R/V YUNUS-S (Istanbul University) cruise report
May 8-9, 2019
Istanbul – Istanbul

Science party

Shipboard
Pierre Henry (CEREGE, Aix-en-Provence, France), henry@cerege.fr
Nurettin Yakupoğlu (ITÜ, Istanbul, Turkey), yakupoglunurettin@gmail.com
Olivier Desprez de Gésincourt (DT-INSU, Plouzané, France), olivier.desprezdegesincourt@cnrs.fr
Christos Papoutsellis (CEREGE, Aix-en-Provence, France), cpapoutsellis@gmail.com

Onshore support
Sinan Özeren (ITÜ), ozerens@itu.edu.tr
Ziyadin Çakır (ITÜ)

Summary

The objective of this cruise was to recover from Çınarcık Basin an instrumented frame deployed during a previous R/V *Yunus-S* cruise, November 12-13, 2018, recover the data recorded by the instruments, do maintenance and redeploy the frame at another site, in the Central basin.

The frame was successfully recovered. The RBR/Paroscientific (Digiquartz) bottom pressure recorder functioned properly throughout the 6-month deployment. The other instrument, a Seaguard doppler recording current meter (RCM) equipped with additional sensors, operated properly for one month after deployment and stopped, presumably because of battery power failure. Pressure records from both instruments match but the noise level of the Digiquartz pressure sensor is about 1/50 of the noise level of the Aandera tide sensor fitted to the RCM. The instrumented frame was redeployed at the planned location without incident.

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 third deployment 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.

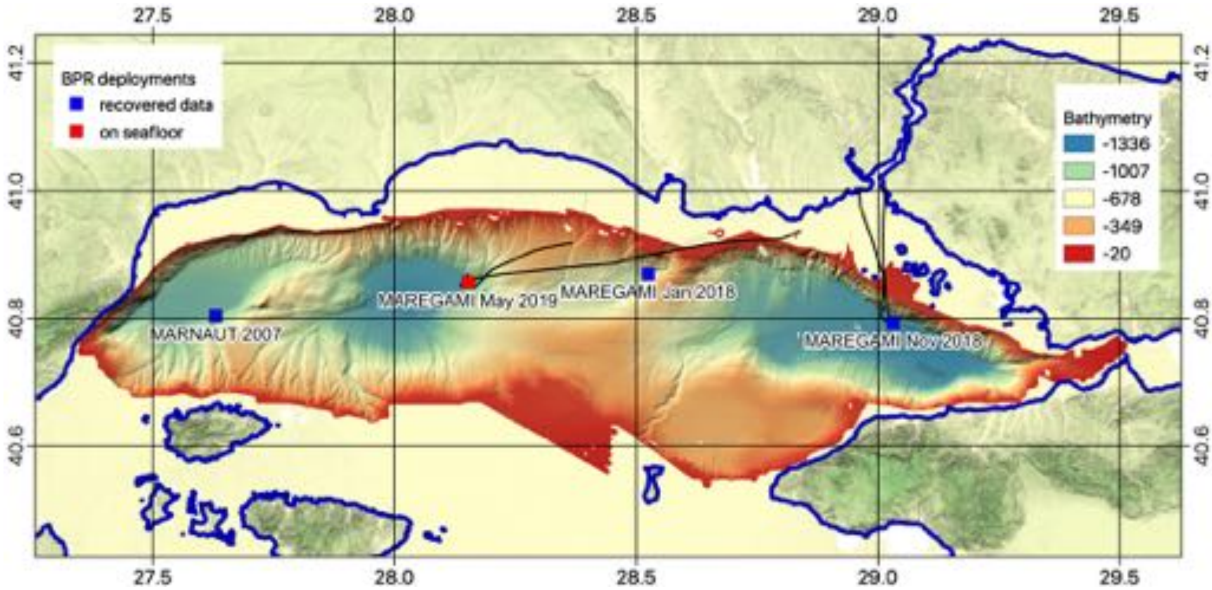

Figure 1*: Ship tracks of YUNUS-S during Mai 8-9, 2019 cruise and location of BPR deployments. Pressure records were previously obtained in Tekirdağ Basin in 2007-2008 (Marnaut cruise of R/V L'Atalante) and Kumburgaz Basin (R/V Yunus January and November 2018 cruises). This cruise recovered instruments deployed in Nov 2018 in Çınarcık Basin and redeployed them in the Central Basin. Recovery cruise is planned in October 2019.*

2-Instrumented frame recovery and redeployment

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 5 minutes (for all sensors). 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° 976 and 1380) attached to each end of the anchoring chain for redundancy. The frame was released at the first attempt (8:24 UTC), the frame surfaced 16 minutes later 400 m from port side (ascending speed 1.3 m/s), upside down as implied by the design and was then lifted on board with the side crane.

***Figure 2**: Recovery of instrumented frame. (left) frame is lifted on board; (top right) dust accumulation on frame; (bottom right) encrusted acoustic releaser hooks*

Bottom Pressure Recorder data

The RBR BPR recorded data for the whole duration from recording start shortly before deployment to manual stop after recovery. Power switching from external to internal battery packs occurred 23/02/2019 17:16:00, about 3 months after deployment which confirms that the autonomy of the instrument is not more than 6-7 months. Clock drift was 3 seconds (slower than UTC). Data exports are available in Ruskin (RBR software) format and in txt format (Table 1).

Table 1 - Time series acquired by RBR BPR

Data export	First record	Last record	Comments
052665_20190508_1110.rsk	2018-11-13 05:03:26	2019-05-08 11:13:06	From before deployment to after recovery
052665_20190509_0547.rsk	2019-05-08 11:16:34	2019-05-09 05:46:39	On board, Clock UTC

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. It was set to record pressure every minute from 08/05/2019 07:17 to 09/05/2019 15:00 UTC. The clock of the instrument was not synchronized, and at UTC + 33 minutes ± 30 s. This offset was only noticed after the cruise. Raw pressure records, uncorrected for clock error, are available as ASCII csv and column tabulated files (2019-05-08_7_50.csv, 2019-05-08_7_50.m70, 2019-05-08_7_50.txt). While on board the ship, the RBR was set horizontally in the same position as on the frame (lettering up, horizontal flat spot) and recording (Figure 3).

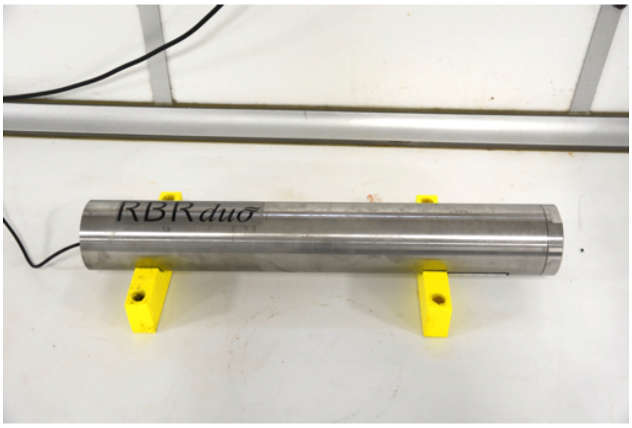

Figure 3: *RBR bottom pressure recorder in shipboard laboratory.*

Seaguard RCM

The Seaguard RCM was found stopped with a black screen, while the power switch was still on. About one month of data was recorded. Battery voltage was about 7V when the device stopped.

Table 2 – Time series acquired by SeaguardRCM

Data export	First record	Last record	Recorded sensors
YUNUS_may_19_data.txt YUNUS_may_19_data.xlsx	2018-11-13 06:05:53	2018-12-11 05:35:53	Temperature #119, DCS #146, Conductivity #788, Tide #393

Repairs and redeployment

The three feet of the frame had been damaged during the first deployment in January 2018. The feet where repaired with new nuts and bolts during this cruise (Figure 5), allowing better adjustment of the tension on the chain tying the metal frame to the concrete ballast. During the first deployment the oxygen optode plugged on the Seaguard data logger had also been damaged because of a faulty plug adapter and had been removed before re-deployment in November 2018. A new oxygen sensor was plugged to the data logger (Figure 5). Considering that the battery autonomy of the Seaguard system was much lower than expected (less than a month vs 6 months) the interval between measurements was increased from 5 minutes to 1 hour. Moreover, the noise level of the pressure record from the tide sensor with 10 s averaging appeared excessive compared to the amplitude of the signal for period <10 minutes recorded by the RBR BPR, and time averaging of the tide sensor was increased to 5 minutes. The RBR BPR was redeployed with the same settings as before (5 s sampling interval).

Figure 4*: Instrumented frame before redeployment. (left) Refit foot; (center) Oxygen sensor; (right) Assembly ready for launch*

Deployment was done without difficulty. A Seacatch releasable hook (Figure 5) fit to a lifting tackle and the warping head of a winch were used to lift the frame/ballast assembly overboard and two ropes passing through slots in the concrete slab allowed lateral stabilization. The assembly weight was then transferred to the acoustic release device attached to the main winch cable (Figure 5).

Water depth at the target deployment site is 1185±5 m according to multibeam maps while the shipboard sounder indicated 1173 m. The wire out indicator on the ship winch has only 3 digits and thus needed to be reset at 1000 m. The device was first lowered at about 1 m/s down to 1000 m and stopped. At this point, acoustic range to the acoustic device on the cable (n° 1973) was measured at 1044 m (assuming 1500 m/s sound speed) and the ship was about 0.25 NM north of target location, near the base of the slope. The ship was brought back on site before lowering the device to the seafloor at 1 m/s to 1000+100 m and then at 0.5 m/s, while interrogating acoustic device n° 1973 every 10s. Touch down occurred between 12:55 and 12:55:30 for an acoustic range of 1193 m and wire out 1155-1170 m. The device acknowledged execution at 12:56 after first release order. Effective release was verified by checking acoustic range to acoustic devices n°853 and n°394 on the frame and to n°1973 on the wire while wiring in. The location of the frame on the bottom was then determined by triangulation (Figure and Table). Two acoustic range measurements (assuming velocity 1500 m/s) were performed at each of three points 1400 m WSW, ESE and N from the releasing point. The frame location thus determined was 80 m SE of ship position at release, with an immersion of 1183 m and a theoretical wire out of 1186 m. It can be concluded again that the wire out indicator on RV Yunus has good accuracy and is consistent within 10 m with the shipboard sounder even for depths > 1000 m. The position of the device is 224 m from the target location in a N024° azimuth, on the floor of the canyon mouth at the NE corner of the Central Basin (Figure).

***Figure 5**: Deployment setup. (Left) Hoisting frame overboard on Seacatch quick-release hook; (Right) Transferring weight to the acoustic release system attached to the main cable*

3-Navigation

Location of remarkable points (Table 3) and detailed navigation maps for Day 1 (May 8, 2019) (Figure 6) and Day 2 (May 9, 2019) (Figure 7) and are given here after.

Table 3 – Remarkable points

Point	Lat	Lon	Lat	Lon	Depth	Comment
MRG BPR1	40.8703	28.5244	N 40° 52.218'	E 028° 31.464'	805 m	previous BPR location
MRG BPR2	40.7934	29.0312	N 40° 47.604'	E 029° 01.872'	1225 m	recovered BPR
Target	40.8550	28.1512	N 40° 51.300'	E 028° 09.072'	1185 m	BPR 3 target location
TRI 1	40.8685	28.1514	N 40° 52.108'	E 028° 09.082'		triangulation point
TRI 2	40.8513	28.1361	N 40° 51.078'	E 028° 08.165'		triangulation point
TRI 3	40.8490	28.1666	N 40° 50.941'	E 028° 09.994'		triangulation point
MRG BPR3	40.8568	28.1523	N 40° 51.408'	E 028° 09.138'	1184 m	relocated position

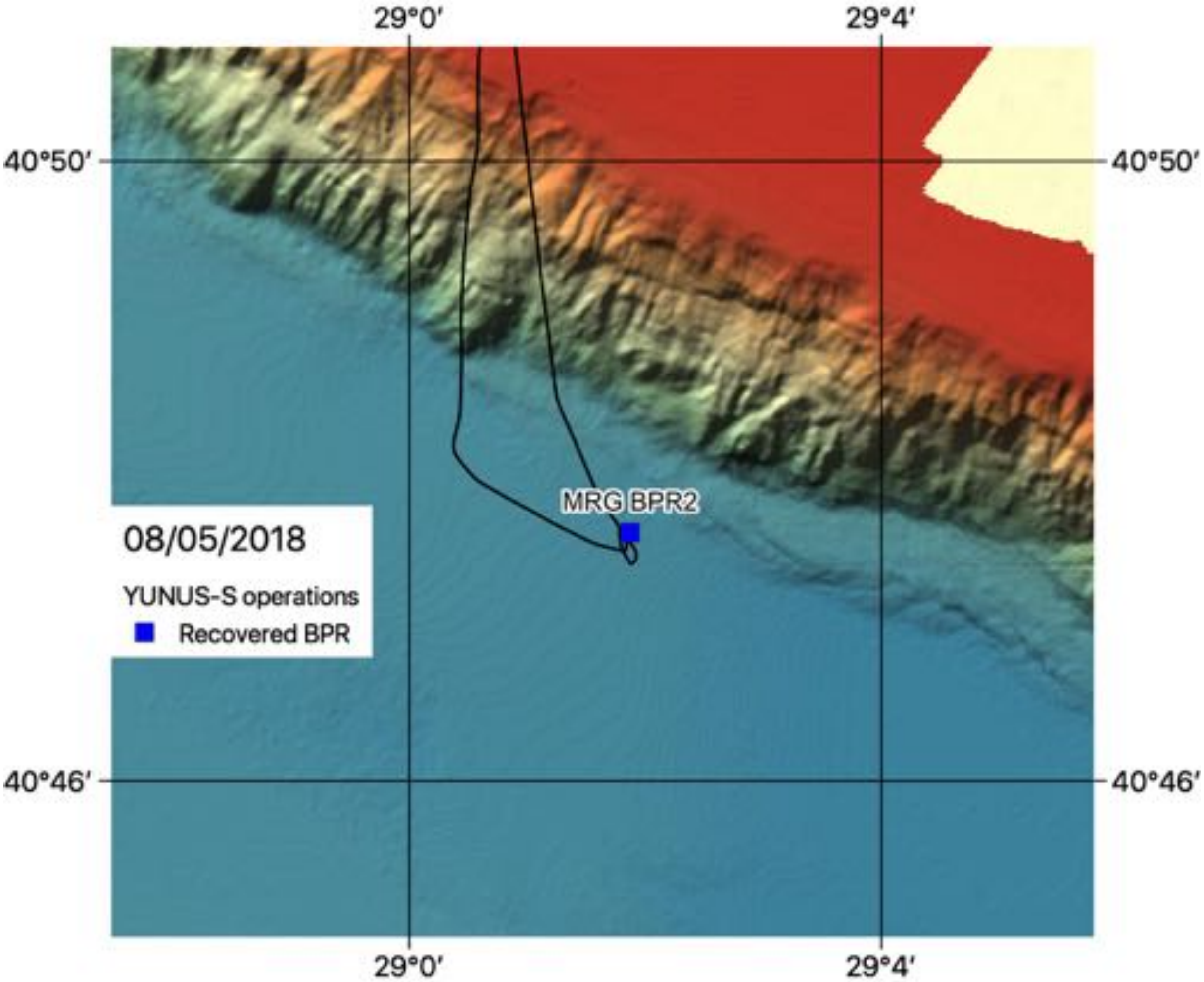

***Figure 6**: YUNUS-S Navigation map and operations on Day 1 in Çınarcık Basin.*

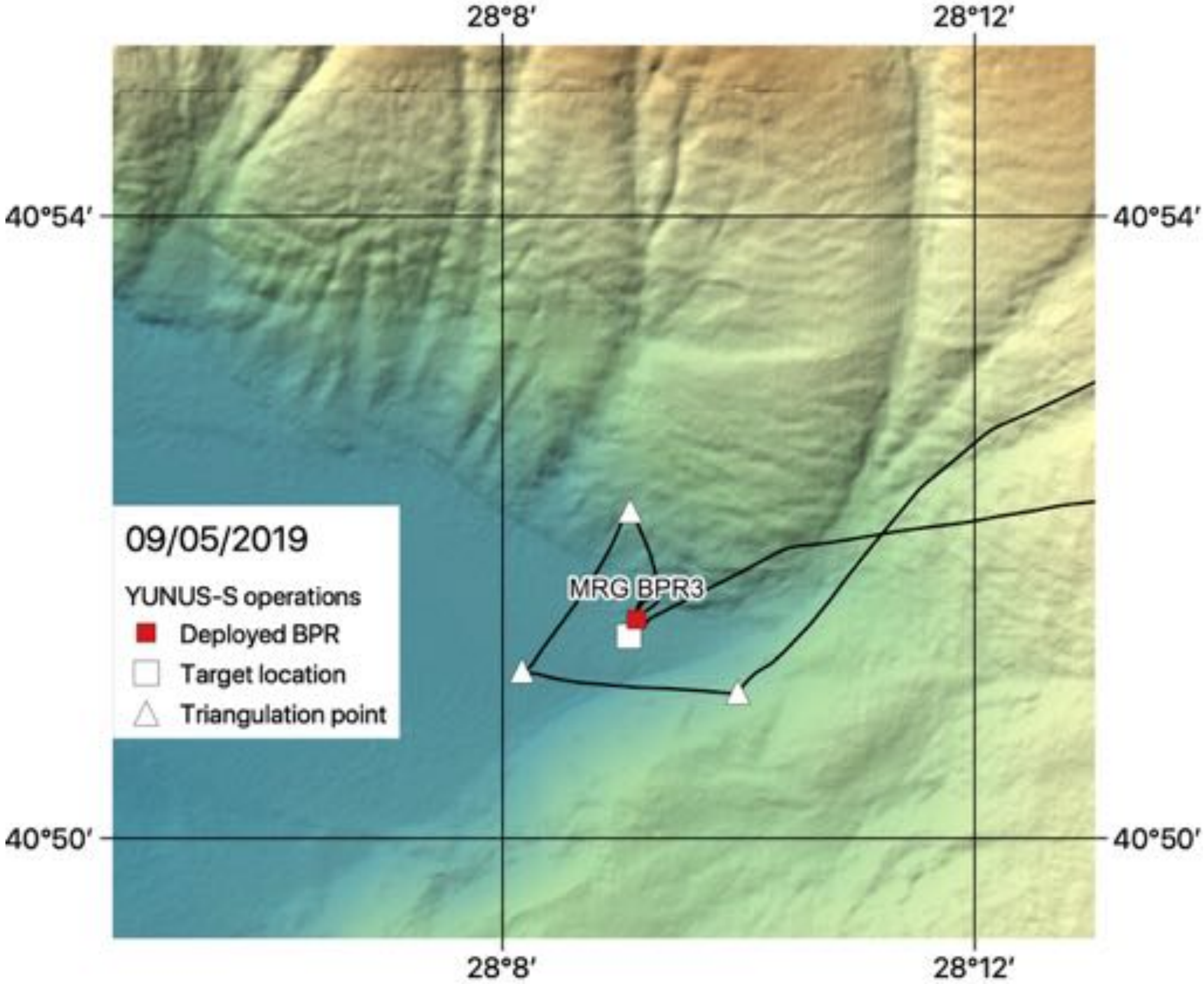

Figure 7: *YUNUS-S Navigation map and operations on Day 2 in Central Basin.*

4- Operation timeline
Wind conditions were 0-2 on Beaufort scale
Local time is UTC+3

Time (UTC)	
8/05/19	**Wednesday**, wind conditions 1-2 on Beaufort scale
6:50	In transit from Haydarpaşa port to MRG BPR2 location GPS on, logging track with OpenCPN
7:04	COG 182°, SOG 8.1 kts, ETA 08:15
7:17	Start recording atmospheric pressure with Vaisala barometer, 1 record per minute. 1015.97 mbar. Barometer clock is UTC + 33 minutes (10:50) but this was not noticed on board and clock was not synchronized
8:17	On site MRG BPR2
8:23	Checking acoustic releaser beacon n°976 range: 1247 m
8:24	Release executed
8:25	range 1160 m
8:25:40	range 1100 m
8:27:40	range 943 m -> ascending speed 1.3 m/s
8:40	At surface 400 m port side
8:45	BPR frame on board – acoustic releaser n°1380 appears to be jammed by encrustations
9:05	Transit back to Haydarpaşa port
9:14	Seaguard open. Dark screen, batteries out of power Data recorded from 13/11/2018 06:05:33 to 11/12/2018 05:35:53 Data exported to YUNUS_may_19_data.txt
10:58	Yunus-S Refueling done
11:06:30	Checking RBR data logger clock: 11:06:27 (3s slow)
11:10	Downloading data
11:13:30	Dowload completed – RBR error log check: A single battery switch from external to internal occurred 23/02/2019 17:16:00, about 3 months after deployment. This is expected
11:14	Stop recording and resync
11:16	Erase memory and restart logging
11:50	At dock in Haydarpaşa port

Time (UTC)	
09/05/19	**Thursday**, wind conditions 0-1 on Beaufort scale
5:46	In transit from Haydarpaşa port to deployment point MRG BPR3 Stop RBR recording (memory used 105.02 kB)
5:51	Download data 052665_20190509_0547, save and check file
5:52	RBR UTC sync
5:54	RBR batteries changed
5:56	Start RBR recording 09/05/2019 05:56:03 -> scheduled end 01/05/2020 08:28:10 Power source USB (external), internal power 12.53 V

6:01	External battery pack connected, RBR closed
7:34:27	Restart GPS tracking with OpenCPN Compare RBR and Seaguard pressure records Considering the insufficient battery autonomy of the Seaguard DCR and its high noise level, it is reconfigured with new parameters: 1 measurement per hour (instead of 5 minutes), tide sensor averaging 5 minutes (instead of 10 s). Oxygen optode is installed. T, DCS, CTD, O_2 and P (tide) data will be recorded
10:54	Seaguard clock synchronized
10:57	Seaguard start recording
11:00	COG: 266°, SOG: 6.85 kts, 6.32 NM from target, ETA 11:55
11:51	Frame ready for deployment, flash and Argos beacons on – photo check
12:01	On site N40°51.370' E028°09.108', water depth on map (EM300): 1182 m
12:16	Device in water, water depth ship from ship sounder: 1173 m
12:22:36	Wire out: 330 m
12:22:56	Wire out: 350 m
12:23:25	Wire out: 380 m -> v ≈ 1 m/s
12:31	Wire out: 900 m, acoustic range to releaser beacon on hook (n°1973): 958 m
12:32	WO: 1000 m stopped, wire out indicator reset. Acoustic range (AR): 1044 m Drifted 0.25 NM North of location
12:41	Moving back to position ≈ 2 knts
12:48	Back on site – AR 1040 m, start lowering to 1000+100 m
12:53	WO 1000+100 m, stopped
12:54	AR 1166 m, WO 137 m, lowering device <0.5 m/s monitoring acoustic range and wire out until touch-down
12:55:05	AR 1187 m, WO 148 m
12:55:29	AR 1193 m, WO 170 m - Touchdown
12:56:05	AR 1193 m, WO 186 m – Release executed
12:56:25	Wiring in
12:58:44	Interrogate beacons n°853 (on frame): 1193 m, n°394 (on frame): 1194 m N° 1973 (on hook): 1116 m
13:01	Check battery power and tilt (in time mode): answer = 5226 (OK)
13:19	Acoustic releaser 1973 on board. Mud on hook and cable. Triangulation point 1: 40°52.1085N, 028°09.0819E AR 1751 (1756) m
13:38	Triangulation point 2: 40°51.0783N, 028°08.1652E AR 1906 (1912) m
13:00	Triangulation point 3: 40°50.9413N, 028°09.9944E AR 1897 (1900) m Start transit to Haydarpaşa port
15:00	Stop Vaisala barometric recording and OpenCPN GPS tracking
16:30	All data saved (Vaisala, RBR, Seaguard, OpenCPN) in Yunus_2019_1 folder on local hard disk, external hard disk (XFAT partition). Time machine backup done.

5- Preliminary data assessment

Data from RBR BPR, Seaguard RCM, and Vaisala PTB were converted to matlab binary format. Explanation of variables in matlab files is given in Table 4, 5 and 6

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

The RBR Bottom Pressure Recorder provided 6 months of useable data (Figure 8). The pressure record indicates that the device landed on the seafloor 2018-11-13 08:52:56 but then subsided at a progressively decreasing rate until about 9:02, after which it may be considered stable. This subsidence is estimated to be 1.5 cm (150 Pa) from the pressure record. The instrument recorded the last point prior releasing from the seafloor at 2019-05-08 08:23:26. The recorded pressure immediately following is higher by 30 Pa indicating either a small downward motion of the sensor (3 mm) during release, or that the sensor is sensitive to acceleration. Clock drift during deployment was estimated 3s (slow), but not corrected. The amplitude or recorded pressure variations is 50 hPa (equivalent to 50 cm of water) as during the previous deployment. Tidal amplitudes are, again, 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 (±Pa). Bad P or T records occasionally occur but can be automatically detected and removed using a 3-point median filter. Some sudden pressure variations followed by oscillations are, however, real and associated with earthquakes (correlation was verified for 2 of them) (Figure 8). Setting a maximum of difference of 5 hPa between raw signal and median-filtered signal detects faulty records, a 1hPa threshold also detects earthquakes and a 0.1°C threshold may be used to clean the temperature record. Temperature appears to be increasing at 0.001°/month. A similar trend (0.0014°/month) was observed in Kumburgaz basin last year but unlike in Kumburgaz basin, transient temperature drops of > 0.01°C were not observed.

Table 5 – Variables in PTB Matlab file (2019-05-08_7_50.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)

The Vaisala PTB was not synchronized, but a clock drift of 0.186±0.001 minute per day was proven post-cruise. A correction of -33 minutes was applied to the raw data before export in matlab binary format. The relative variations of pressure recorded in the lab on board with the PTB and BPR appear consistent. However, the Digiquartz pressure gauge displays additional variations due to its sensitivity to temperature variations and to acceleration as well as to non-linear drift resulting from the sudden pressure change upon instrument recovery. However, the BPR pressure record stabilizes with respect to the PTB record after about 12 hours. BPR value is then 69 hPa above PTB at 16.75°C (Figure 9). This may be compared with the 72.5 hPa offset at 20.25°C observed before deployment in Nov. 2018. The 3.5 hPa difference between these two calibrations may either reflect temperature dependency or drift over 6 months.

Table 5 – Variables in Seagard RCM Matlab file (May_2019_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)
MemoryUsedBytes	double array	Memory Used Bytes
		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 (no averaging)
TemperatureDegC2	double array	Temperature (°C), measured

The Seaguard data logger acquired about 4 weeks of record at the seafloor while the RBR PBR was also operating. The pressure and temperature time series acquired with the various sensors are compared in Figure 10. The Digiquartz and the piezoresistive Aandera Tide sensor display different drifts during the first 3 days, but then remain with a constant offset of 112 hPa (Digiquartz values being higher) that was corrected on the plots showing relative variations. The noise level of the Tide sensor is about 50 times larger than that of the Digiquartz (±0.5 hPa vs ±0.01 hPa). The data plotted, however, where not averaged. Variations are otherwise consistent, and the longer-term stability of the Tide sensor is thus worth investigating, which is why the sampling interval and averaging window where increased for the third deployment (to 1 hour and to 5 minutes, respectively). The Seaguard data logger recorded temperature variations with 3 different sensor: a specific temperature probe, a temperature sensor on the conductivity meter and a temperature sensor on the tide sensor. The temperature probe yields very poor results with random drifts and jumps. 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 sensor provides the best record, with variations consistent with that recorded by the temperature sensor of the RBR BPR, but a static offset between the two instruments of 0.016 °C. Also, the RBR BPR is an internal sensor that has a slower response to short term seawater temperature variations and may thus average out rapid variations, as observed for instance Nov. 16.

The heading and tilt of the current meter remained constant for the recorded interval. Graphs of most environmental parameters (current speed and direction, backscatter signal strength, temperature, pressure, conductivity and derived parameters) are included in an XLSX file (YUNUS_may_19_graphs.xlsx) in annex. Salinity, density and sound velocity parameters could be better estimated by combining the conductivity of the CTD with the temperature of the Tide gauge. Variations of current directions and strength appear complex and correlate with small temperature variations.

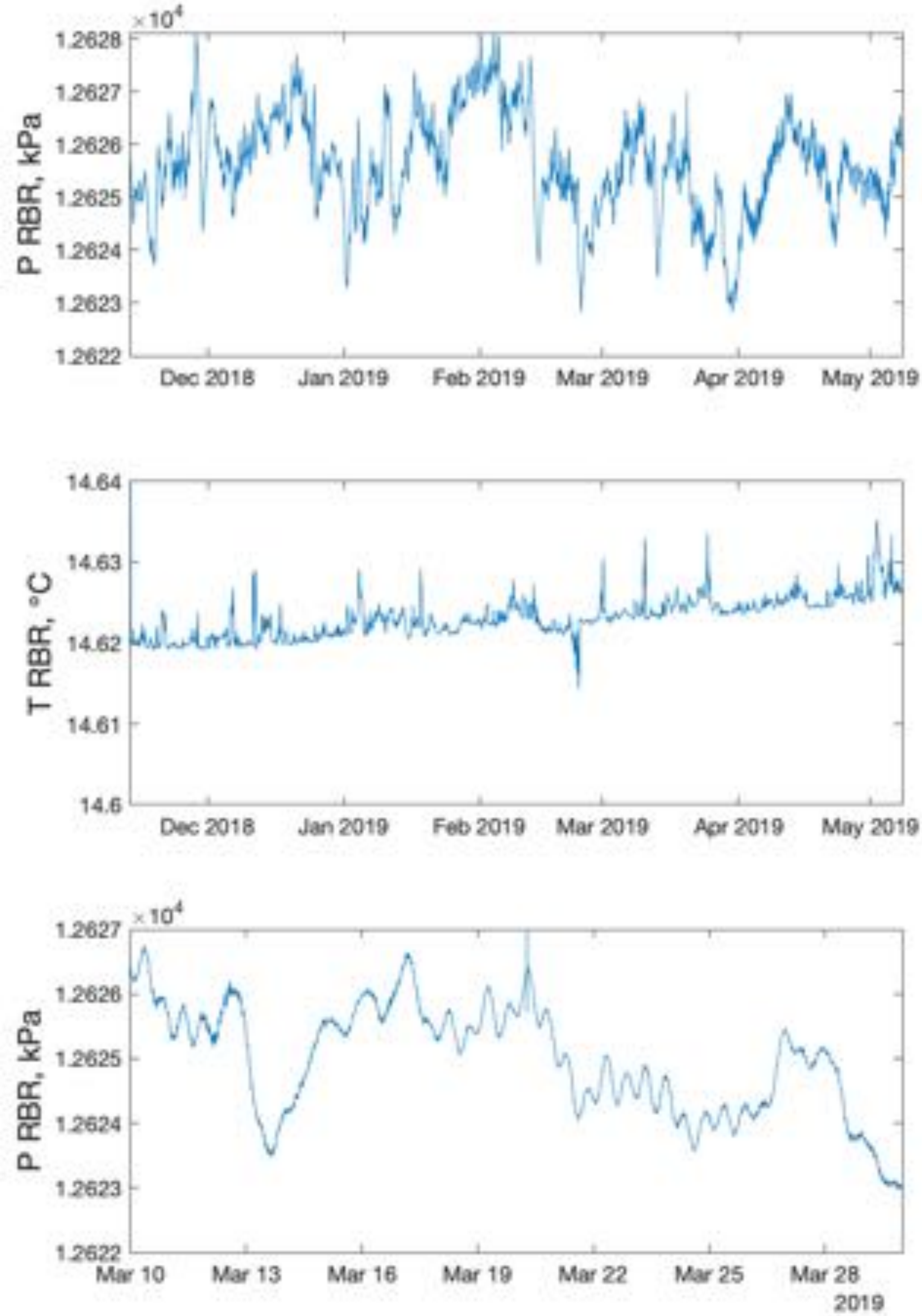

***Figure 8**: Bottom pressure and temperature records from RBR BPR. Anomalous single values were removed using a 3 point median filter (medfilt1): (top) complete usable pressure record (middle) complete usable temperature record (bottom) zoom showing weather perturbations (March 13-15, March 29-30) and tidal variations. The excursion March 20 06:35:21 likely corresponds to a M5.7 earthquake near Acipayam at 06:34:27, 370 km away.*

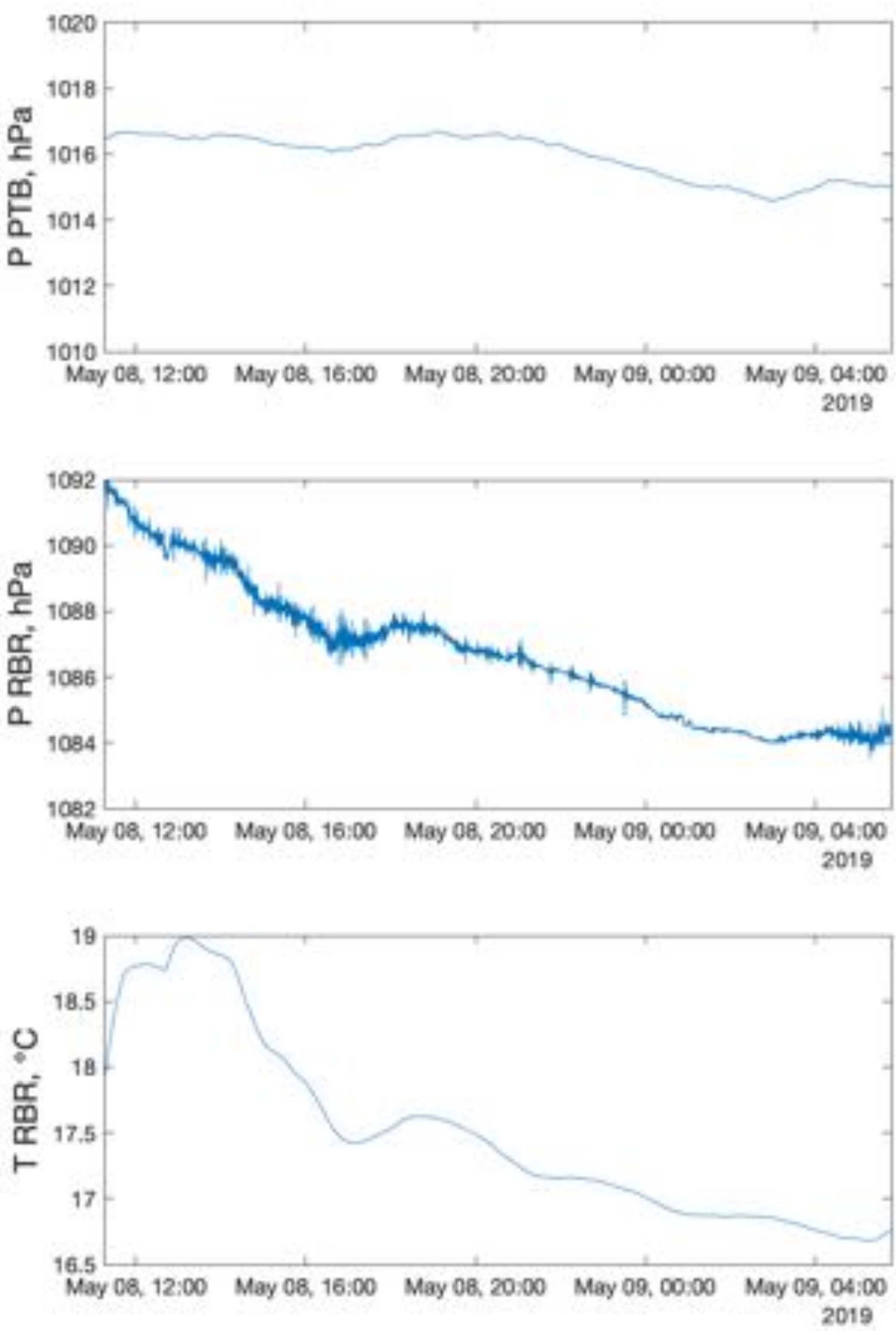

***Figure 9**: Records acquired on the ship. (top) Vaisala PTB record; (middle) RBR Digiquartz pressure record; (bottom) RBR temperature record.*

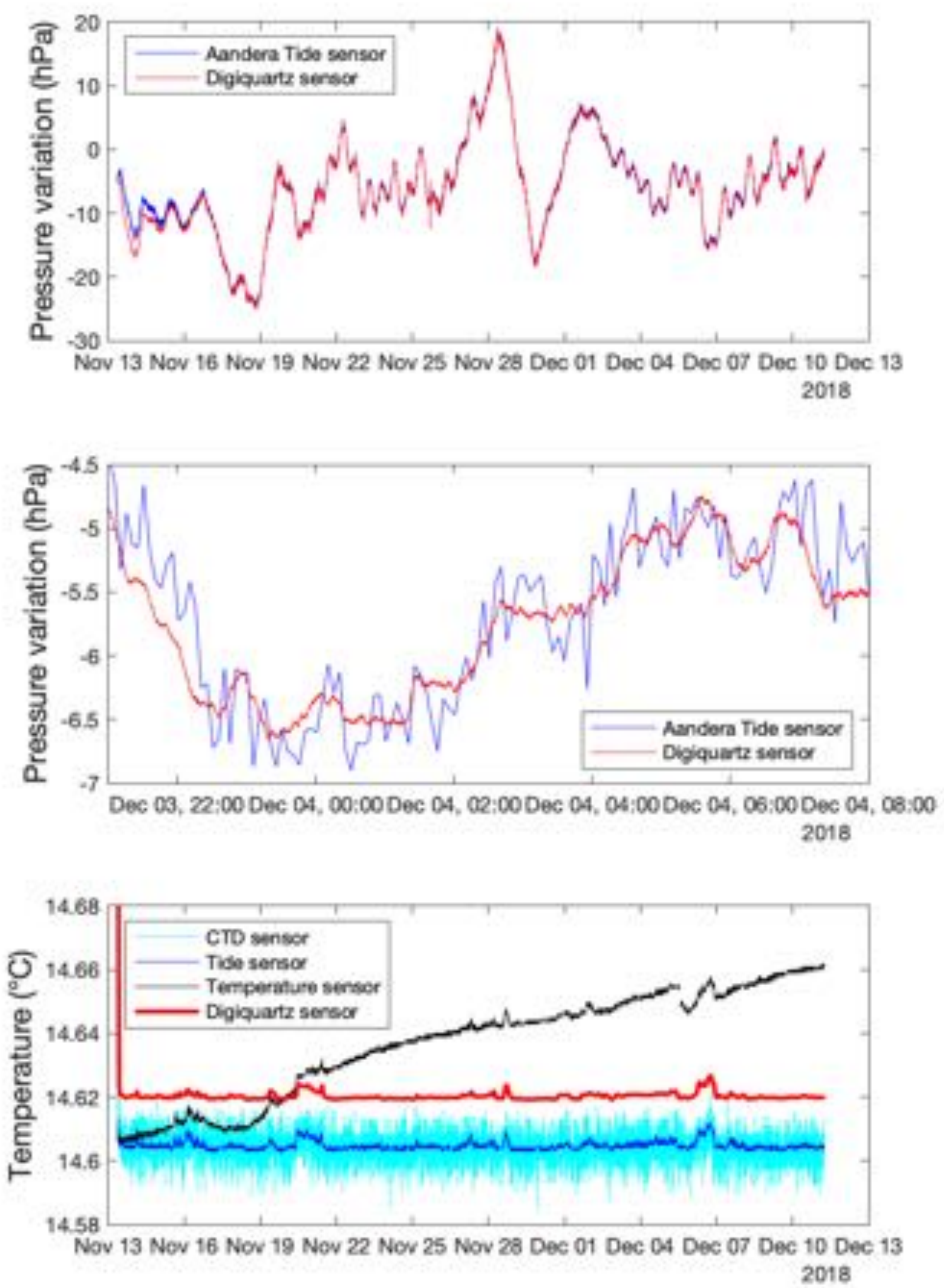

Figure 10: *Comparison of pressure and temperature records obtained at the seafloor with the various sensors fit to the Seaguard and RBR data loggers*