Istituto Nazionale di Oceanografia e di Geofisica Sperimentale

Assessment of APEX float tests in the Catalan Sea

by

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Approved for release by: ……………………………………

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1 Introduction

This work is part of Work Package 4 (Subtask 4240: Assessment of filed test results and hardware/software modifications) of the MFSTEP (Mediterranean Forecasting System Toward Environmental Prediction) project sponsored by the European V Framework Program Energy, Environment and Sustainable Development.

In the framework of this Work Package (also called MEDARGO), profiling floats will be deployed throughout the Mediterranean starting in late summer 2004 to provide temperature and salinity profile (T/S) data in near-real time to forecasting models of the Mediterranean. In order to assess the functionality of the floats and define their sampling characteristics, four units were operated in the Catalan Sea in fall 2003. The float data in the Catalan Sea are briefly described and interpreted, with particular focus on the thermohaline structures and the vertical shear of the currents. The functioning of the floats (only of APEX type) is assessed in this report with particular emphasis on their cycling and sampling characteristics and about the data telemetry.

2 The profiling float systems

Two types of profiling floats were operated, one called APEX (manufactured by Webb Research Corporation, USA) and the other one PROVOR (produced by Martec, France). The APEX is the successor of the ALACE (Davis et al., 1992) whereas the PROVOR is based on the MARVOR technology (Loaec et al., 1998; 1999). Two units of each type were acquired. All floats were equipped with Sea-Bird CTD sensors (model 41 pumped MicroCAT). They were programmed in the "Park and Profile" configuration with a neutral parking depth of 350 dbar (near the salinity maximum of the Levantine Intermediate Water - LIW) and a maximum profiling depth of 700 dbar. Details about the cycle timing and sampling are listed in Table 1. When at surface, the floats are located by, and transmit data, to the Argos system onboard polar orbiting satellites. The data are processed and archived in near-real time at the CORIOLIS Data Center (Brest, France; Loaec et al., 1999) and are disseminated on the GTS following the standards of the international ARGO program.

3 General results in the Catalan Sea

The details of the float operations in the Catalan Sea are available in Font et al. (2004). A summary of the operations and the most salient results are as follows.

The two APEX floats were deployed in the Catalan Sea on 26 September 2003. A week later, on 2-3 October 2003, the two PROVOR floats were deployed with the R/V Garcia del Cid in the vicinity of the APEX floats. CTD casts (from the ship) were made close to the float profiles. All floats were operated in "Park and Profile" mode until 7 November 2003 providing a total of 33 ascending T/S profiles. Thereafter, the floats remained at surface until they were recovered.

The floats were deployed in an area where the prevailing slope currents are generally southwestward (Northern Current; Font et al., 1988). After showing some indication of subsurface flow towards the northeast after deployment, all the floats were trapped in the Northern Current and moved to the southwest (Figure 1). Speeds at the 350 dbar level vary between 1 and 6 cm/s. Displacements during the time spent at surface can be of the same order of magnitude as the deep displacements especially for float 35503. They show no preferential direction due to the large variability of the surface currents at meso and inertial scales. In some cases, the surface and intermediate displacements are in opposite directions, revealing a significant shear between the two levels.

The T/S profiles obtained by the floats (Figures 2 and 3) are typical for the region, with a marked salinity maximum in the LIW at about 400 m on the 29.08 isopycnal. The structure in the upper layer is highly variable and the depth of the seasonal thermocline varies between 30 and 70 m.

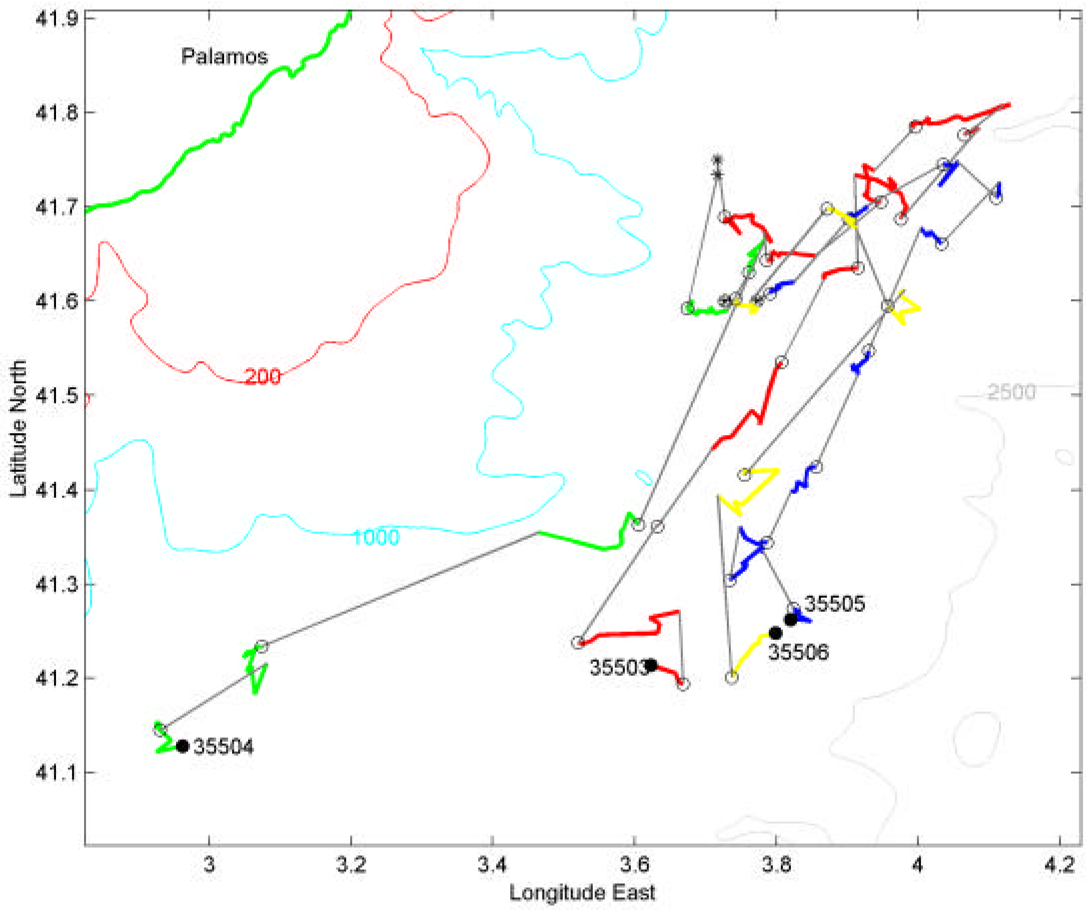

Figure 1. Float trajectories in the Catalan Sea. Thin straight (heavy curvy) segments denote the subsurface (surface) float displacements. Star and solid circles represent the deployment and last profile locations, respectively. Open circles represent the locations of the T/S profiles. The 200,1000 and 2500 m isobaths are shown.

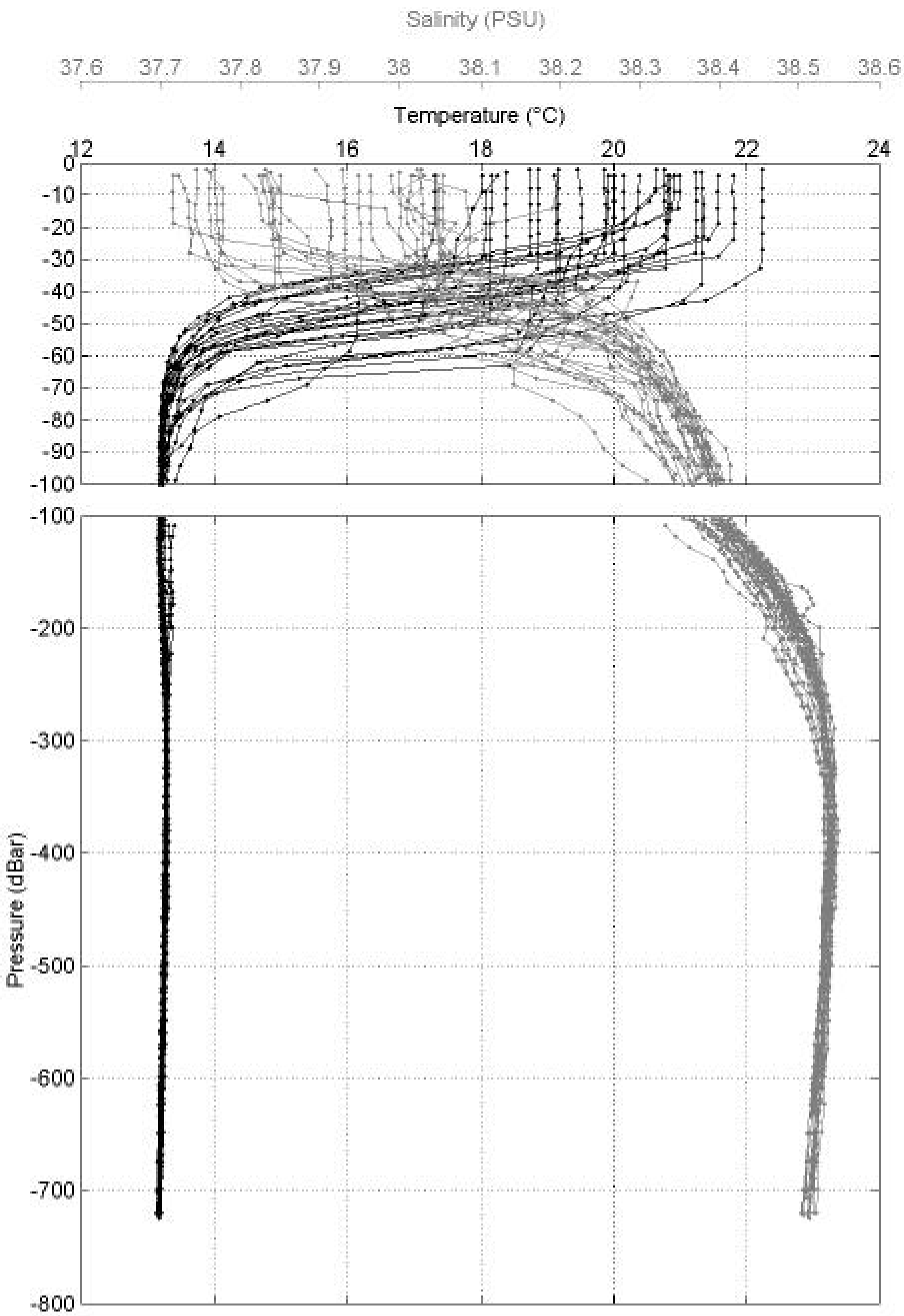

Figure 2. Temperature (black) and salinity (gray) profiles provided by all the floats between 3 October and 7 November 2003.

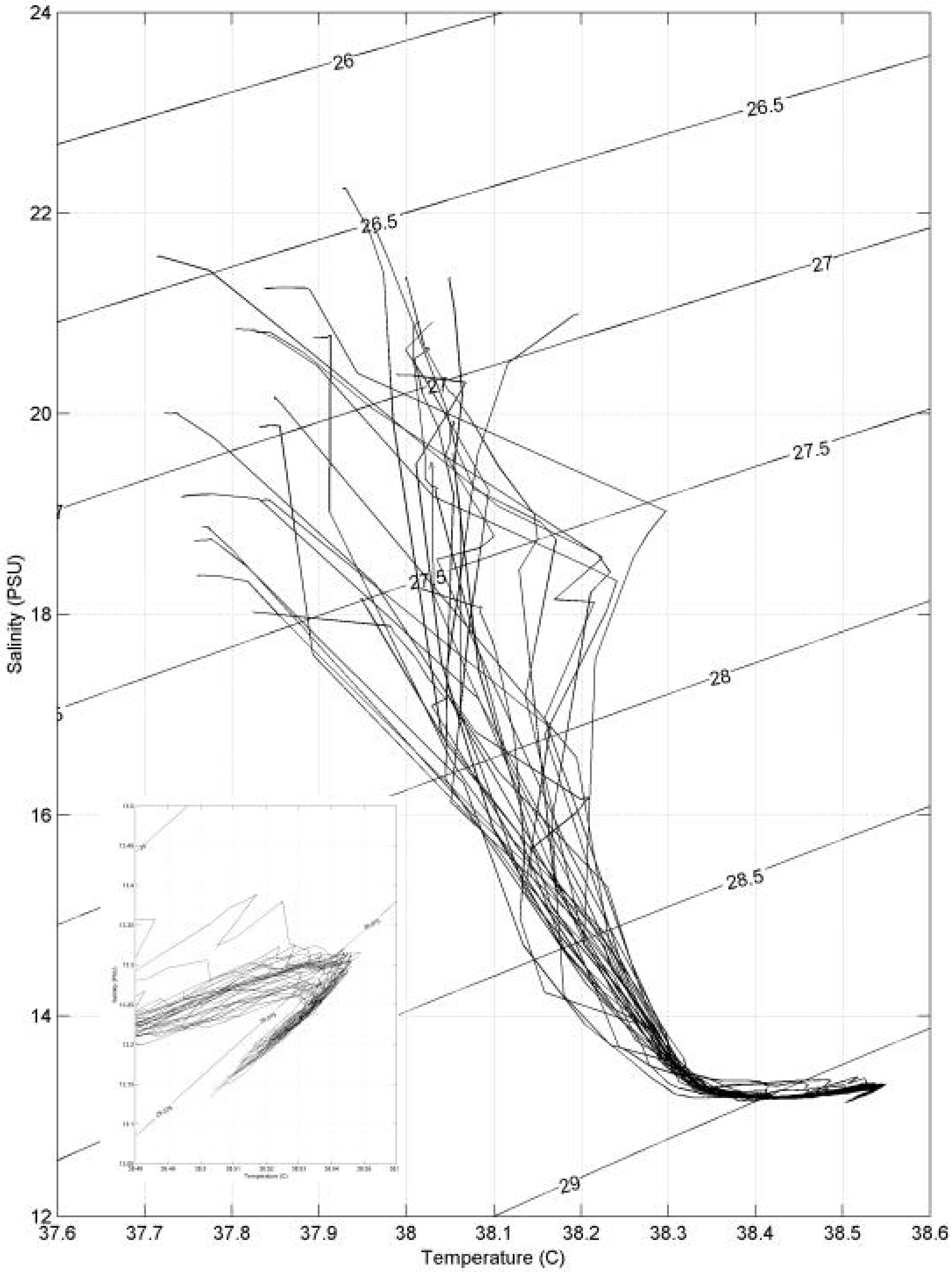

Figure 3. Temperature-salinity diagram of all the float data between 3 October and 7 November 2003. The maximum salinity of the LIW is clearly seen on the 29.08 isopycnal.

4 Assessment of the APEX float results

4.1 Cycling and data telemetry

The main float characteristics are summarized in Table 1. A schematic representation of the APEX float cycle (depth versus time) is shown in Figure 4. Some times and durations are defined: *Tstart* is the start time of the first cycle (known); *down times* and *up times* are parameters programmed in the float software; *Te* is the time interval between the first transmission of the float at surface and one of the Argos fix (obtained from the float data); Argos fixes are denoted by the letters F_1, F_2,…F_n. Some of them have Argos positions.

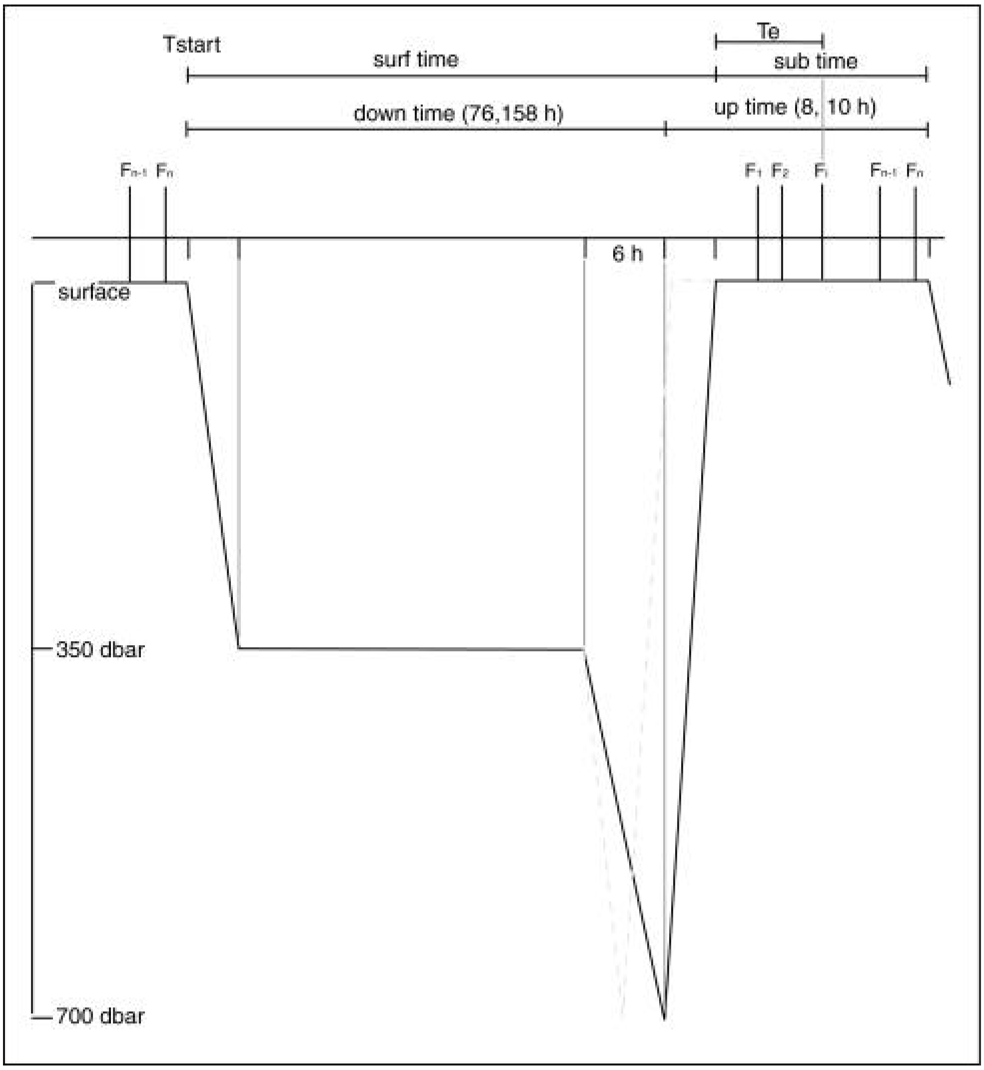

Figure 4. Schematic diagram of the APEX float cycle (see text for symbol explanations).

Float Type	WMO Number	Argos PTT Number	Cycle Length (days)	Cycle Start (GMT hours)	Down time (hours)	Up time (hours)	Sampling levels (dbar)
APEX	6900226	35503	3.5	16:02/ 04:02	76	8	60 pts (4,10,15 …200,225…675,700)
APEX	6900227	35504	7	16:00	158	10	80 pts (4,10,15 …100, 110…690,700)

Table 1. Float cycling and sampling characteristics.

Given the main characteristics of the APEX floats listed in Table 1, it is important to examine the details of their cycles and, in particular, the actual values for the time periods spent in the water and at the surface. Figures 5 and 6 depict the distribution of Argos fixes as a function of time and hour of the day. The time windows spent at the surface are clearly seen for all cycles. After a total of 12 (6) cycles, float 35503 (35504) stayed at the surface and transmitted continuously until it was recovered. Horizontal lines represent the programmed times for the start and end of the surfacing period, as well as the start of the ascent.

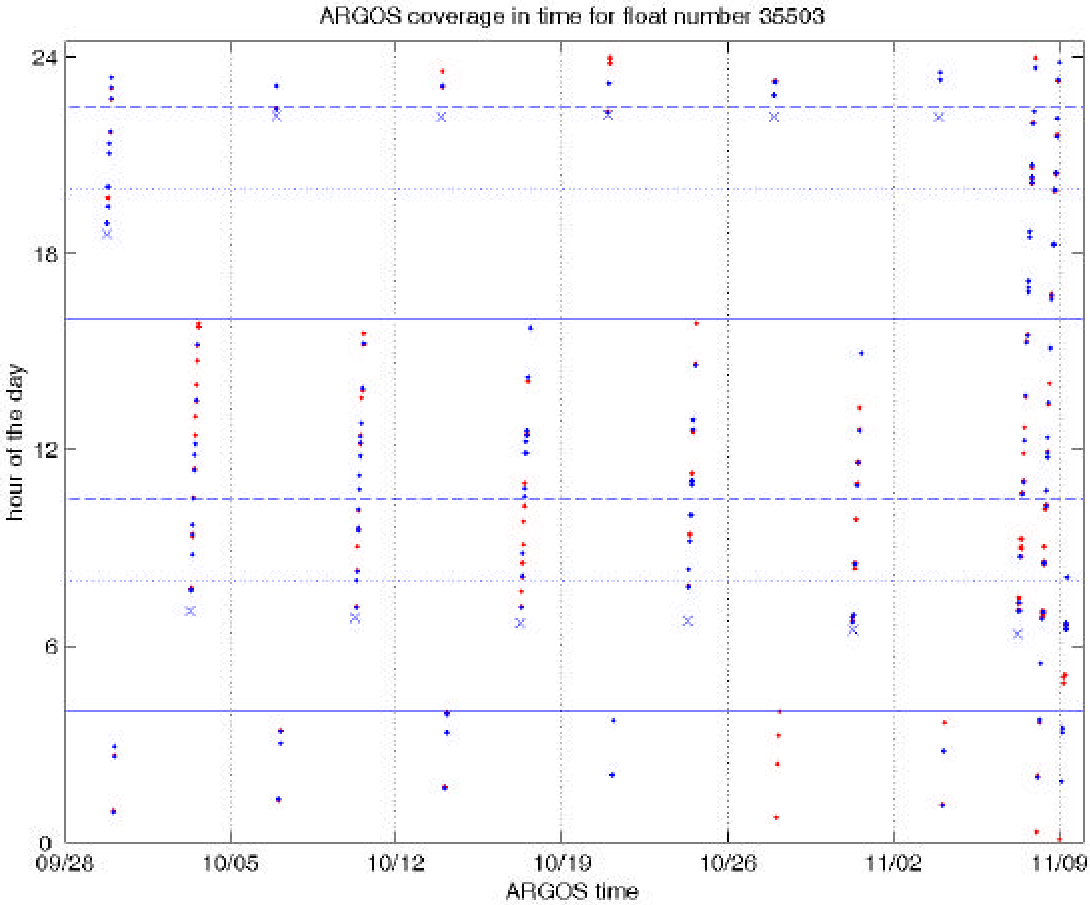

Figure 5. Temporal coverage of Argos fixes for float number 35503. Points for which Argos position is available are depicted in blue. The programmed times for the start of the ascent, the start and end of surfacing period are represented by dotted, dashed and solid lines, respectively. The first Transmission at the surface are represented by a “x” symbol. It has been calculated using *Te*.

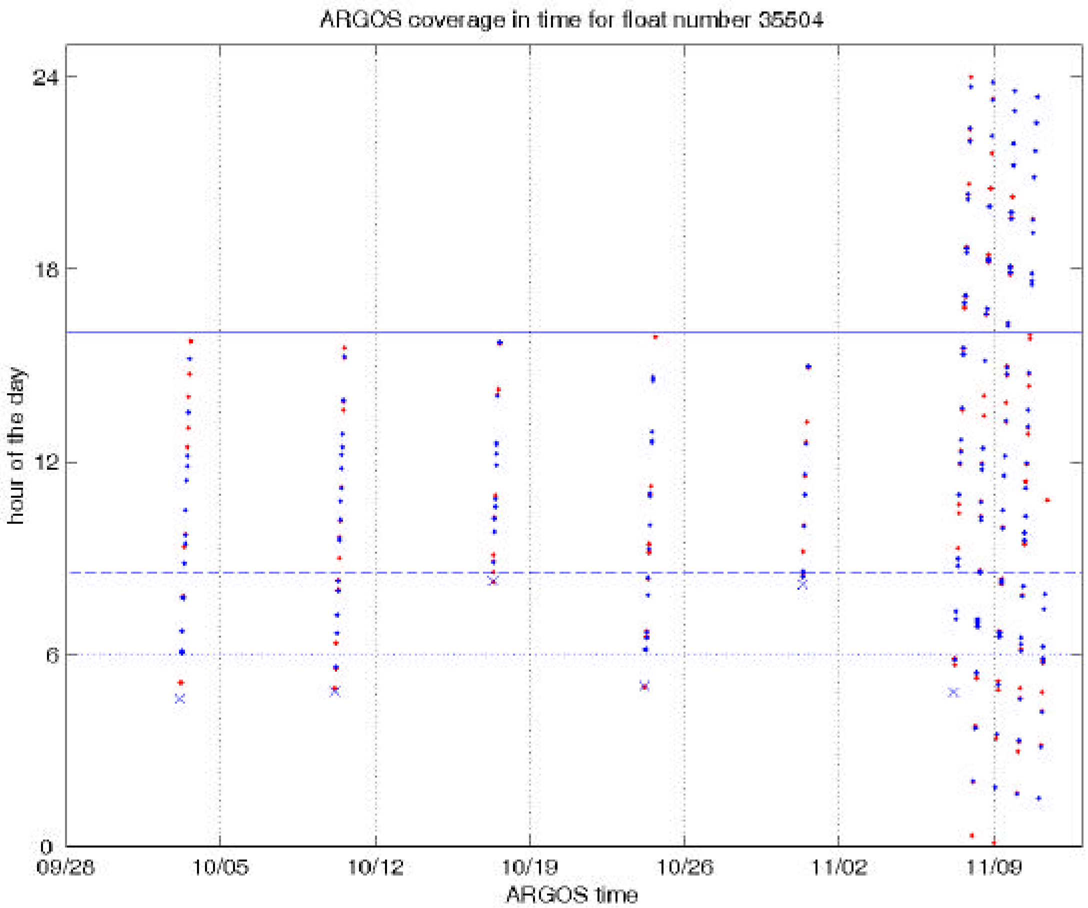

Figure 6. Same as Figure 4 but for float number 35504.

Argos transmissions for all floats were programmed every 45 s. Using the Argos multi-satellite service, the transmissions were received by 7 polar-orbiting satellites (NOAA-11, 12, 14, 15, 16, 17 and ADEOS-2; see Figures 5 and 6). When the floats stay at the surface at the end of their mission, it can be seen that these transmissions are well distributed over the entire day with maximum (minimum) density around midday (midnight). Argos fixes including locations are shown in blue. Figures 5 and 6 show that locations are not always provided at the first (last) fix after (before) the float ascent (descent). The surfacing times estimated using *Te* (shown with "x" symbols) and some Argos fixes can happen before the programmed surfacing period (before the dashed line in Figures 5 and 6). Some surfacing times are more than 3 hours before the expected values.

Using these estimates of surfacing time and the start times of the cycles (first start time *Tstart* plus n-times the cycle length), the intervals the float spend at the surface (*surf time*) and in the water (*sub time*) were estimated (Tables 2 and 3). Corresponding distances are also listed. They were estimated by linearly interpolating the Argos positions to the start and end times of the surfacing periods.

Cycle #	Date	Surf dist (km)	Surf time (hours)	Sub dist (km)	Sub time (hours)
0	26/09/03	-	-	6.3001	74.5575
1	29/09/03	4.8980	9.4425	3.3852	75.0464
2	3/10/03	5.8446	8.9536	9.8649	78.1803
3	7/10/03	3.8071	5.8197	7.0149	74.8400
4	10/10/03	10.4606	9.1600	5.5299	78.1556
5	14/10/03	1.8727	5.8444	14.0182	74.6561
6	17/10/03	7.5366	9.3439	10.9594	78.1969
7	21/10/03	4.2405	5.8031	10.7904	74.7308
8	24/10/03	13.4337	9.2692	10.8652	78.1558
9	27/10/03	0.9754	5.8442	15.6561	74.4828
10	31/10/03	12.4402	9.5172	8.3384	76.1444
11	4/11/03	4.3564	5.8556	7.9575	74.3317
Mean	**-**	**6.3514**	**7.7139**	**9.2233**	**76.1232**
STD	-	4.1444	1.8063	3.5224	1.8123

Table 2. Time intervals when float number 35503 is at the surface (*surf time*) and when it is submerged (*sub time*) surface. Estimates of distance traveled by the float during surface permanence and submergence period.

Cycle #	Date	Surf dist (km)	Surf time (hours)	Sub dist (km)	Sub time (hours)
0	26/09/03	-	-	15.4496	156.5997
1	3/10/03	4.7336	11.4003	5.0504	156.8306
2	10/10/03	4.2892	11.1694	36.5287	160.2569
3	17/10/03	11.8452	7.7431	35.0110	156.9889
4	24/10/03	2.1801	11.0111	14.7512	160.1767
5	31/10/03	3.2691	7.8233	10.8712	156.7992
Mean	**-**	**5.2634**	**9.8294**	**19.6103**	**157.9420**
STD	-	3.8090	1.8733	13.0591	1.7666

Table 3: Same as in Table 2 but for float number 35504 .

Tables 2 and 3 show that the time interval at the surface can exceed the *up time* programmed in the float software. Indeed for float 35503, the *up time* is 8 hours whereas the *surf time* can be as large as 9.52 hours. For float 35504, this latter time can be up to 11.4 hours which exceeds the *up time* of 10 hours. By definition, the *up time* includes the duration of the ascent plus the surfacing time, that is 700/0.08= 8750 seconds = 2 hours 26 min, so the surfacing time should be near 5.5 hours for float 35503 and near 7.5 hours for float 35504.

The earlier surfacing of the floats can be explained because a duration of 6 hours was set for the float to descent from the parking depth of 350 dbar down to 700 dbar. When the float reaches that pressure it automatically starts the ascending profile. Apparently, the float needed only 1-2 hours to descend to 700 dbar and the profile was shifted in time accordingly (as illustrated with a light dashed curve in Figure 4.) As explained by the manufacturer, this is linked to the piston position. On the first descent, the piston is retracted to a programmed value called "profile piston position". Two cases are possible:

1) If profile depth is reached before 6 hours, ascent begins immediately, and the float reaches the surface earlier than target. In this case, buoyancy is increased by one increment (one count) on the next descent, to reduce descent speed.

2) If profile depth is not reached in 6 hours, ascent begins at 6 hour, and the float reaches the surface at the expected time. In this case, buoyancy is decreased by one increment on next descent, to increase descent speed.

The adjustment of buoyancy by plus or minus one count causes the variability of surfacing times seen in Figure 5 and 6, and the corresponding variations in time intervals listed in Tables 2 and 3. The time interval spent at the surface is either ~5.8 or ~9.4 hours for float 35503 where it is alternating between ~7.8 and ~11.2 hours for float 35504.

During the surfacing time and every 45 s, the float transmitted the data in sequential messages including one message (#1) with engineering parameters and pressure, temperature and salinity at parking depth, and the other 13 (or 17 for 35504) messages with consecutive segments of the T/S profile data. It is interesting to examine the efficiency of these transmission of these data. The histograms depicted in Figures 7 to 22 show the numbers of times the individual messages where received while the floats are at the surface. The number of satellite passes, the length of the surfacing period and the minimum/maximum numbers of message repetitions are tabulated in Tables 4 and 5. It is crucial that all messages be at least transmitted once in order to retrieve the full datasets.

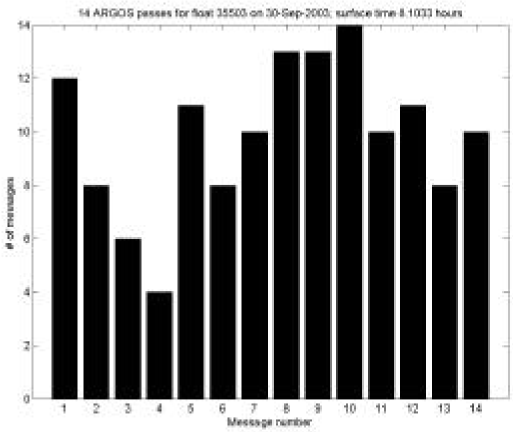

Figure 7. Histogram of number of repetition for each message number (14 messages are necessary for float 35503 in order to transmit the complete CTD profile), during the surfacing time of float 35503 on 29-30 September 2003 (cycle #1).

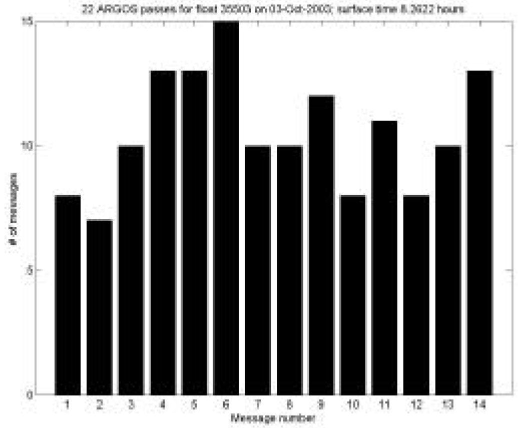

Figure 8. Same as Figure 7 but for float 35503 on 3 October 2003 (cycle #2).

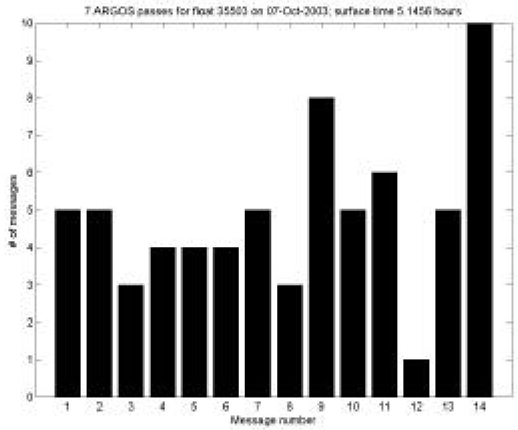

Figure 9. Same as Figure 7 but for float 35503 on 7 October 2003 (cycle #3).

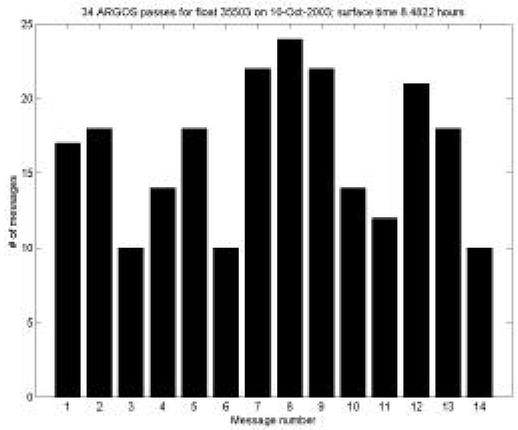

Figure 10. Same as Figure 7 but for float 35503 on 10 October 2003 (cycle #4).

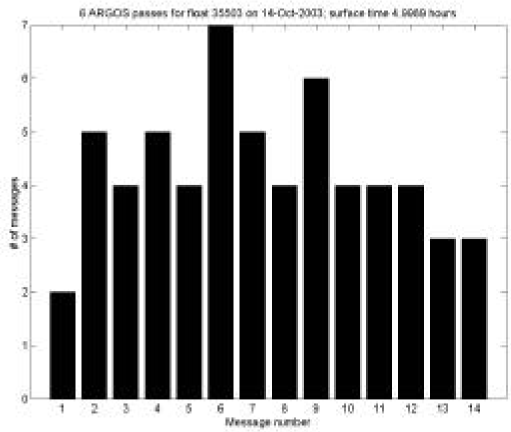

Figure 11. Same as Figure 7 but for float 35503 on 14 October 2003 (cycle #5).

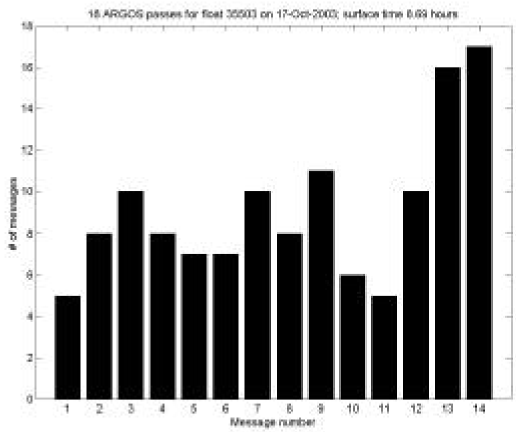

Figure 12. Same as Figure 7 but for float 35503 on 17 October 2003 (cycle #6).

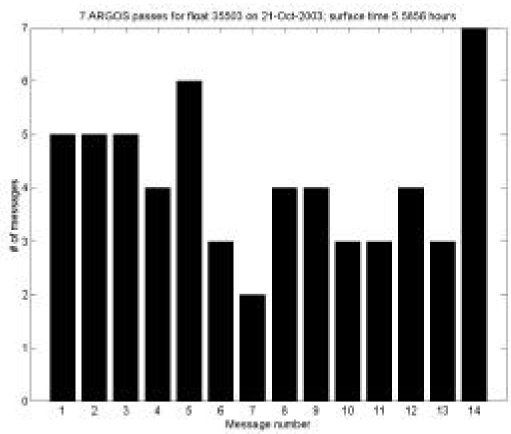

Figure 13. Same as Figure 7 but for float 35503 on 21 October 2003 (cycle #7).

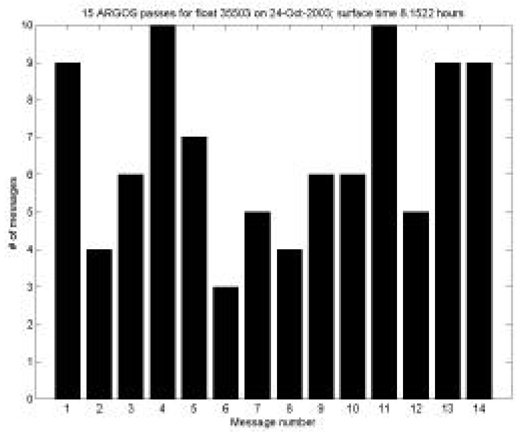

Figure 14. Same as Figure 7 but for float 35503 on 24 October 2003 (cycle #8).

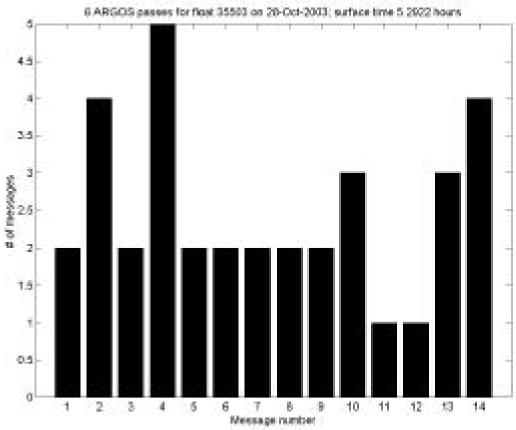

Figure 15. Same as Figure 7 but for float 35503 on 28 October 2003 (cycle #9).

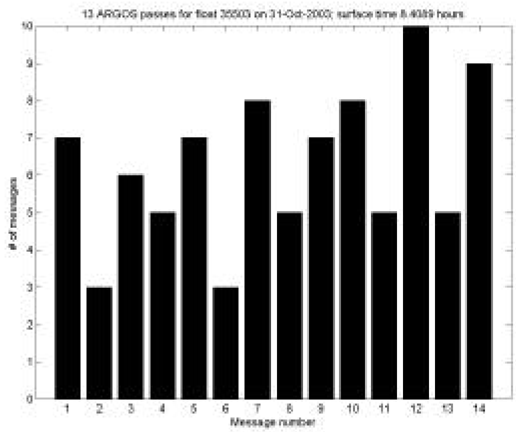

Figure 16. Same as Figure 7 but for float 35503 on 31 October 2003 (cycle #10).

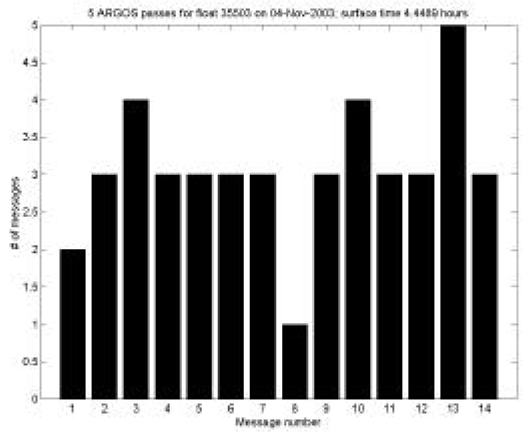

Figure 17. Same as Figure 7 but for float 35503 on 4 November 2003 (cycle #11).

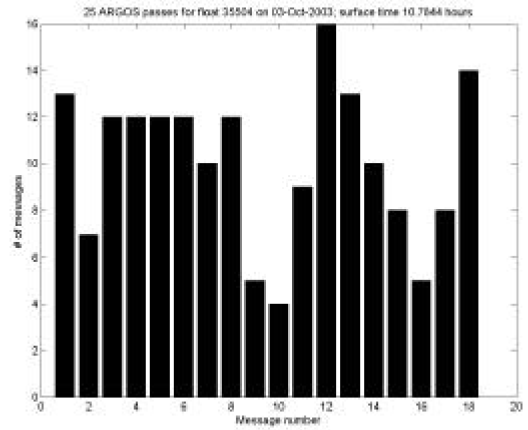

Figure 18. Histogram of number of repetition for each message number (18 messages are necessary for float 35504 in order to transmit the complete CTD profile), during the surfacing time of float 35504 on 3 October 2003 (cycle #1).

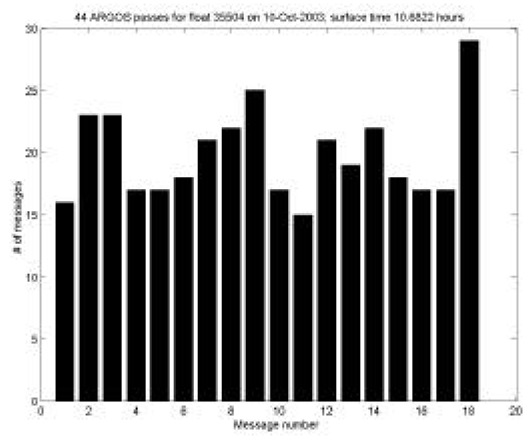

Figure 19. Same as Figure 18 but for float 35504 on 10 October 2003 (cycle #2).

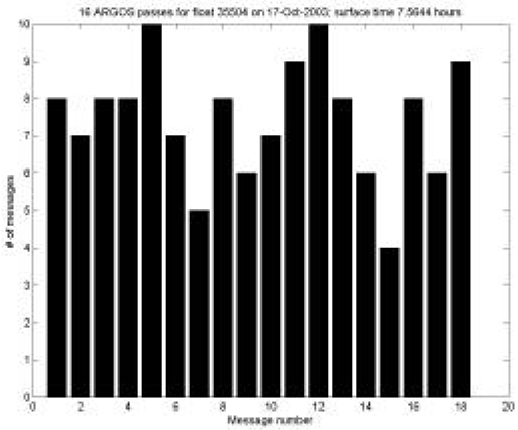

Figure 20. Same as Figure 18 but for float 35504 on 17 October 2003 (cycle #3).

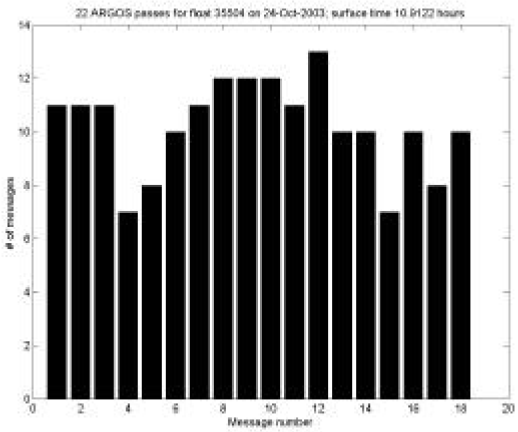

Figure 21. Same as Figure 18 but for float 35504 on 24 October 2003 (cycle #4).

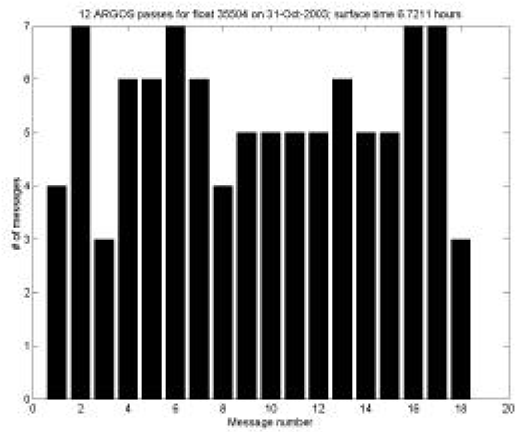

Figure 22. Same as Figure 18 but for float 35504 on 31 October 2003 (cycle #5).

35503	Number of satellite passes	Time interval (hours)	Minimum # of repetitions	Maximum # of repetitions
1*	14	9.4425	4	14
2	22	8.9536	7	15
3*	7	5.8197	1	10
4	34	9.1600	10	24
5*	6	5.8444	2	7
6	18	9.3439	5	17
7*	7	5.8031	2	7
8	15	9.2692	3	10
9*	6	5.8442	1	5
10	13	9.5172	3	10
11*	5	5.8556	1	5

*surfacing around midnight.

Table 4. Number of satellite passes, time interval and minimum/maximum number of message repetitions during the surfacing periods of float number 35503.

35504	Number of satellite passes	Time interval (hours)	Minimum # of repetitions	Maximum # of repetitions
1	25	11.4003	4	16
2	44	11.1694	16	29
3	16	7.7431	4	10
4	22	11.0111	7	13
5	12	7.8233	3	7

Table 5. Same as Table 3 but for float number 35504.

As it can be seen in Figures 7-22 and Tables 4-5 all the data were telemetered and received at least once. For some cycles (3, 9 and 11) of float 35503, portions of the T/S profiles were indeed only received once. In contrast, other pieces of data we received up to 24 times. For float 35504, the repetitions of the 18 messages vary between 3 and 29.

4.1 Data at parking depth

The APEX floats measure temperature, salinity and pressure just before they descent to the target depth of 700 dbar. Hence, it is possible to examine the time evolution of these parameters measured at (or near) the parking depth of 350 dbar once per cycle (Figures 23 and 24). It can be seen that the programmed depth of 350 dbar was reached and maintained to within plus or minus ~5 dbar. Temperatures at these depths were near 13.3 ºC and salinities were close to 38.55 PSU.

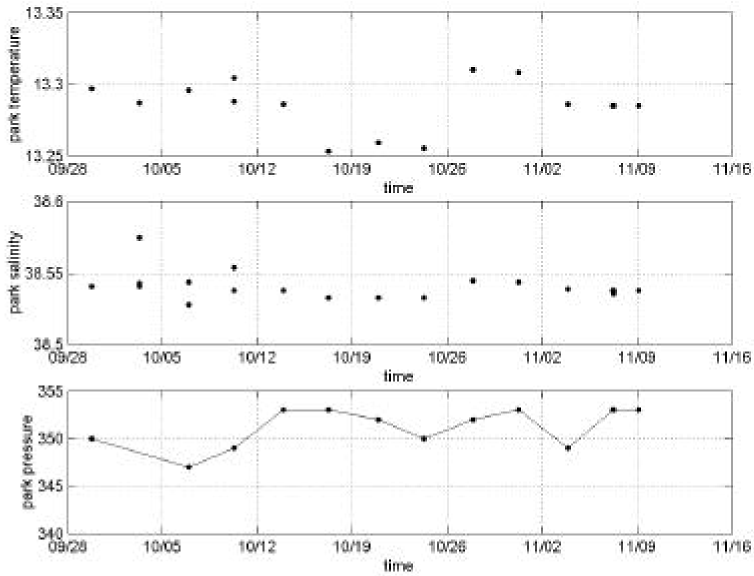

Figure 23. Temperature, salinity and pressure for float number 35503 measured at the end of the subsurface drift (at park depth).

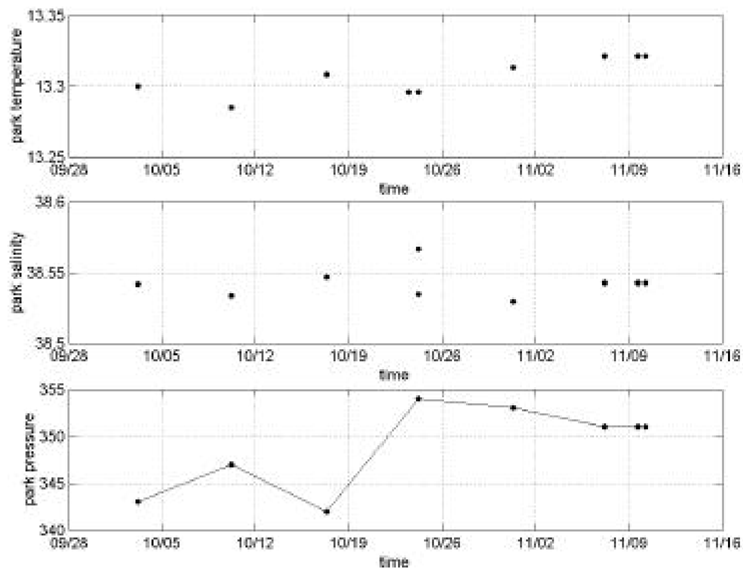

Figure 24. Same as Figure 22 but for float number 35504.

4.3 T/S profiles: Sampling depths and calibration

The sampling levels programmed for the two APEX floats are listed in Table 1. The upper layer has higher resolution (5 or 10 dbar) whereas sampling is coarser deeper (intervals of 25 or 10 dbar). For a given precision of the T/S values (0.001 for both temperature and salinity), only a limited number of T/S values can be transmitted during a prescribed surfacing time interval. We have seen that 60 (80) points were successfully received during intervals as little as 5.8 (7.7) hours for floats 35503 (35504).

All the T/S profiles obtained from the two APEX floats are shown in Figures 25 and 26. Values lying outside a given range (10-25ºC for temperature and 37-40 PSU for salinity) were edited out. Substantial depth ranges without data occur for cycle 3 and 4 of float 35503. Despites occasional spikes (e.g., for salinity of cycle #3 of float 35504), the profile data are relatively clean.

Let us now compare some profile data of the float to those obtained in the close vicinity by means of a Neil Brown Mark III CTD onboard a research vessel (Font et al., 2004). We focus on the data obtained on 3 October when the APEX floats had just performed one (35504) or two (35503) cycles. Table 6 contains information about the CTD and float data used in the comparison. The float and ship measurements were separated by less that 6 hours in time and 4 km in space.

Temperature differences in excess of 1 ºC can be seen in both profiles in the thermocline (near 40 m). We suspect that the vertical resolution of 5 dbar and depth averaging method are responsible for this discrepancy. Ship CTD values have been averaged over 1 m whereas the float measurements are more point-wise at the various levels chosen. In the surface mixed layer and below the thermocline, the temperatures agree well (below 100 m, they agree to within 0.02ºC). In addition to important inter-leaving haline structure in the first 60 m of water not resolved by the float sampling every 5 dbar, a significant offset in salinity exists between the float and ship profile. The ship CTD is about 0.02 PSU lower than the float value. The cause for this offset is still being investigated but we suspect that that the Neil Brown Mark III CTD was not correctly calibrated. If we correct for this 0.02 PSU offset, the salinities below 100 m agree within 0.004 PSU.

	GMT Time ship	Lat ship	Lon ship	GMT Time float	Lat float	Lon float	Delta-t (hours)	Dist (km)	Delta-T (°C)	Delta-S (PSU)
CTD5 35504	10:25	41.583	3.6835	04:36	41.593	3.6744	5.8	1.35	0.0107 (0.0124)	-0.0181 (0.0035)
CTD6 35503	12:20	41.634	3.8260	07:05	41.643	3.786	5.25	3.62	-0.0181 (0.0035)	-0.0162 (0.0062)

Table 6. Times and locations of the CTD profiles performed by the float and by the ship on 3 October 2003, along with the interval and distance between the measurements. Mean and standard deviation (between parentheses) of temperature and salinity differences computed from the values below 100 m.

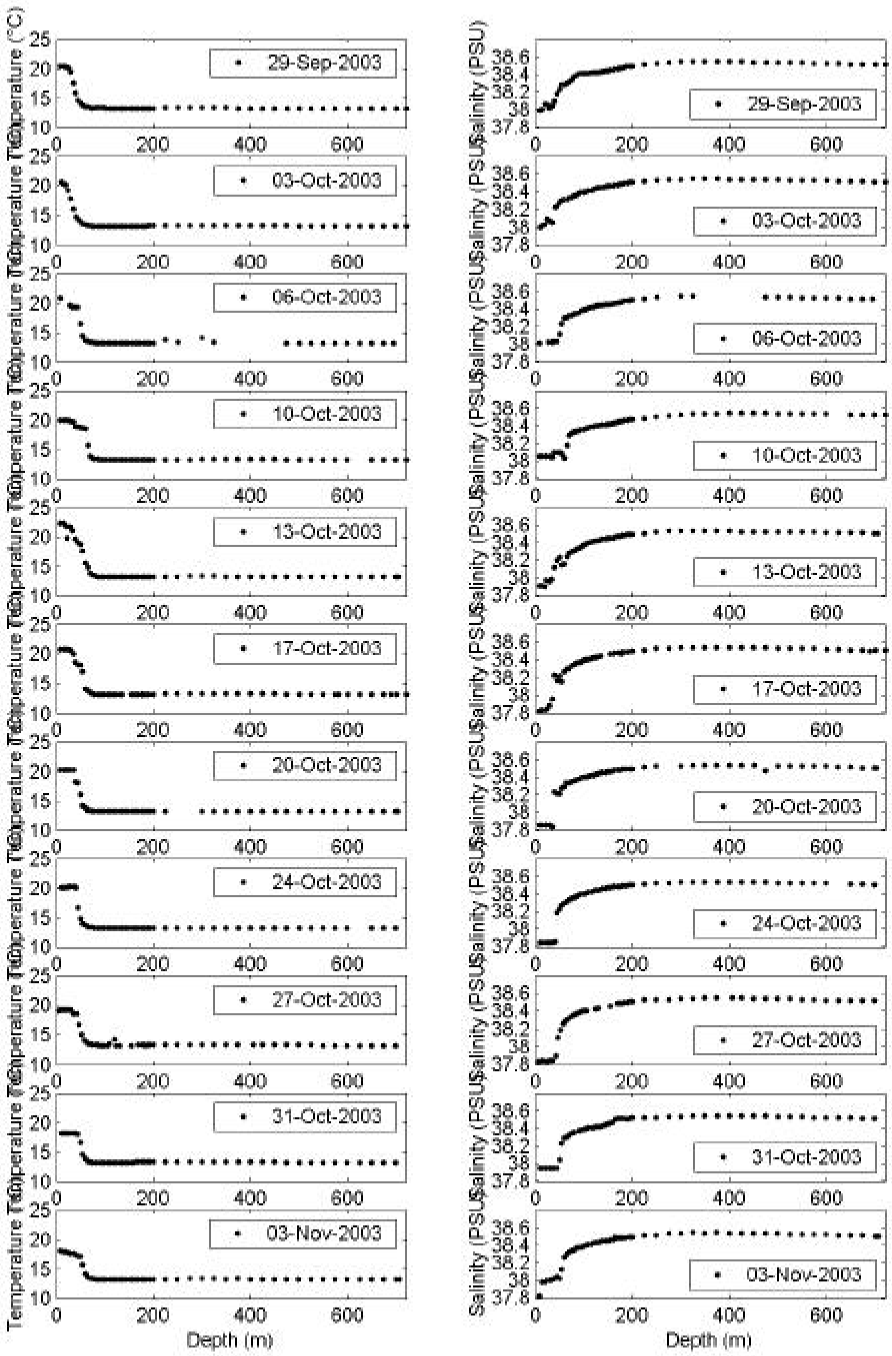

Figure 25. Temperature (left) and salinity (right) profiles obtained from float number 35503 showing the sampling depths chosen. Only values in the range 10-25 °C and 37-40 PSU are plotted for temperature and salinity, respectively.

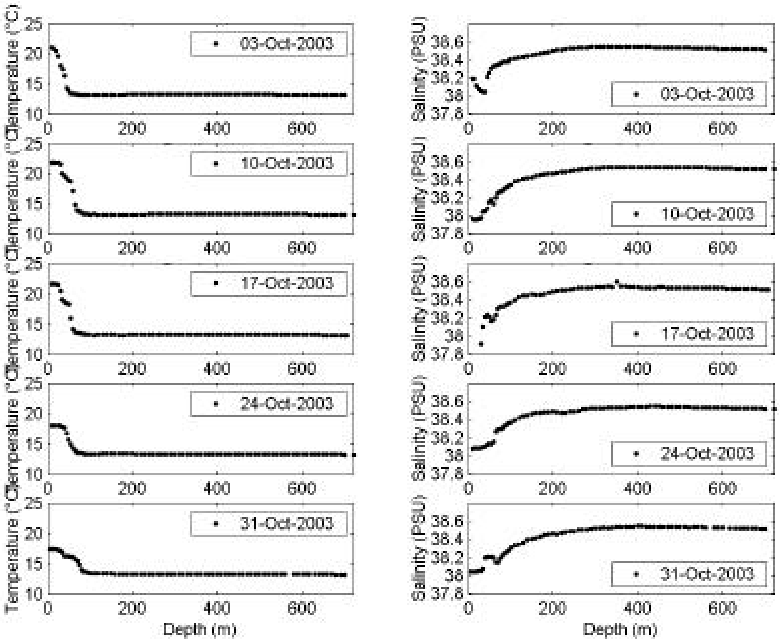

Figure 26. Same as Figure 24 but for float number 35504.

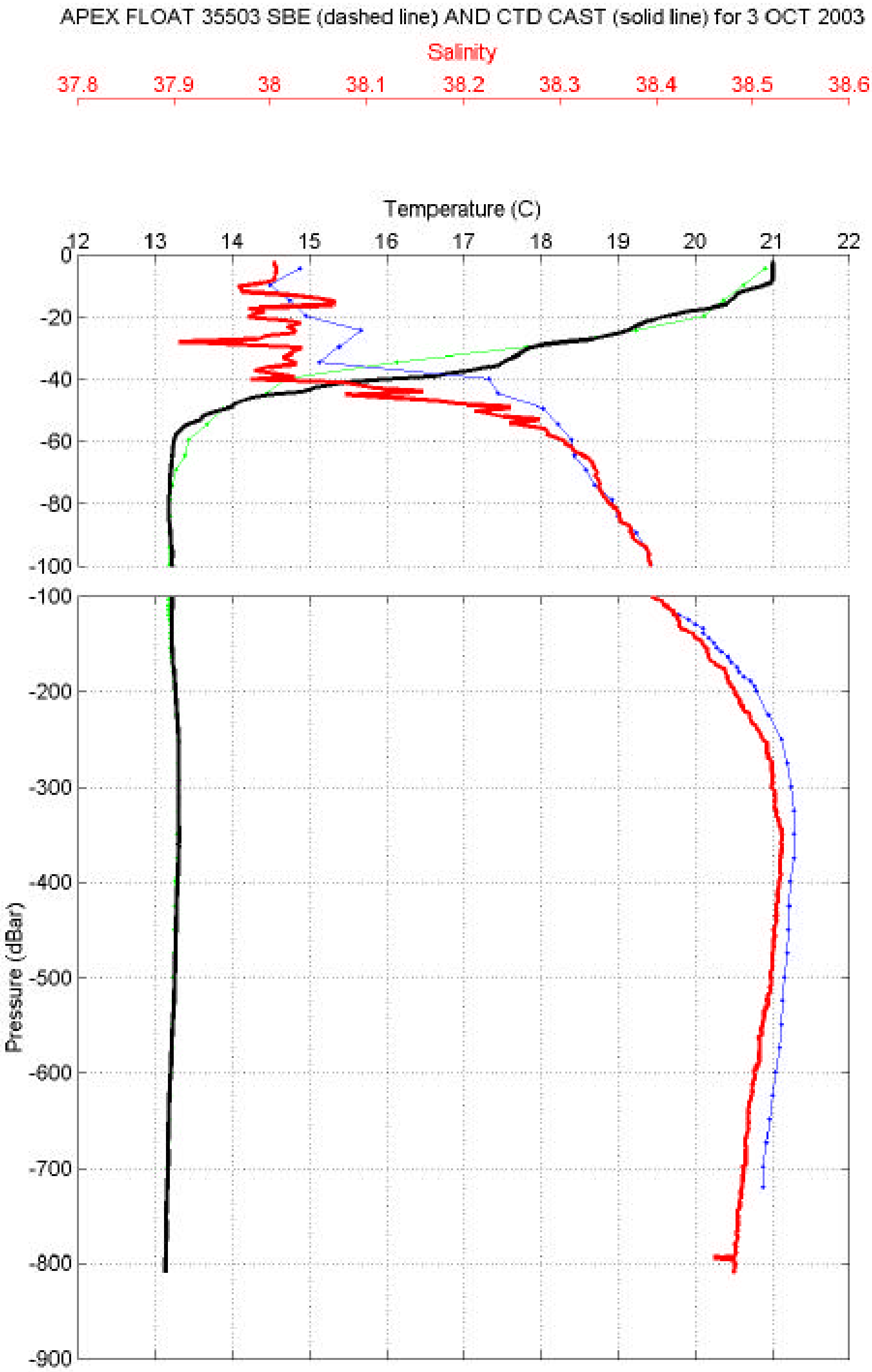

Figure 27. T/S profiles obtained from APEX float 35503 (green and blue curves) and from the ship CTD (black and red curves) on 3 October 2003.

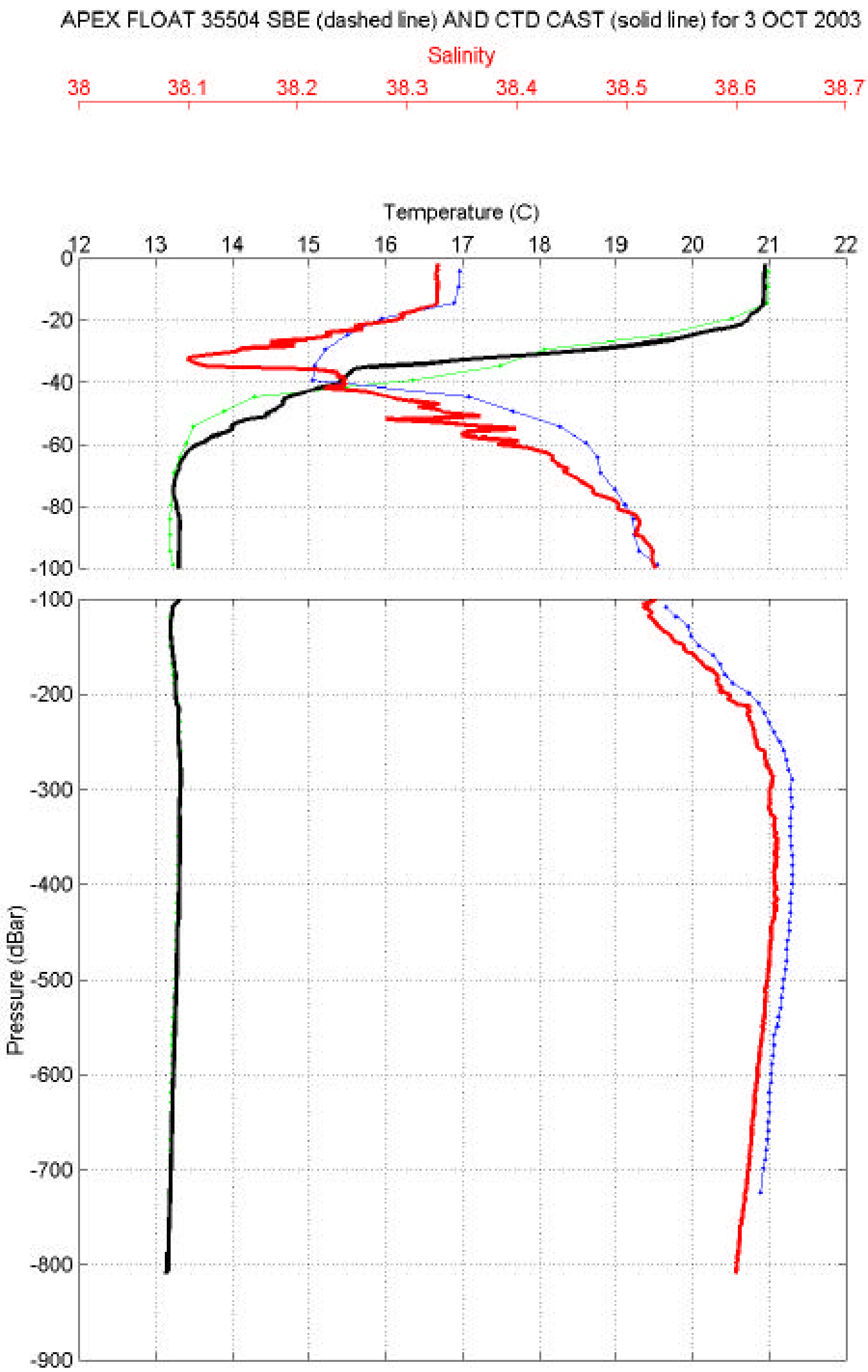

Figure 28. Same as Figure 24 but for float number 35504.

4.4 Subsurface velocities

Using all the Argos positions of each float along with the GPS location of deployment, the positions were linearly interpolated at the start and end times of the surfacing period. The time intervals between the surfacing time and the time of the first Argos location, and between the last Argos location and the start of the next cycle are listed in Tables 7 and 8. These periods vary between 6 minutes and about 5 hours.

The time interval spent in the water (~76 hours for 35503 and ~158 hours for float 35504) includes about 3 hours to descend to 350 dbar, about 76-6-3=67 hours (or 158-6-3=149 hours) at the parking depth, about 3.5 hours to descend to 700 dbar and finally another 2.5 hours for the ascent. This means that float 35503 (35504) stays about 88% (94%) of its submergence period at the parking depth.

Also included in Tables 7 and 8 are the estimates of subsurface speeds, and the east-west and north-south components of subsurface velocities. The two floats sampled a mean southwest current (the Northern Current) of about 3 cm/s and the variability around that means is limited to a few cm/s in both directions (standard deviation of about 2 cm/s).

Cycle #	**Date**	**Distance (km)**	**Duration (hours)**	**Delta-t (min)**	**Speed (cm/s)**	**Velocity E-W (cm/s)**	**Velocity N-S (cm/s)**
0	26/09/03	6.7492	74.5575	37.0/21.0	2.5145	0.3146	-2.4948
1	29/09/03	3.3852	75.0464	66.0/37.6	1.2530	0.1202	-1.2472
2	3/10/03	9.8649	78.1803	48.3/12.0	3.5050	2.7095	2.2234
3	7/10/03	7.0149	74.8400	37.3/19.3	2.6036	1.7633	1.9156
4	10/10/03	5.5299	78.1556	46.7/55.3	1.9654	-1.5573	-1.1991
5	14/10/03	14.0182	74.6561	6.5/29.1	5.2158	-3.3693	-3.9815
6	17/10/03	10.9594	78.1969	18.2/6.1	3.8931	0.1467	-3.8903
7	21/10/03	10.7904	74.7308	17.2/63.4	4.0108	-1.8223	-3.5730
8	24/10/03	10.8652	78.1558	85.1/39.1	3.8617	-2.2237	-3.1571
9	27/10/03	15.6561	74.4828	286.7/13.8	5.8388	-3.2404	-4.8571
10	31/10/03	8.3384	76.1444	63.3/68.1	2.9640	0.1446	-2.9605
11	4/11/03	7.9575	74.3317	74.6/42.8	2.9737	-2.2851	-1.9029
Mean	**-**	**9.2608**	**76.1232**	**-**	**3.3833**	**-0.7749**	**-2.0937**
STD	-	3.4908	1.8123	-	1.2983	1.9345	2.2345

Table 7. Subsurface displacements, time intervals, speeds and components of velocity for float number 35503. The time intervals (Delta-t) between the surfacing time and the time of the first Argos position, and between the last Argos position and the beginning of the subsequent cycle (*Tstart* plus n-times the cycle length) are listed in minutes.

Cycle #	Date	Distance (km)	Duration (hours)	Delta-t (min)	Speed (cm/s)	Velocity E-W (cm/s)	Velocity N-S (cm/s)
0	26/09/03	15.9453	156.5997	54.0/86.4	2.8284	-0.6202	-2.7595
1	3/10/03	5.0504	156.8306	47.1/44.2	0.8945	0.4375	0.7802
2	10/10/03	36.5287	160.2569	44.9/37.4	6.3316	-2.5614	-5.7904
3	17/10/03	35.0110	156.9889	16.6/68.7	6.1949	-5.7280	-2.3593
4	24/10/03	14.7512	160.1767	83.713.6	2.5582	-2.1696	-1.3554
5	31/10/03	10.8712	156.7992	62.1/61.4	1.9259	-1.1870	-1.5166
Mean	**-**	**19.6930**	**157.9420**	**-**	**3.4556**	**-1.9715**	**-2.1668**
STD	-	13.0290	1.7666	-	2.2748	2.1328	2.1580

Table 8. Same as in Table 7 but for float number 35504.

To finish this report, we would like to calculate the order of magnitude of the error affecting the estimate of velocity at the parking depth of 350 dbar. For simplicity, let us consider the following one-dimensional situation to estimate the error on the parking depth speed given the cycle characteristics of our two floats. We assume:

Mean speed during descent to 350 dbar: 10 cm/s,
Mean speed at parking depth (350 dbar): 3 cm/s,
Mean speed during descent to 700 dbar: 2 cm/s,
Mean speed during ascent to surface: 5 cm/s.

With these above values, which could correspond to a typical velocity profile in the Mediterranean, our estimate of parking depth speed is:

Float 35503:

Mean speed = (3 h * 10 cm/s + 67 h * 3 cm/s + 3.5 h * 2 cm/s + 2.5 h * 5 cm/s)/76 h = 3.3 cm/s

Float 35504:

Mean speed = (3 h * 10 cm/s + 149 h * 3 cm/s + 3.5 h * 2 cm/s + 2.5 h * 5 cm/s)/158 h = 3.1 cm/s

It can be seen that using cycle lengths of 3.5 and 7 days would result in errors of 0.3 and 0.1 cm/s, respectively, which are less that 10% of the estimated speeds. Note that the actual descending rates are nonlinear (fast at first, then slowing asymptotically as the float approaches the neutral depth). Since the largest contribution to the error comes from the relatively fast near-surface currents where the float descends rapidly, the linear estimation presented above overestimates the errors.

5. Conclusions and recommendations

The main conclusions on the assessment of the APEX test results and the related recommendations for future uses are:

1) Cycle lengths of 3.5 and 7 days are adequate to estimate speeds at the parking depth of 350 dbar. We propose to use 5 days as cycle length for the MEDARGO floats to be deployed starting in summer 2004. We expect that the relative error on the velocity estimates due to the vertical shear of horizontal currents in the upper sea above 700 dbar will be less than 10%.

2) To avoid problems with the calibrations of the SeaBird CTD on the floats, we propose to program the float to descend to a deeper level every n cycles in order to reach stable waters where temperature and salinity are known (i.e., using the seasonal climatologies of MEDAR/MEDATLAS). We propose to descend down to 2000 dbar every 10 cycles.

3) We propose to set the float timing in order to have surfacing time periods centered around noon time to garantee a maximum number of satellite passes. The surfacing time should be the same for the cycles with short (700 dbar) and long (2000 dbar) profiles. Three hours (instead of 6) should be programmed to descend from the parking depth to 700 dbar. Six hours should be kept for the descent to 2000 dbar.

4) Ten hours (i.e., 8% of the cycle length) of surfacing time should be enough to transmit 100 T/S pairs. Hence, a *down time* of 104 hours and a *up time* of 16 hours can be used. After the short profiles, the floats will arrive at the surface about 3 hours ahead of schedule, resulting in a surfacing time of 13 hours. The sampling levels could be (96 levels): 4,10,15,20,…,95,100,110,…,690,700,750,…,950,1000,1100,…,2000 dbar. If we can transmit every 30 s instead of every 45s, 7 hours of surfacing time would be sufficient (i.e., 6% of the cycle length). A *down time* of 107 hours and a *up time* of 13 hours could be used.

6. References

Davis, R.E. , D.C. Webb, L.A. Regier, and J. Dufour (1992) The Autonomous Lagrangian Circulation Explorer (ALACE), *J. Atmos. Ocean. Tech*., 9, 264-285.

Font, J., J. Salat and J.Tintoré (1988) Permanent features of the circulation in the Catalan Sea. *Ocean. Acta*, vol.sp. 9, 51-57.

Font, J., M. Emelianov, A. Julià, J. Puertas and M. Lloret (2004) MFSTEP-MEDARGO Subtask 4230 Final Report, ICM, Barcelona, 15 January 2004.

Loaec G., N. Cortes, M. Menzel and J. Moliera (1998) PROVOR: a hydrographic profiler based on MARVOR technology, *IEEE-Oceans'98*, September 1998.

Loaec G, Carval T, Le Reste S, Maudire G (1999) : Provor and Coriolis Data Center: a step towards operational oceanography, *Data Buoy Conference Panel Workshop.*