to 8.43 cm/s. Oscillations of up to 4 cm/s amplitude may have periods compatible with tides (close to 12 or 24 hours). Longer period variations of current speed occur in December, January, and from mid-march to the end of the record. These current variations correlate with variations of salinity and temperature. However, the relationship with acoustic backscatter in unclear, as turbidity variations often appear anticorrelated with current.

The *conductivity sensor* yielded believable results (around 46.66 mS/cm at the seafloor). This was unexpected as this sensor yielded anomalously high values (> 60 mS/cm) during the previous deployment and no action was taken to solve this problem.

The *oxygen optode* sensor logged an oxygen saturation of 98±0.5% before deployment and its drift during this deployment could not be evaluated on board as the device was out of battery power and no replacement batteries were available. At the seafloor, the oxygen concentrations varied between 1 and 16 µM (0.3 to 5% air saturation) and were thus much lower than during the previous deployment in Central Basin where a progressive decrease from 50 µM at the begining of the deployment to about 35 µM at the end was recorded

Table 5 – Variables in Seagard RCM Matlab file (Nov_2020_RCM.mat)

Name	**Type**	**Comment**
Time_RCM	datetime array	Time in datetime format Time_RCM.TimeZone='UTC' Time_RCM.Format='yyyy-MM-dd HH:mm:ss.S'
Timestring_RCM	cell array	Time as character string
BatteryVoltageV	double array	Battery Voltage (V)
		Temperature Sensor #119 parameters
TemperatureDegC	double array	T (°C)
		Doppler Current Sensor #146 parameters
AbsSpeedcms	double array	Current absolute speed (cm.s^{-1})
DirectionDegM	double array	Current direction (° wrt magnetic north)
Northcms	double array	Current north-south component (cm.s^{-1})
Eastcms	double array	Current east-west component (cm.s^{-1})
HeadingDegM	double array	Instrument Heading (° wrt magnetic north)
TiltXDeg	double array	Instrument tilt in X direction
TiltYDeg	double array	Instrument tilt in Y direction
SPStdcms	double array	Single Ping Standard deviation (cm.s^{-1})
StrengthdB	double array	Signal strength (dB)
		Conductivity Sensor #788 parameters
ConductivitymScm	double array	Conductivity (mS.cm^{-1}), measured
TemperatureDegC1	double array	Temperature (°C), measured
SalinityPSU	double array	Salinity (PSU), derived
Densitykgm3	double array	Density (kg.m^{-3}), derived
Soundspeedms	double array	Sound speed (m/s), derived
		Tide sensor #393 parameters
PressurekPa	double array	Pressure (kPa), measured
TemperatureDegC2	double array	Temperature (°C), measured
TidePressurekPa	double array	Pressure (kPa), 300 s average
		Oxygen Optode sensor #3127 parameters
O2ConcentrationuM	double array	O_2 concentration (µM), measured
AirSaturation	double array	O_2 saturation wrt air (%), derived
TemperatureDegC3	double array	Temperature (°C), measured

Faulty data are outlined in grey.

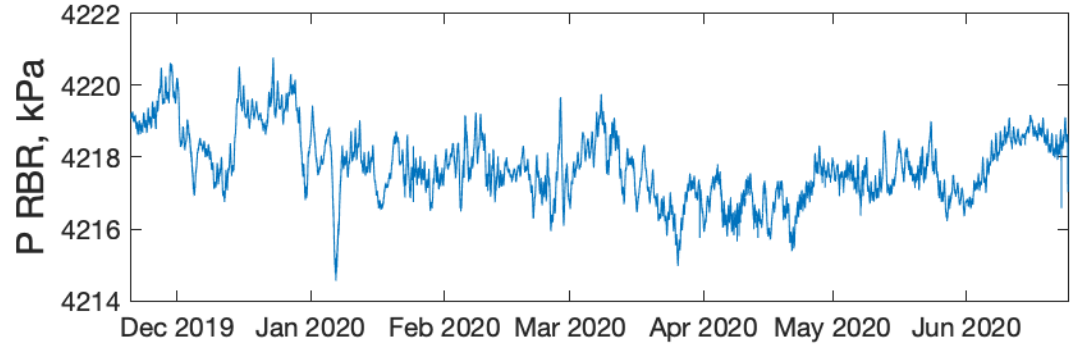
4-3-Vaisala shipboard atmospheric pressure record

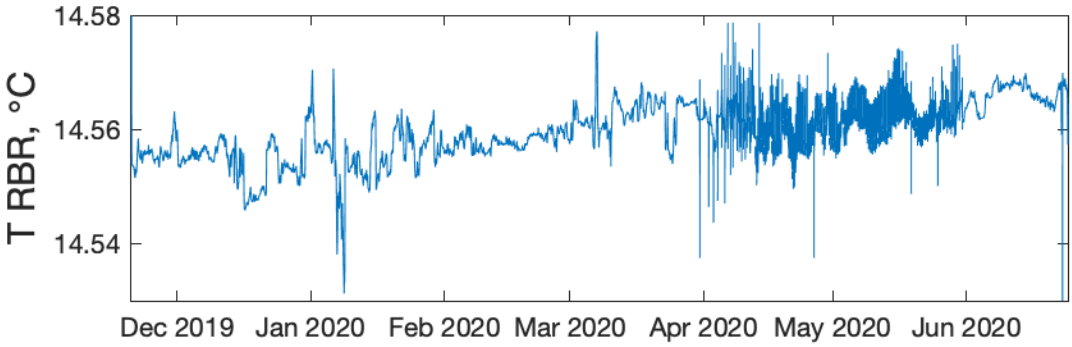
The Vaisala PTB and RBR BPR recorded simultaneously pressure on board for about 1.5 hour. During that time, atmospheric pressure measured by the Vaisala remained stable between 1019.3 and 1019.4 hPa. The pressure measure by the RBR BPR first decreased by 1 hPa during the first 15 minutes, then more slowly while temperature was equilibrating. From 14:45 to 15:00, temperature is stable at 17.75°C and pressure is 1060.75±0.25 hPa. It follows that the offset between the instruments is 41 hPa. This may be compared with offsets measured during previous cruises: 72.5 hPa offset at 20.25°C in Nov 2018, 69 hPa at 16.75°C in May 2019, 73 hPa at 20.12°C in Nov 2019. This suggests that the RBR digiquartz sensor had a stronger drift, of about -30 hPa, during this last deployment. However, a comparison with the Seaguard RCM data suggests that the drift during the 4 months interval when the intrument was operating is less than 5 hPa and with P_{RBR} increasing.

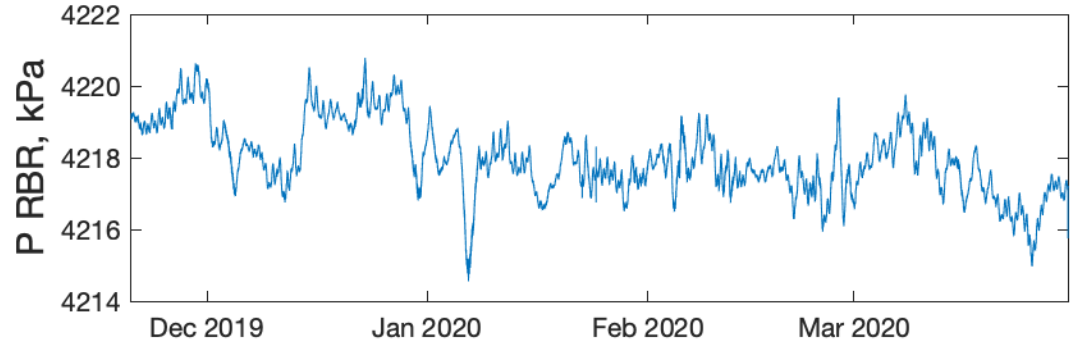
Table 6 – Variables in PTB Matlab file (2020-11-28_PTB.mat)

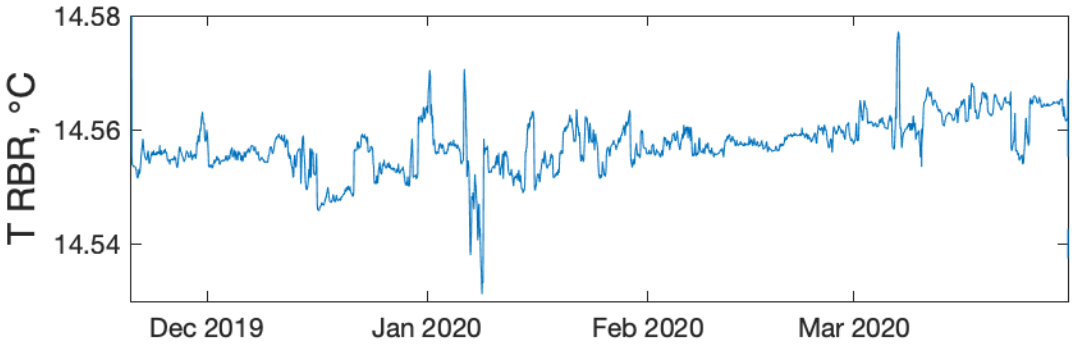
Name	**Type**	**Comment**
Time_PTB	datetime array	Time in datetime format Time_PTB.TimeZone='UTC' Time_PTB.Format='yyyy-MM-dd HH:mm:ss.S'
Timestring_PTB	cell array	Time as character string
P_hPa	double array	Atmospheric Pressure in hPa (mBar)

***Figure** 7: (On following page) Bottom pressure and temperature records from RBR BPR. Anomalous single values were removed using a 3 point median filter (medfilt1): (top) complete bottom pressure record (upper middle) complete bottom temperature record. Battery management problems caused cyclic perturbations in April and May. (lower middle and bottom) continuous record obtained between deployment and first battery fairure*


P RBR, kPa
4222
4220
4218
4216
4214
Dec 2019
Jan 2020
Feb 2020
Mar 2020
Apr 2020
May 2020
Jun 2020


T RBR, °C
14.58
14.56
14.54
Dec 2019
Jan 2020
Feb 2020
Mar 2020
Apr 2020
May 2020
Jun 2020


P RBR, kPa
4222
4220
4218
4216
4214
Dec 2019
Jan 2020
Feb 2020
Mar 2020


T RBR, °C
14.58
14.56
14.54
Dec 2019
Jan 2020
Feb 2020
Mar 2020

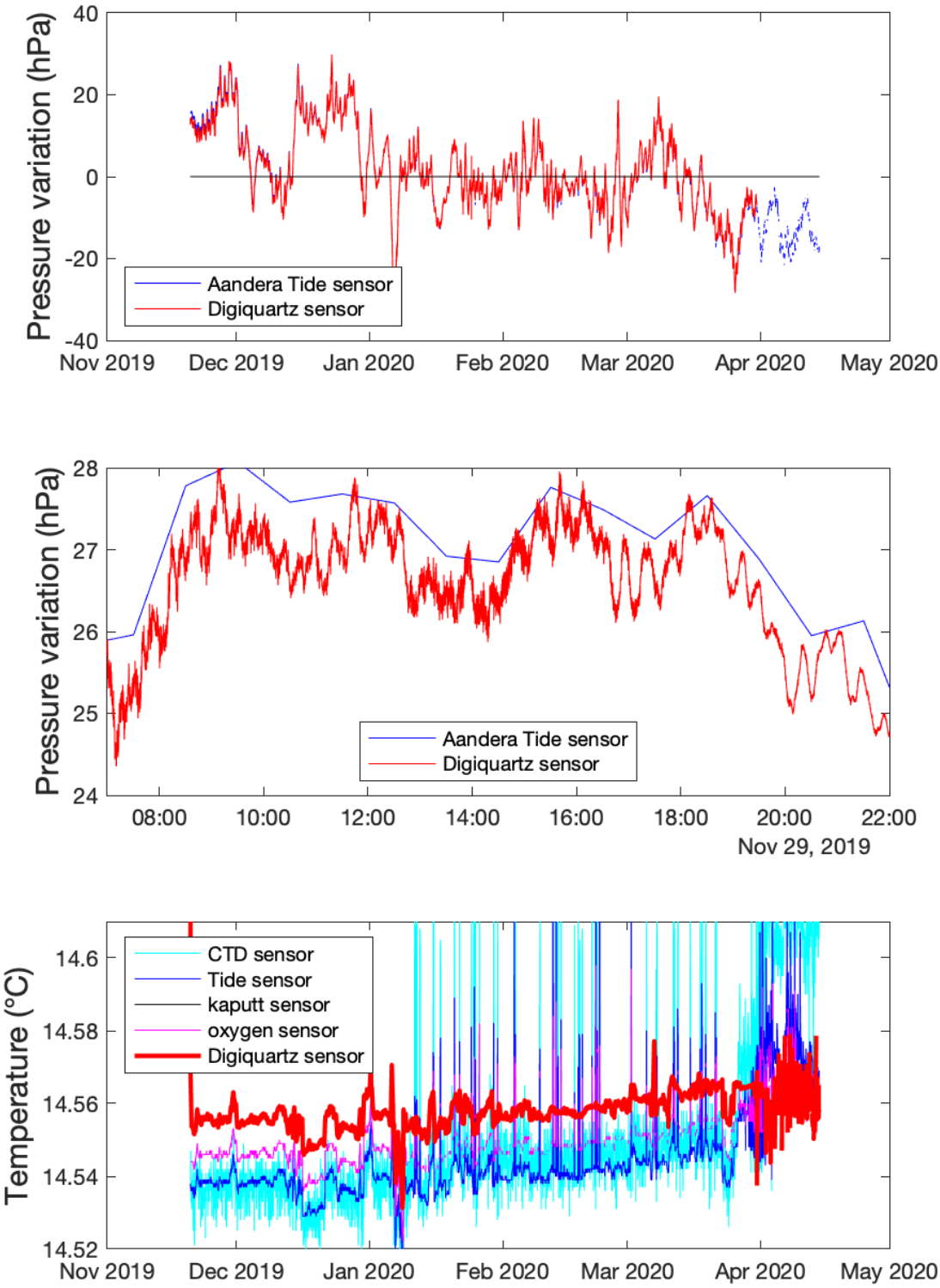


***Figure 8**: Comparison of pressure and temperature records obtained at the seafloor with the various sensors fit to the Seaguard and RBR data loggers*

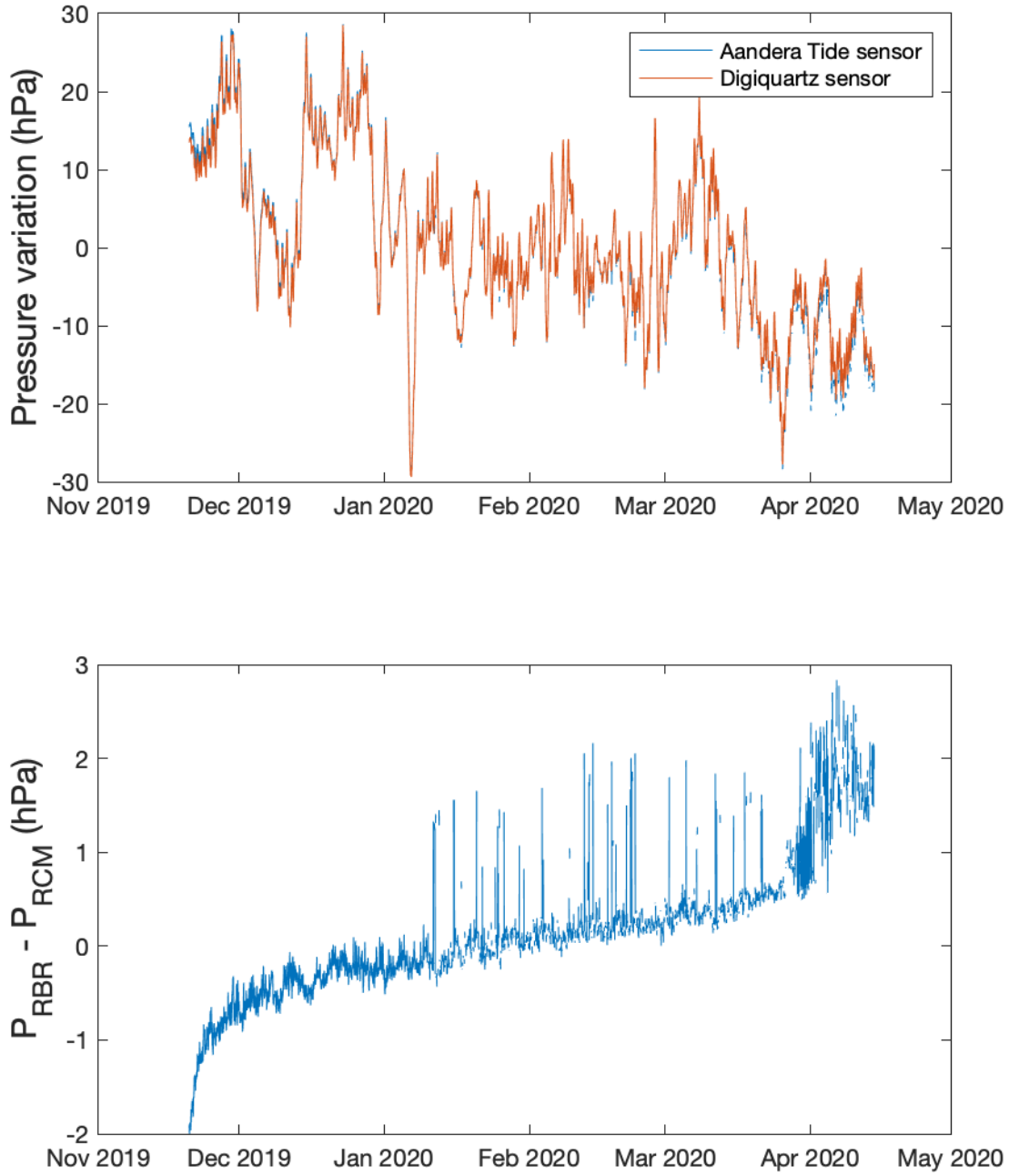


Figure 9*: Comparison of pressure time series obtained at the seafloor with the the Seaguard RCM and RBR Digiquartz systems with the same averaging duration (5 minutes) and recording interval (1 hour). Averaging is done during acquisition for the RCM, and on time series originally sampled at 5s for the RBR.*

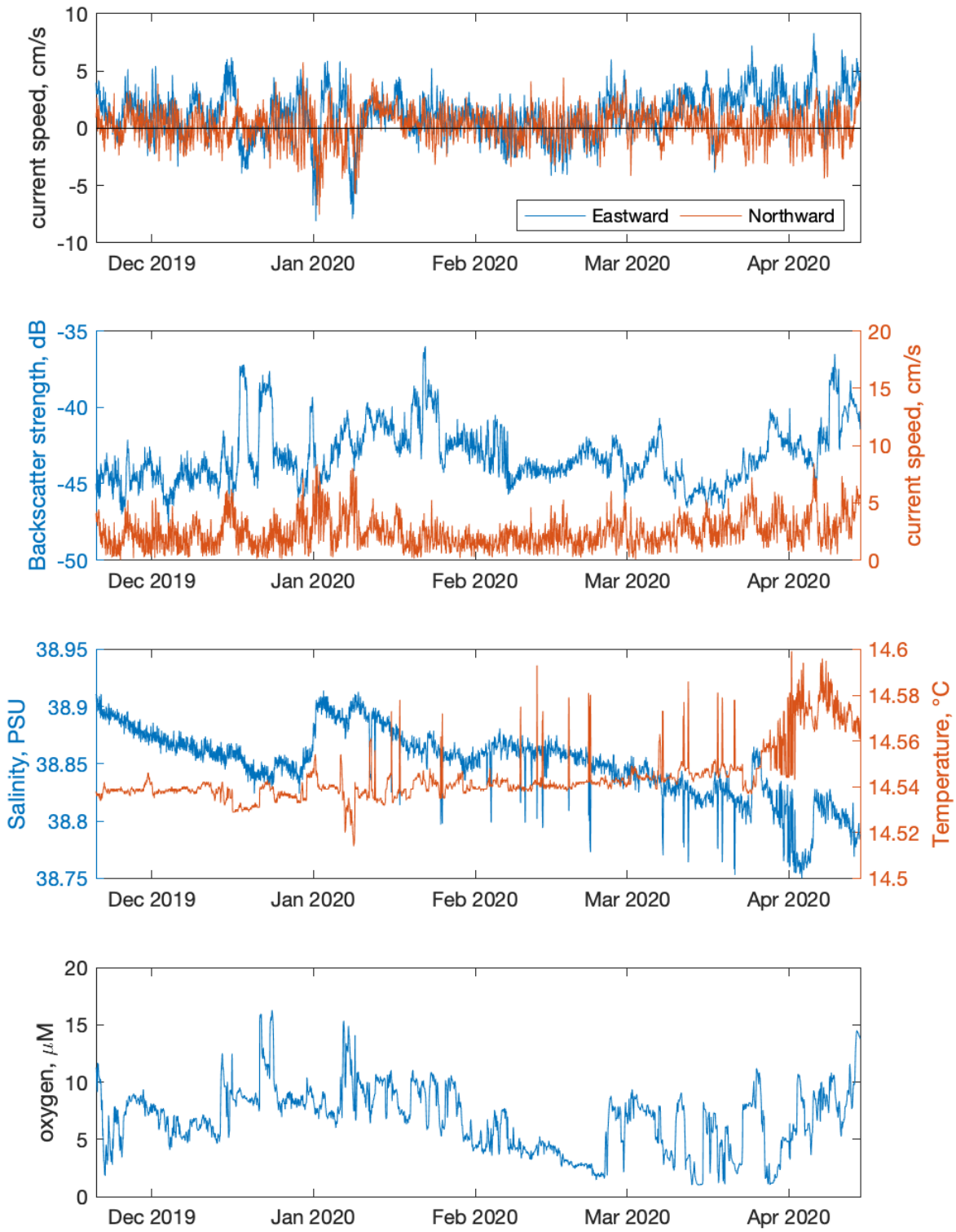
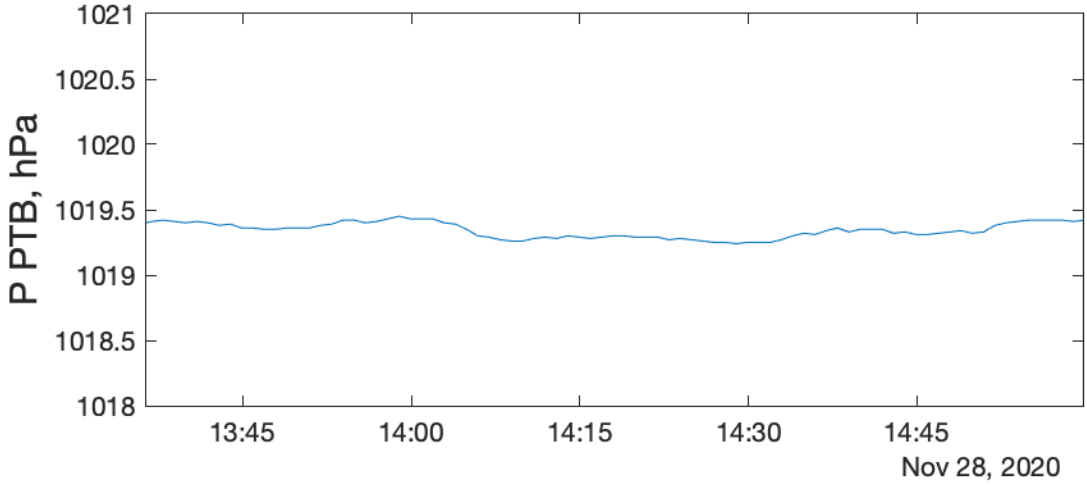
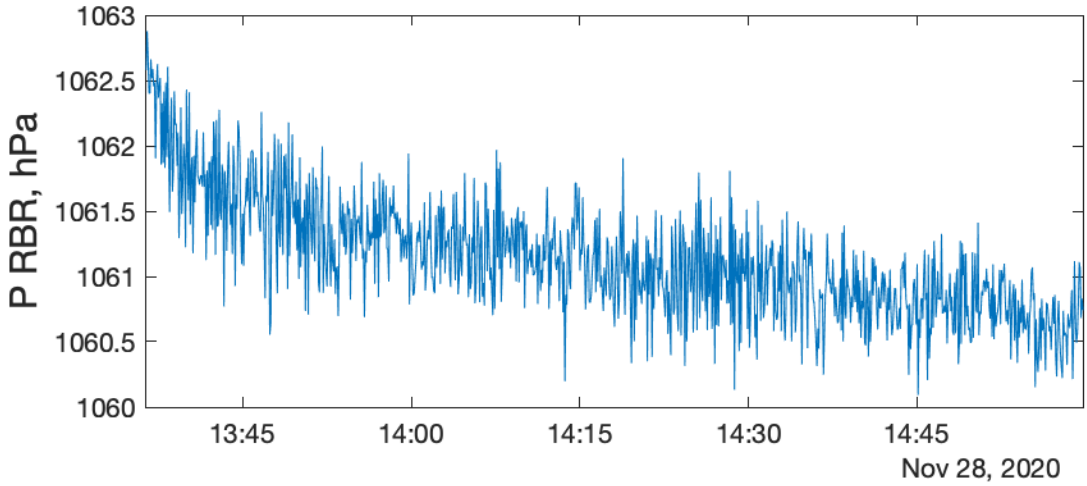


Figure 10: *RCM records of current, doppler backscatter strength, salinity, temperature and oxygen .*


P PTB, hPa
1021
1020.5
1020
1019.5
1019
1018.5
1018
13:45
14:00
14:15
14:30
14:45
Nov 28, 2020


P RBR, hPa
1063
1062.5
1062
1061.5
1061
1060.5
1060
13:45
14:00
14:15
14:30
14:45
Nov 28, 2020

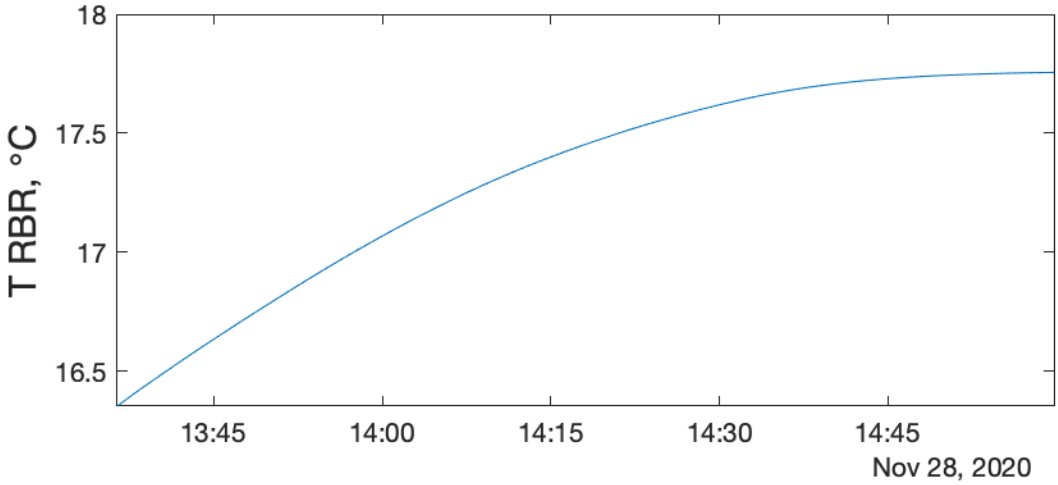

T RBR, °C
18
17.5
17
16.5
13:45
14:00
14:15
14:30
14:45
Nov 28, 2020

Figure 11*: Records acquired on the ship. (top) Vaisala PTB record; (middle) RBR Digiquartz pressure record; (bottom) RBR temperature record.*