HIGH-FREQUENCY DATA OF ARVOR-I WMO 6903242 SOUTH OF MALTA

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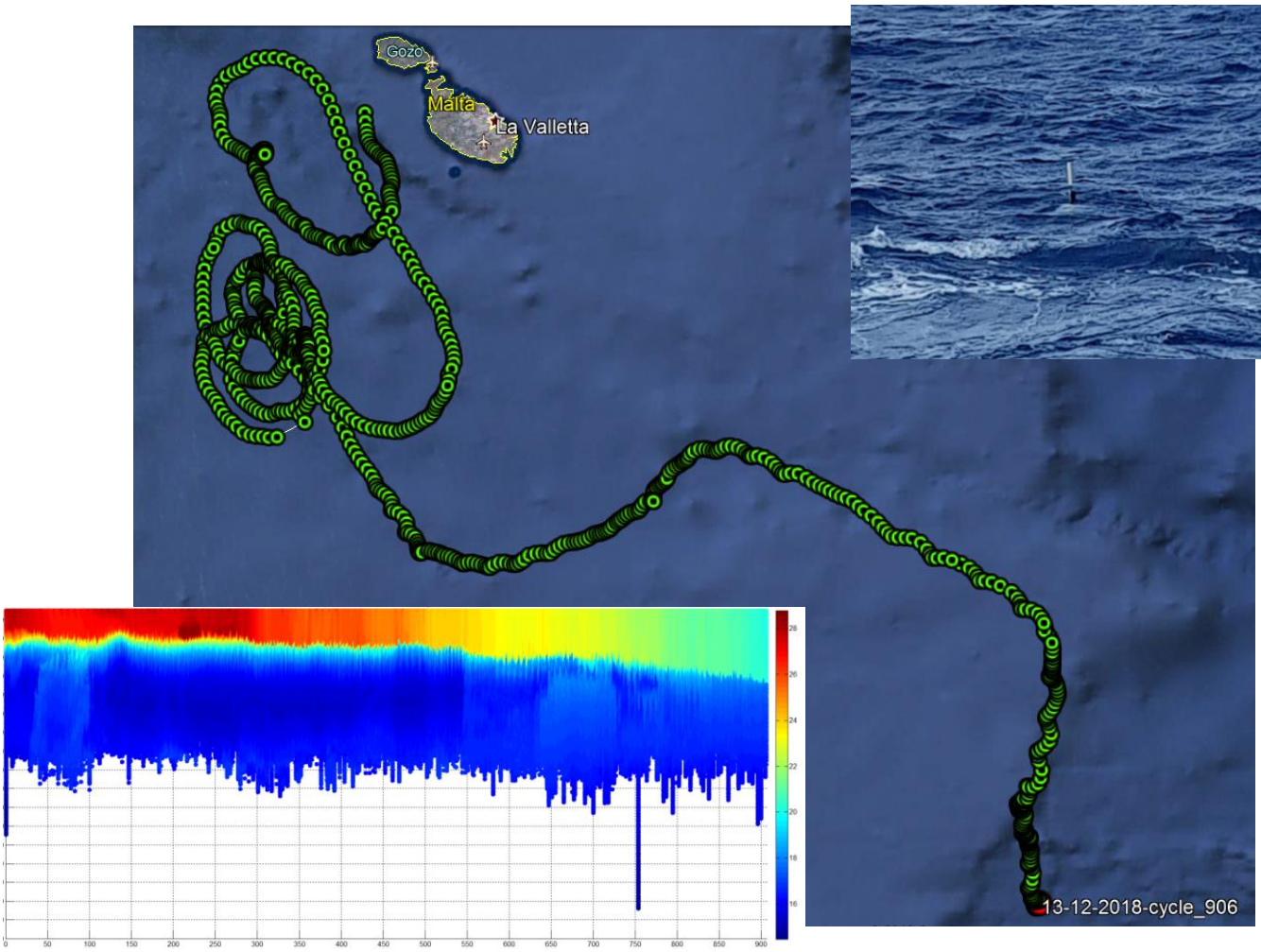

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1. Introduction

The Arvor-I floats are manufactured by NKE, and allow high resolution and continuous measurements as deep as 2000 m in the water column. They are also designed in accordance to the Argo program requirements.
Floats perform multiple cycles with predefined parking and maximal profiling depths. Data can be registered during descent, parking and ascent periods and then saved in the internal memory. When at surface, floats establish a communication with Iridium satellites for data transmission (data are reduced by means of a specific algorithm).

The Arvor-I discussed in this work was deployed far away from Western coast of Malta in August 2018. The cycling period was set at 3 hours for the entire mission duration (20 Aug. – 13 Dec. 2018) and the float performed 906 vertical profiles.

2. Float configuration

The Arvor float was programmed to perform 500 cycles (MC0, see table 1 and Appendix A for a complete list of the mission parameters) with cycling period of 3 hours (MC2); MC1 and MC3 in this case are not used (they are taken into account only if MC1 is different from MC0).
The parking (MC11) and maximum profiling depth (MC12) were set to 200 dbar. The threshold between the upper and intermediate zones (MC17) was at 100 dbar, while the separation between the intermediate and bottom zones was at 500 dbar (MC18), even though the float never reached such depth.
The vertical resolution in the upper zone was set to 1 dbar (MC19).
The grounding mode (i.e., the float behavior in case of contact with the sea bed) is controlled by the MC24 parameter, equal to zero in this case, that means a shift upward of MC25 dbar; otherwise (MC24=1) the float remains close to the bottom.

MC0	500		MC16	2000
MC1	500		MC17	100
MC2	3		MC18	500
MC3	3		MC19	1
MC4	0		MC20	1
MC5	12		MC21	5
MC6	30		MC22	60
MC7	1		MC23	0
MC8	0		MC24	0
MC9	12		MC25	100
MC10	10		MC26	30
MC11	200		MC27	0
MC12	200		MC28	2
MC13	200		MC29	0
MC14	200		MC30	30
MC15	1		MC31	5

Table 1. Arvor-I 6903242 mission parameters.

TC0	800		TC13	25
TC1	11		TC14	0
TC2	290		TC15	10
TC3	720		TC16	90
TC4	30000		TC17	2
TC5	30		TC18	10
TC6	2100		TC19	36
TC7	1		TC20	1
TC8	7		TC21	0
TC9	2		TC22	33000
TC10	36		TC23	120
TC11	200		TC24	1348
TC12	50		TC25	-74

Table 2. Arvor-I 6903242 technical parameters.

3. Arvor-I deployment, trajectory and vertical profiles

In collaboration with the University of Malta and a local military vessel the float was deployed the 20th of August about 10 nautical miles on the west side of Malta island (Figures 1 and 2).

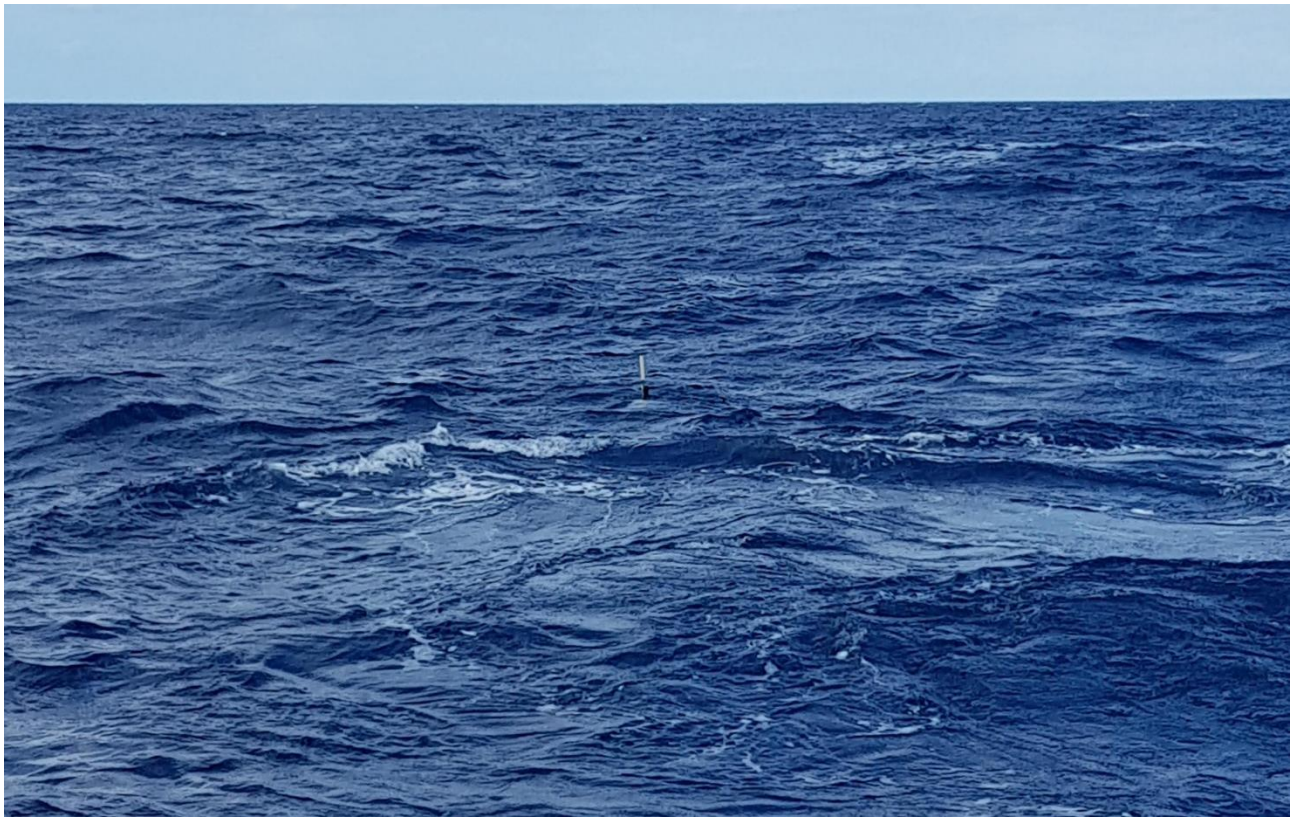

Figure 1. A picture of Arvor-I just deployed.

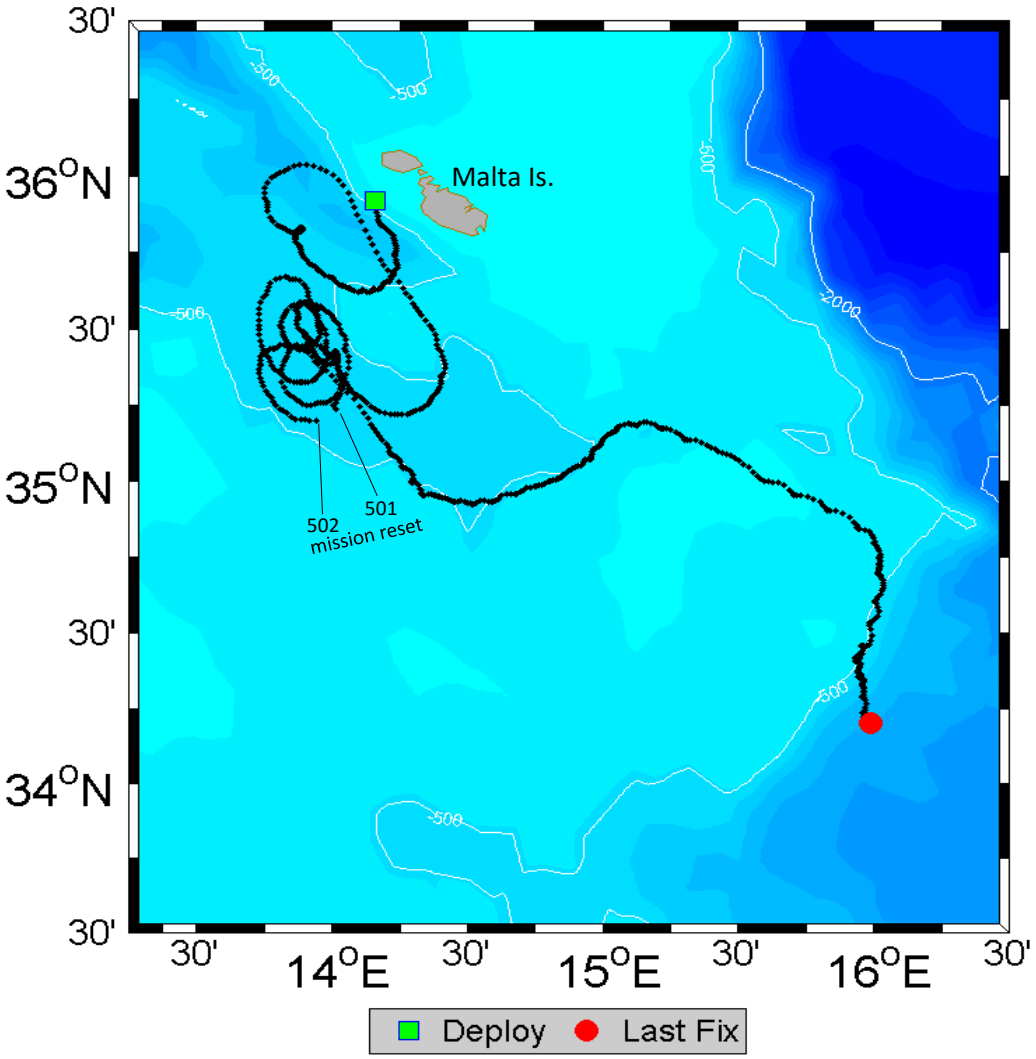

Figure 2. Deployment point, trajectory and last transmission position as of 13 December 2018.
The bathymetry interpolation is based on the ETOPO1 database (Amante, C. and B.W. Eakins, 2009).

The float trajectory (Figure 2) follows clockwise rotations for the first 550 cycles (till the end of October), then the float moved towards South-East.

After the cycle 500 a mission resume command was sent in order the float can continue its mission. The battery was quite good (about 10.1 V).

The float ran away towards East South-East until the battery was too low to work; the last communication occurred on 13 December, after 906 cycles.

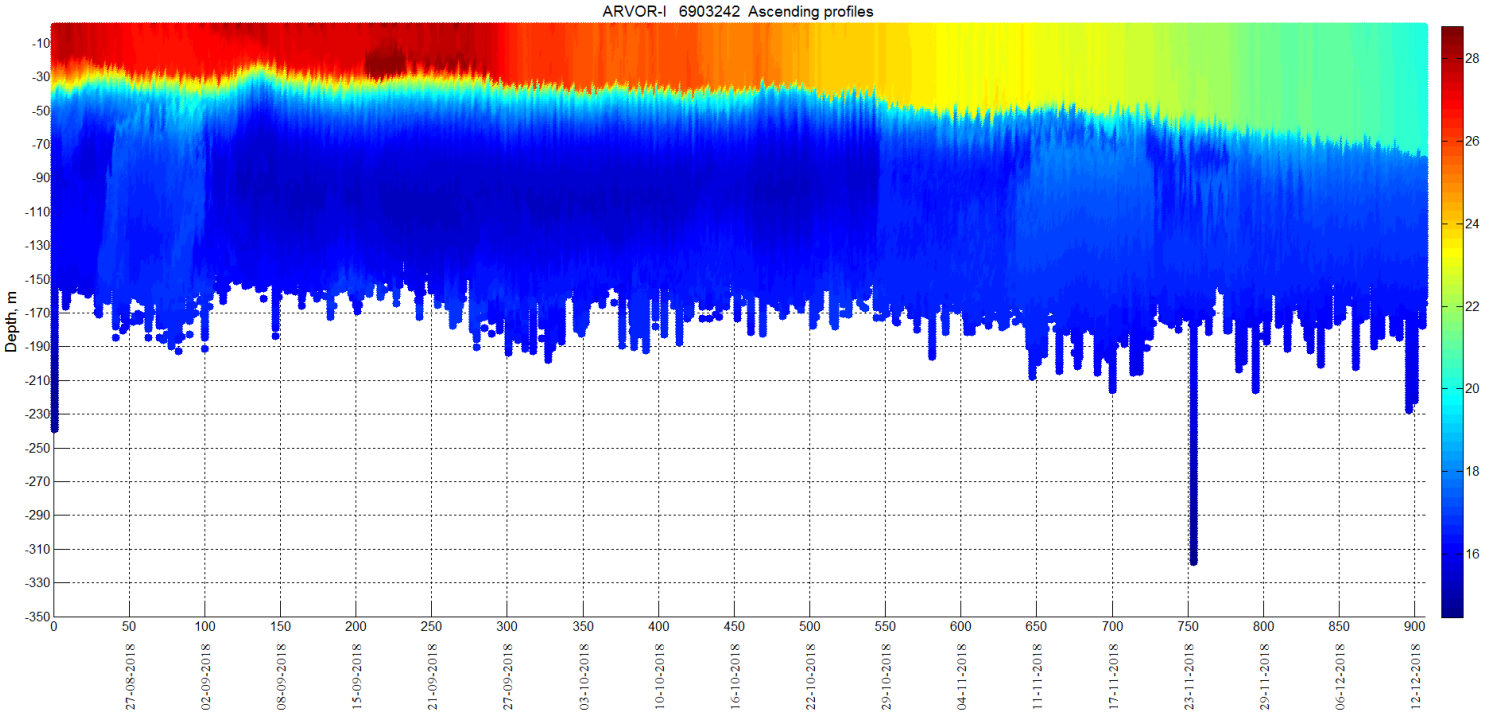

Figure 3. Potential temperature (°C) vertical profiles.

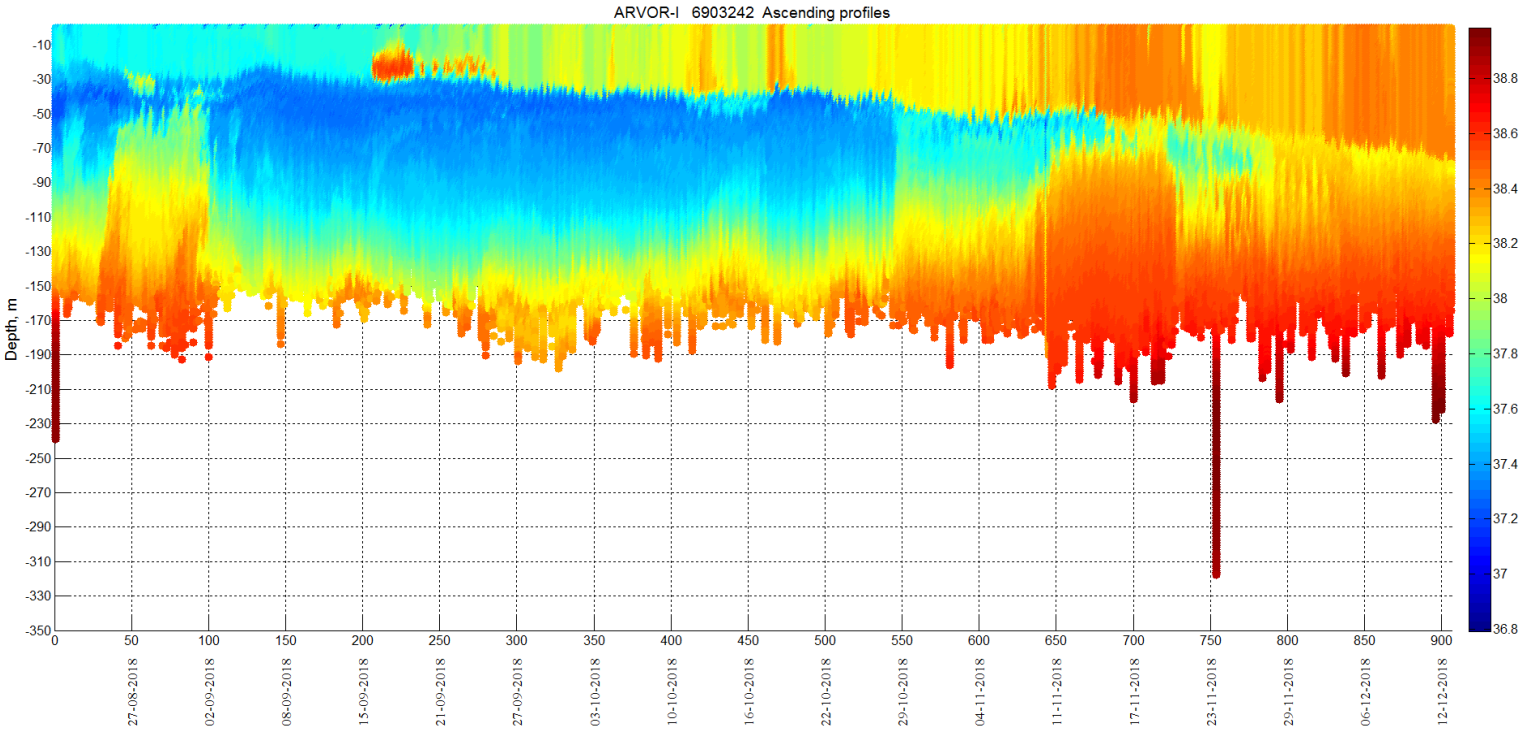

Figure 4. Salinity (practical scale unit) vertical profiles.

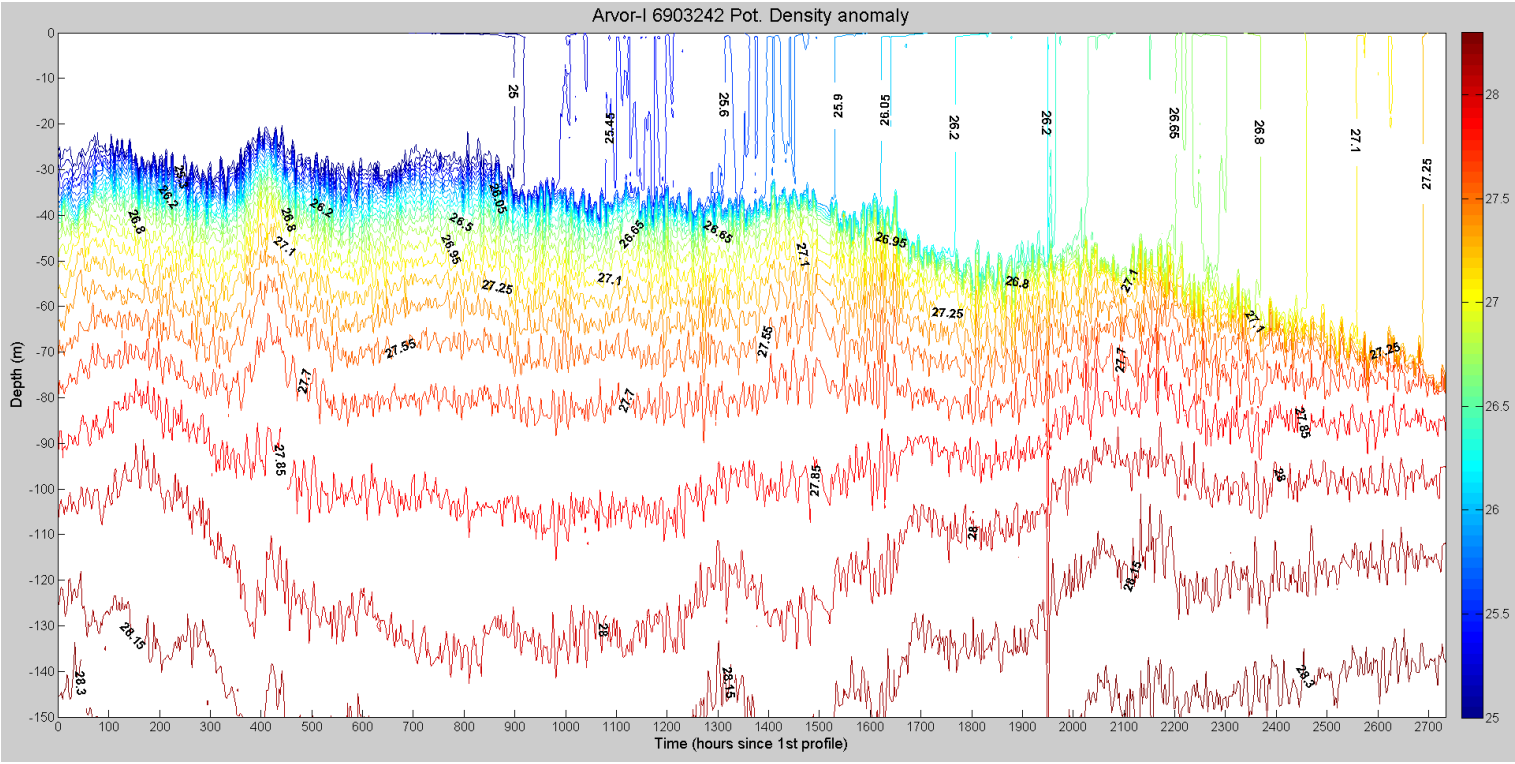

Figure 5. Vertical and temporal potential density anomaly (kg m^{-3}) interpolation.

Figures 3 and 4 show the potential temperature and salinity scatter plots versus depth (cycle numbers are on x-axis); measurements were very continuous in space all over the entire mission. No grounding was detected being the cycling period of 3 hours and the bathymetry around 500 m.
The thermocline was detected at 30-40 m in August, September and October, then the float moved away in a different area (especially after cycle 600) showing different thermohaline properties.
A relative deep profile was performed at cycle 754 (24-Nov-2018) with a depth around 325 dbar, in accordance with an averaged descending speed of 0.057 dbar/sec, twice the expected velocity.
The averaged maximum profile depth was around 170 m, sometimes exceeding the value of MC12 but still in accordance with accuracy in TC12 (see technical parameters in Table 2).

The potential density anomaly computation is represented in Figure 5. The anomalous signal in the right part of the panel is due to low detected salinity, probably unrealistic.

Figures 6 to 11 describe the behavior of the main operational parameters during the 906 mission cycles. The internal vacuum (Figure 6) was around optimal values; the battery voltage started to decrease around cycle 800 and then drastically dropped down to a minimal value of 5.2 V.

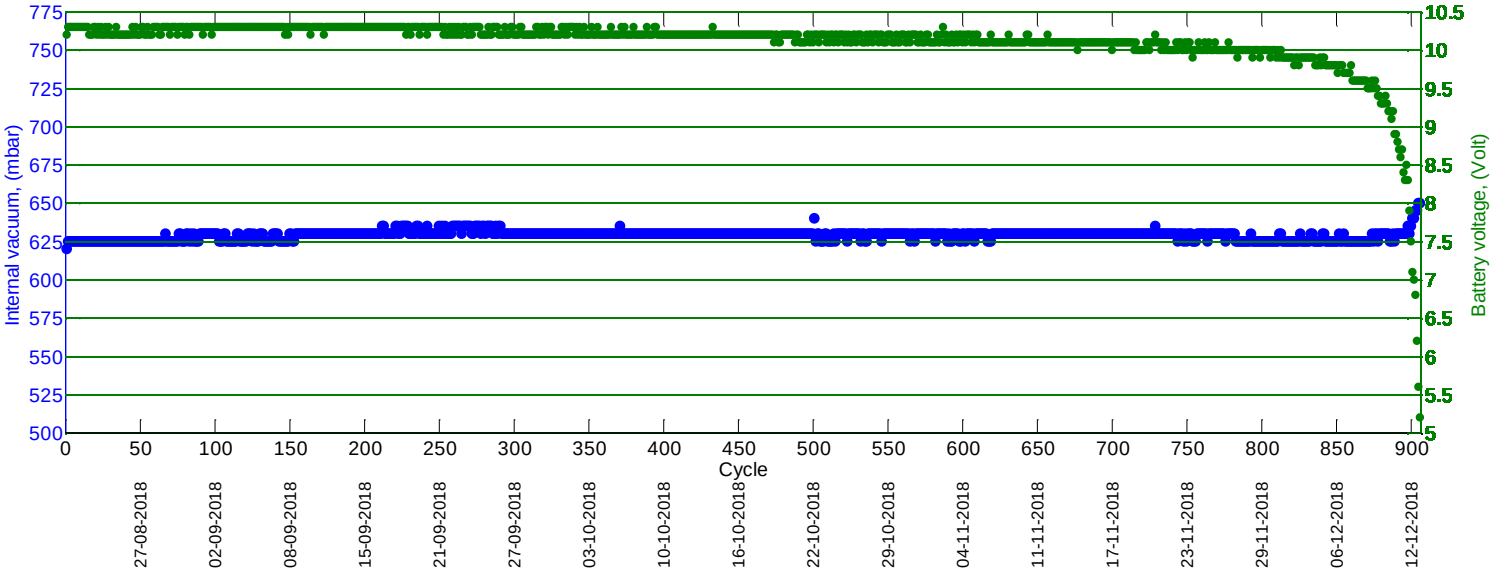

Figure 6. Internal vacuum and battery voltage.

The oil pump and the electrovalve actions during the descent to parking depth (in this phase the bladder gradually deflates) are represented in Figure 7.
The maximum depth of profile and the parking depth are equal in this mission.

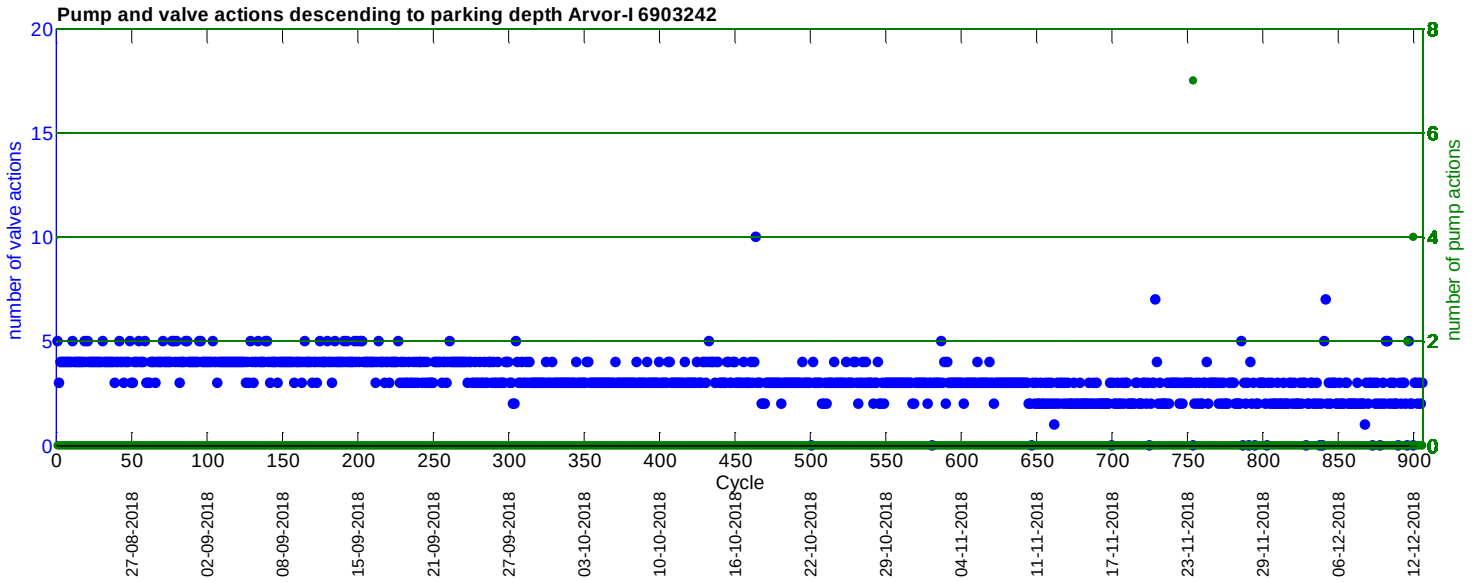

Figure 7. Number of electrovalve and oil pump actions during the descent towards parking depth.

The Iridium time sessions (Figure 8) registered quite regular durations between 80 and 120 seconds and also the number of pump actions was within the typical range of 5-7.

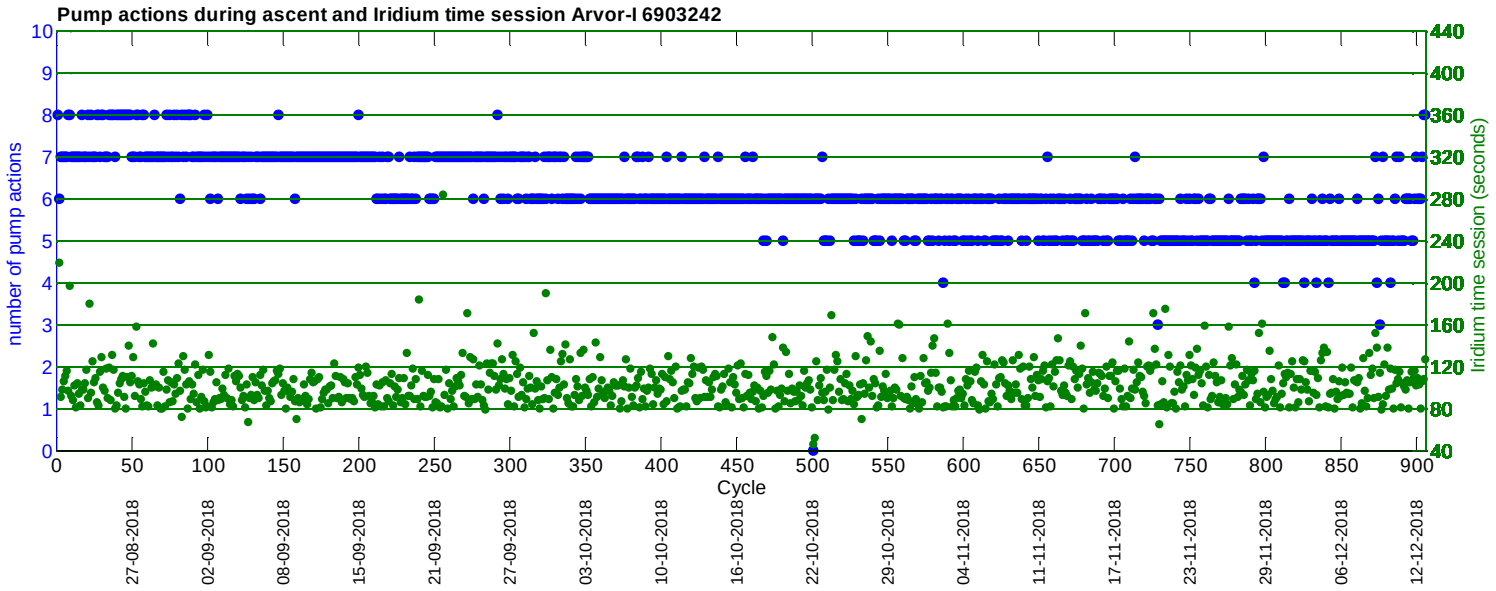

Figure 8. Number of electrovalve actions during the descent from parking to maximum profile depth. In green the Iridium time session.

The time required by the float to reach the profiling maximal depth as well as the ascent duration are shown in Figure 9. The time required to ascent and descent is approximately constant, and the float needs more time to descent (about 90-100 minutes) than to ascent (about 50 minutes). The float seems to descent faster after cycle 700.

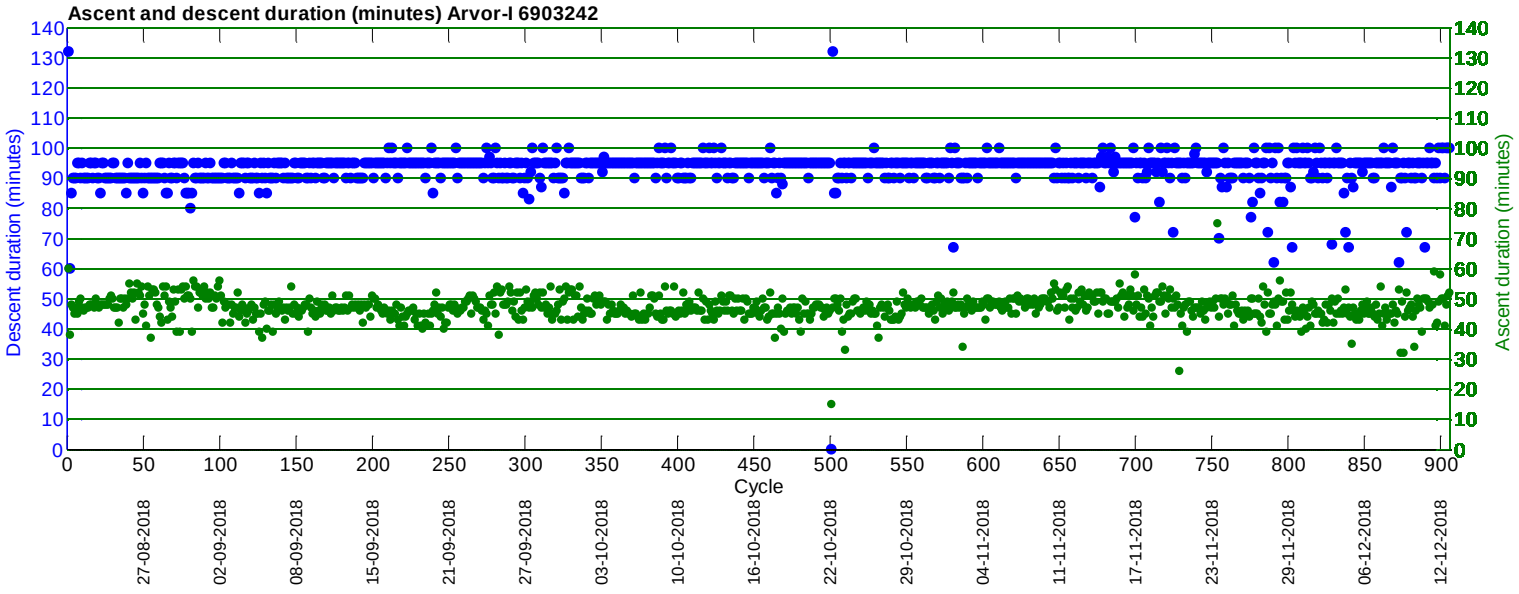

Figure 9. Descent to maximum profile depth and ascent durations.

The first stabilization pressure and the relative time, computed as minutes since cycle beginning, are reported in Figure 10. Small irregularities can be observed after cycle 500, basically after the mission restart.

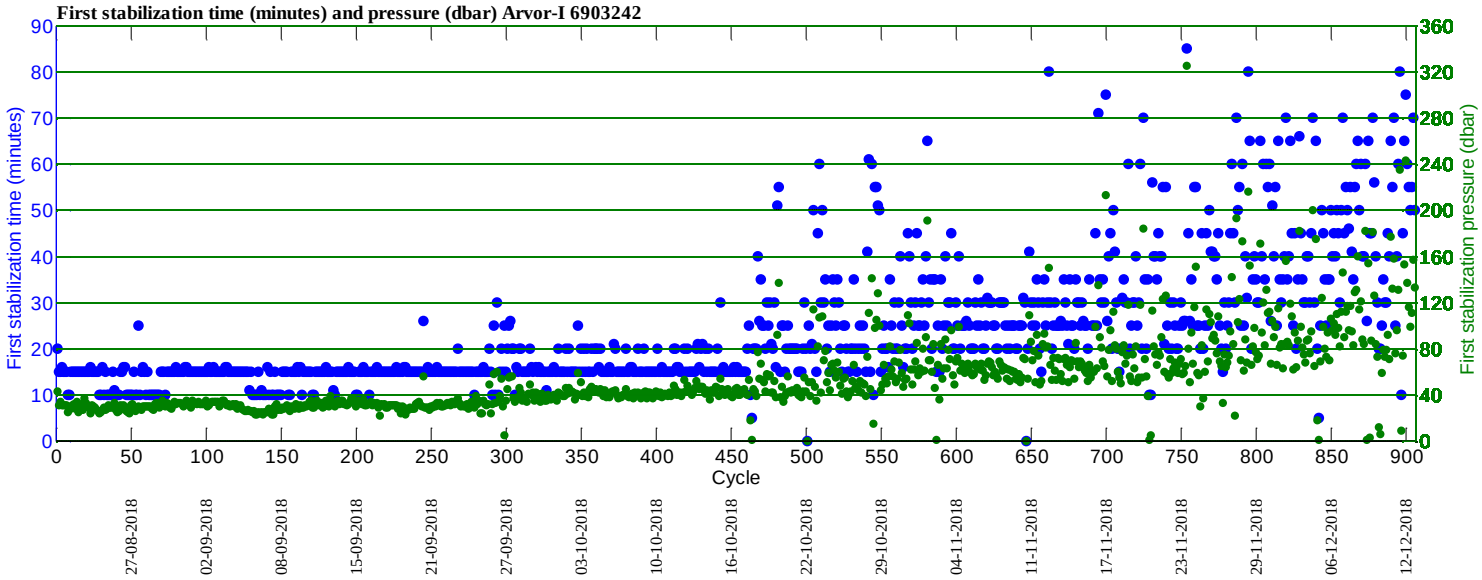

Figure 10. First stabilization time, as minutes since cycle beginning, and pressure.

The maximal parking and profile depth are shown in Figure 11. The two parameters are overlapped because they are configured with the same value.

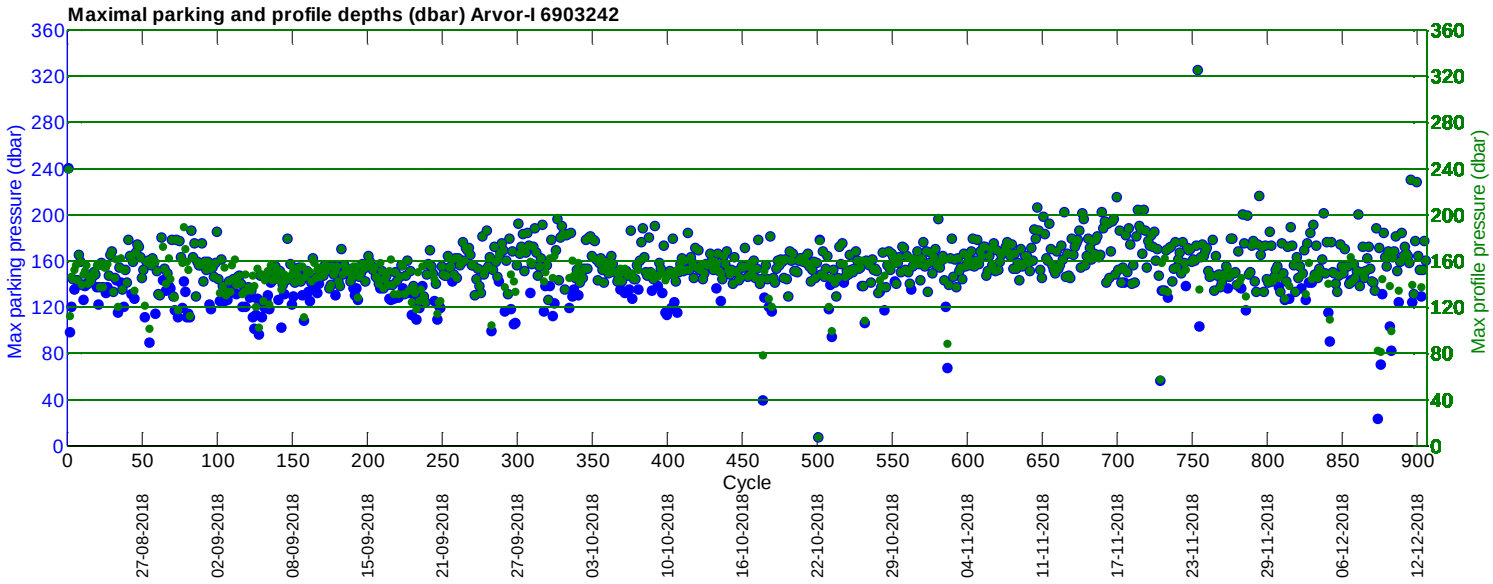

Figure 11. Parking and maximum profile depth.

4. Conclusions

In the framework of the Argo program, an Arvor-I float was successfully released off the western coast of Malta island in August 2018. The float carried out 906 cycles from the deployment date (the 20th of August) until the 13th of December providing high frequency (every 3 hours) vertical profiles of temperature and salinity, with a maximal depth of about 180-200 m.
The cycling period was perfectly regular and a restart mission was carried out once the float reached cycle number 500, the standard Argo value.
The float ended its mission because of the battery voltage, dropped down to 5.2 volts.

5. References

Amante, C. and B.W. Eakins, 2009. ETOPO1 1 Arc-Minute Global Relief Model: Procedures, Data Sources and Analysis. NOAA Technical Memorandum NESDIS NGDC-24. National Geophysical Data Center, NOAA. doi:10.7289/V5C8276M. Web: https://www.ngdc.noaa.gov/mgg/global/global.html

Arvor-I user manual, 2018. DOC33-16-033 rev.9.

6. Acknowledgments

The authors would like to thank Adam Gauci and Aldo Drago from University of Malta for their support and collaboration with the deployment activities.

APPENDIX A

A summary of the available mission and technical commands are shown in Tables A1, A2.

Command no.	Name	Default Value	Units	Min Value (*)	Max value (*)
MC0	Total number of cycles	300	Whole number	0 (**)	999
MC1	Number of cycles with cycle period 1	300		0	999
MC2	Cycle period 1	240	Hours	1	480
MC3	Cycle period 2	240	Hours	1	480
MC4	Reference day	2	Number of days	0	40
MC5	Expected time at the surface	6	Hours	0	23
MC6	Delay before mission	0	Minutes	0	1440
MC7	CTD sensor acquisition mode	1		1	4
MC8	Descent sampling period	0	Seconds	0 (***)	600
MC9	Drift sampling period	12	Hours	0	240
MC10	Ascent sampling period	10	Seconds	8	600
MC11	Drift depth for "MC1" first cycles	1000	dBar	0	2020
MC12	Profile depth for "MC1" first cycles	2000	dBar	0	2020
MC13	Drift depth after "MC1" cycles are done	1000	dBar	0	2020
MC14	Profile depth after "MC1" cycles are done	2000	dBar	0	2020
MC15	Alternated profile period	1		1	20
MC16	Profile pressure of alternated profile	2000	dBar	0	2020
MC17	Threshold surface/Intermediate Pressure	10	dBar	0	2000
MC18	Threshold Intermediate /Bottom Pressure	200	dBar	0	2000
MC19	Thickness of the surface slices	1	dBar	1	1000
MC20	Thickness of the intermediate slices	10	dBar	1	1000
MC21	Thickness of the bottom slices	25	dBar	1	1000
MC22	Iridium End of Life transmission period	60	Minutes	2	7200
MC23	2nd iridium session wait period	0	Minutes	0	360
MC24	Grounding mode (0: shift, 1: stay grounded)	0		0	1
MC25	Grounding switch pressure	50	dBar	10	200
MC26	Delay after grounding at surface	10	Minutes	0	2400
MC27	Optode type (0: none, 1: 4330, 2: 3830)	0		0	2
MC28	CTD sensor Cut-Off pressure (Pump stop)	5	dBar	2	60
MC29	"In Air" acquisition cycle periodicity	0		0	250
MC30	"In Air" acquisition sampling period	30	Seconds	10	300
MC31	"In Air" acquisition total duration	5	Minutes	0	3600

Table A1. Arvor-I mission commands, taken from Arvor-I user manual.

TC 0 Max valve activation on surface (cs)
TC 1 Max volume of valve action during descent and repositioning (cm^3)
TC 2 Max pump duration during repositioning (10 cs)
TC 3 Max pump duration during ascent (10 cs)
TC 4 Nominal pump duration during buoyancy acquisition (1000 cs)
TC 5 Pressure target tolerance for stabilization (+/- 1 dbar)
TC 6 Max pressure before emergency ascent (1 dbar)
TC 7 1^{st} threshold for buoyancy reduction (1 dbar)
TC 8 2nd threshold for buoyancy reduction (1 dbar)
TC 9 Number of out of tolerance pressures before repositioning
TC 10 Max volume before grounding detection (cm3)
TC 11 Min pressure for «shift» grounding mode (1 dbar)
TC 12 Pressure target tolerance during subsurface drifting (+/- 1 dbar)
TC 13 Average descent speed (1 mm/s)
TC 14 Parking pressure increment between cycles (1 dbar)
TC 15 Ascent End pressure (1 dBar)
TC 16 Average ascent speed (1 mm/sec)
TC 17 Pressure check time period during ascent (1 min)
TC 18 Vertical threshold for buoyancy action during ascent (1 dBar)
TC 19 GPS timeout (1 min)
TC 20 Hydraulic message transmission, 0: no 1: yes
TC 21 Delay before reset offset (1 min)
TC 22 Pump duration for surfacing with “In Air” acquisition (1000 cs)
TC 23 Iridium timeout (1 min)
TC 24 Internal pressure calibration coef A (*0,001)
TC 25 Internal pressure calibration coef B (*-1)

Table A2. Arvor-I technical commands, taken from Arvor-I user manual.