Increasing of Effectiveness and Reliability of Data from Drifting Buoys

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Introduction.
One of the features of investigations directed on evaluation of novelties developed to progress drifter technology is that duration of experimental jobs has to be for 2-3 years at least and sometimes much longer. 2012 was the year when a few important jobs, including the jobs completed under the DBCP Pilot Projects, were carried out or close to this. These results are presented in this article in the following order:

Barometric drifters:

- Argos-2 drifter tracking capabilities;
- Long-living reliable air pressure samples under rough weather conditions;
- Increasing of duration to keep the drogue attached;
- Packaging of a drifter for safety deployment.

Argos-3 and Iridium Pilot Projects drifters:

- Argos-3 drifters;
- Iridium and Iridium/GPS drifters.

New temperature-profiling drifters.
Ice micro buoys with parachute deployment.
Water level measuring device.

The operational status of all the drifters in this article was fixed by September 10, 2012.

Argos-2 drifter tracking capabilities

Two SVP-B buoys with 64 alkaline D-cells and with continuous mode in operation continue their movements, visible via Argos-2 tracking capabilities. The buoys were deployed by BOM Australia and kept their tracking capabilities for a very long period of time after deployment in South Ocean. The drifters are visible via JCOMMOPC web: http://wo.jcommops.org/cgi-bin/WebObjects/JCOMMOPS.woa/1/wo/aLRIIProQYwON6XRyNVDsg/0.0.96.3.

Full information about those drifters is shown in the Table 1.

Table 1

Deployment and operational information about the drifters

ID	WMO	Depl.	Owner	AP failure	Tracking	
					Days	**Years**
67381	56631	11 May 06	BOM	848	2314	6.3
67379	56532	06 Dec 06	BOM	564	2105	5.8

ID67381/WMO56531 was deployed on May 11, 2006 and emitted for 2314 days (6.3 years). GTS distribution was stopped on 1183 day (3.2 years). ID67379/WMO56532 was deployed on December 12, 2006 and emitted for 2105 days (5.8 years). GTS distribution was stopped on 710 day (1.9 years). The view of buoy’s trajectory with longer lifetime is shown on the Figure 1.

Figure 1. The 6.3 year trajectory of SVP-B drifter (ID67381/WMO56531) deployed by May 11, 2006 in South Indian Ocean.

This information demonstrates the adequate power budget of Argos-2 drifters and should force efforts of manufacturers to develop sensors with longer lifetime.

Long-living reliable air pressure samples under rough weather conditions
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Drifter network has currently in general two types of barometric drifters: SVP-B with 41-cm hull and SVP-B mini with hull having smaller diameter (30-35 cm). Design of SVP-B mini drifter was suggested by the DBCP as a decision to keep density of drifter network by means of wide use of ships of opportunity for deployments of the drifters.

SVP-B mini drifter has smaller number of batteries and correspondingly shorter lifetime. On the other hand this technical decision could be optimal for low latitudes because mean lifetime of buoys here is smaller. Mean reason for this is high probability to get a buoy beached or become a victim of sea vandalism.

Both versions of Marlin drifters of last prototypes were evaluated to determine the quality of air pressure (AP) samples.

<u>AP data from SVP-B drifters.</u>

The Table 2 shows AP data from last prototypes of mix of SVP-B drifters (Argos-2 and Iridium). Some buoys came ashore after near 3 years in operation, some buoys have similar duration and continue working. The current battery voltage for operational buoys allows seeing them definitely with theoretical lifetime more than 3 years. Two buoys ID84146/WMO56939 and ID49679/WMO62505 have 3-year duration overpassed. Second buoy from this pair was the SVP-BTC temperature-profiling drifter with increased power consumption, so it got faster the battery power emptied.

It is obviously from the Table 2 that all the buoy had mean RMS at 0.7 – 0.8 hPa level. Most interesting is SVP-B drifter ID84146/WMO56939, which had 1385 days of reliable AP data on September 10, 2012. This buoy was deployed in Indian Ocean, passed the Ocean from east to west and got the sough high latitudes reached on the second part of its lifetime. Full trajectory of this drifter is shown on the Figure 2.

Table 2

AP data from last prototypes of Argos-2 and Iridium SVP-B drifters

ID	WMO	Telemet.	Depl.	Owner	Failure of buoy		AP duration days	RMS mean, hPa
					Date	Days		
84146	56939	Argos-2	25.11.08	BOM	in operation		1385	0.6
49678	62505	Argos-2	15.06.08	M-Fr.	18.08.11	1159 (bat)	1159	0.7
84147	56943	Argos-2	04.01.09	BOM	19.08.11	957(beach)	957	0.9
84152	56941	Argos-2	13.01.09	BOM	13.08.11	942 (beach)	942	0.8
	16551	Irid/GPS	13.04.10	SAWS	in operation		881	0.8
	17526	Irid/GPS	15.11.09	SAWS	in operation		1030	0.8
	17572	Iridium	15.12.09	SAWS	in operation		1000	0.8

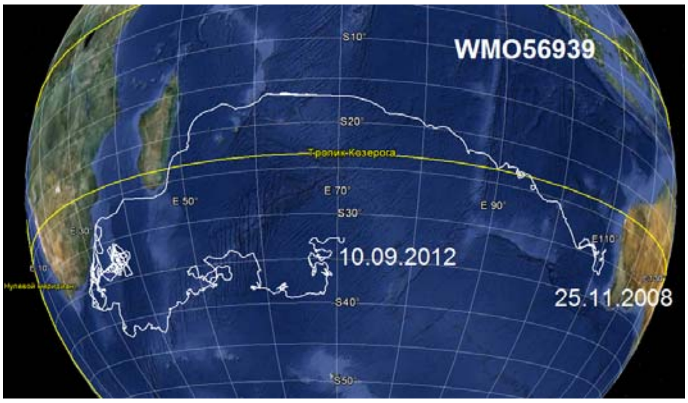

Figure 2. Full trajectory of SVP-B drifter ID84146/WMO56939 in the Indian Ocean.

The trajectory shows that, this buoy was under influence of different weather conditions from tropical temperature and moisture to low latitudes of South Ocean, well known with rough weather condition.

The graph on Figure 3 shows the variability of AP data from deployment to September 10, 2012. It is obviously that mean RMS was near 0.6 hPa and did not have a tendency to increase after 3 years in operation.

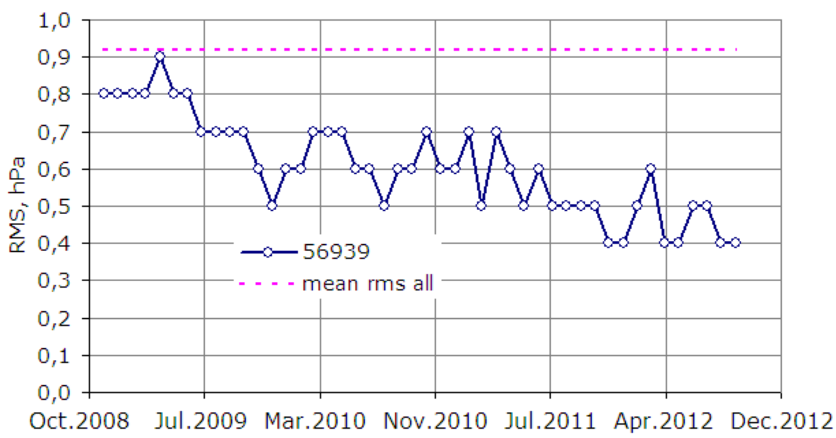

Figure 3. Mean monthly RMS for SVP-B drifter ID84146/WMO56939 during its lifetime.

AP data from SVP-B mini drifters.

The Table 3 below includes data from three intercomparison Argos-2 drifters and one Argos-3 PP buoy. All buoys were SVP-B mini drifters deployed approximately at the same time and continued its operation on September 10, 2012. It is obviously that RMS as a whole for SVP-B mini drifters is a little larger in contrast with standard SVP-B buoys.

Table 3

AP data from last prototypes of Argos-2 and Argos-3 SVP-B mini drifters

ID	WMO	Telemet.	Depl.	Owner	Failure of buoy		AP duration, days	RMS mean, hPa
					Date	Days		
43869	13600	Argos-2	19.08.10	NOAA		in operation	753	0.7
43877	55614	Argos-2	23.08.10	NOAA		in operation	749	0.9
43878	15501	Argos-2	26.08.10	NOAA		in operation	746	0.9
41803	55962	Argos-3	30.09.10	A3 PP		in operation	711	0.6*

* Sometimes for buoys in the Tasman Sea the AP samples had too scattered data depending on weather conditions

The buoy ID43869/WMO13600 from this cluster had a longest lifetime. Its trajectory in low latitudes of the Atlantic Ocean is shown on the Figure 4.

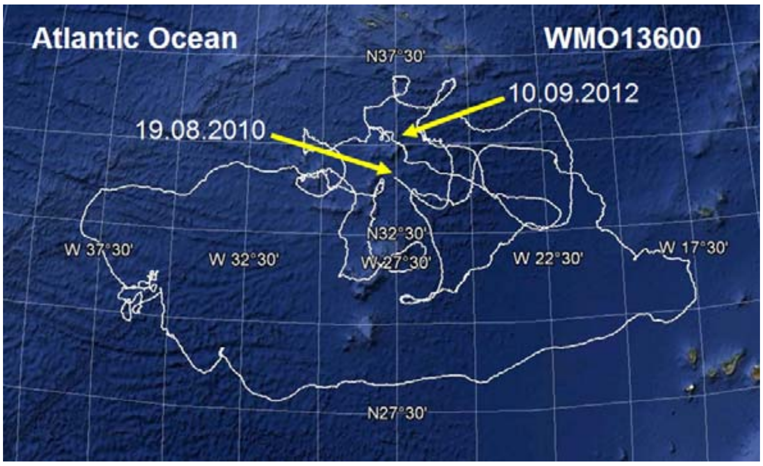

Figure 4. Full trajectory of SVP-B mini drifter ID43869/WMO13600 in the Atlantic Ocean.

The graph on Figure 5 shows the variability of AP data for ID43869/WMO13600 from deployment to September 10, 2012. It is obviously that mean RMS was near 0.7 hPa and there is a tendency of RMS increasing after 2 years in operation. What does it mean either sensor's problem or environmental influence should be clear later from AP data after September 10.

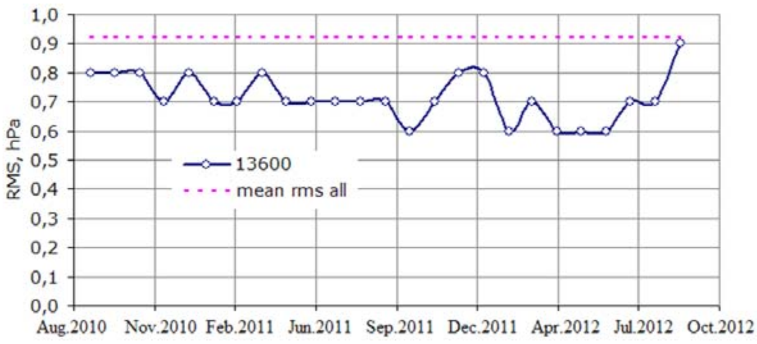

Figure 5. Mean monthly RMS for SVP-B mini drifter ID43869/WMO13600 during its lifetime.

Another feature of AP variability had Argos-3 SVP-B mini drifters deployed in the Tasman Sea. Table 3 shows one of Argos-3 SVP-B mini drifter deployed here. This buoy was a single buoy which had operation in the Sea without beaching and following redeployment. This buoy as well as other Argos-3 buoys deployed in the Tasman Sea did not have a problem with AP while they had their drogues attached. After the drogues were lost, the buoys had sometime too scattered data as it is shown on the Figure 6 for Argos-3 SVP-B ID42961/WMO55644.

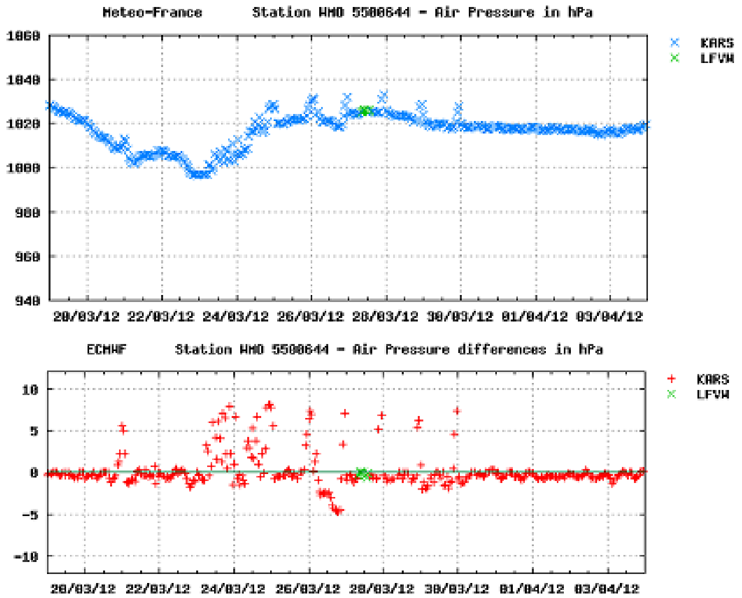

Figure 6. Too scattered AP data, which took place sometimes for Argos-3 SVP-B mini drifter ID42961/WMO55644, deployed in the Tasman Sea.

It is visible from Figure 6 that AP spikes had positive value, i.e. abnormal AP samples were larger in contrast with nominal air pressure. We guess that main reason for those positive spikes was difference to swim at sea surface for floats from standard and mini drifters after they got its drogues lost. The matter of this point of view is explained on Figure 7.

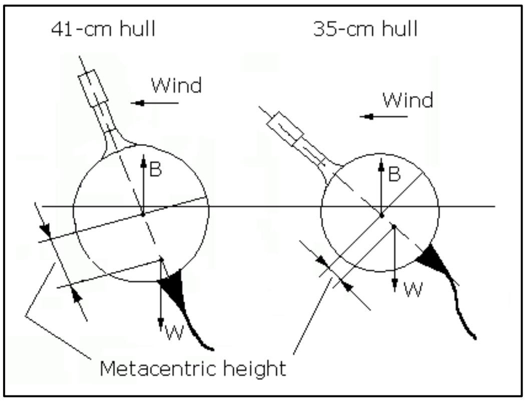

Figure 7. Different conditions to swim at sea surface for floats from standard and mini SVP-B drifters.

The float swimming at sea surface has two main characteristics, which determine vertical orientation of the float and stability of this orientation. The characteristics are: B – center of water displacement volume and W - center of gravity. If positions of B and W are determined from lower point of the float, the difference B – W has to have positive sign. In this case the float has vertical orientation independently of drogue presence or absence as well as environmental wind-wave conditions. The difference B – W is named as metacentric height. The more this parameter is, the more vertical stability the float has.

It is obviously also that float with larger outside diameter can have larger B – W value and correspondingly it keeps better vertical orientation, when wind pressure is applied to barometric port. Because the ports have same outside sizes for both drifters, the heeling pressure is same for both floats. Different diameters of floats provide small input, because of float's streamline and possible submergence.

Thus, the float of SVP-B mini drifter has larger dependence on wind pressure and its inclination from vertical is more in contrast with float of standard SVP-B drifter if same wind is applied to both buoys. Larger inclination of SVP-B mini drifter provides getting the port's inlet opened for wind pressure and its influence on AP sensor. As a result the AP samples have wrongly increased reading.

This effect is clear visible for buoys, deployed in the Tasman Sea and might be the wind-wave conditions, specific for this sea, make to get inclinations larger here.

Currently we suggest the following. The long-living drifters with 41-cm hulls and reliable AP measurements under any weather conditions should be used in difficult of access South Ocean and may be in North high latitudes, while the mini drifters with smaller diameter of float and shorter lifetime could be used in low latitudes, where there is large probability to get a buoy lost because of beaching or vandalism, but there is good probability to support density of drifter network by means of ships of opportunity.

Nevertheless the problem to keep reliable AP samples by SVP-B mini drifters continues to be and one of the possible ways to reach this result is higher probability to stay the drogue attached longer in contrast with current situation.

Increasing of duration to keep the drogue attached

This item has two important things: keeping of the drogue attached as long as possible and confirmation of the fact that drogue has been materially lost. Our point of view, which is confirmed with all the Marlin drifters, is that submergence sensor is a reliable tool to determine loss of drogue. Correct design of this sensor provides very clear signal, which fixes the moment, when drogue was lost. SVP-B as well as SVP-B mini drifters have same output from this sensor as it is shown on the Figure 8. In a future buoy keeps zero signal during full remainder of its lifetime.

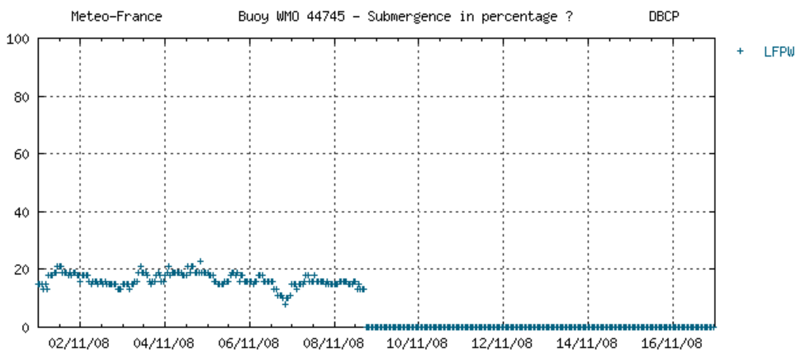

Figure 8. Determination of the moment, when drogue was lost.

Below are the comments about our understanding why the drogues are lost. It seems "wire" technology of tether connection with drogue is a reliable method. As well the drogue, built from firm synthetic fabric under technology, described in DBCP #4 document, has good strength to operate under rough wave conditions. We studied a few buoys beached in the Black Sea after near one year in operation and they had good quality of drogue and “wire” connection. Figures 9 below shows the main view of SVP-BTC temperature-profiling drifter, which was recovered by Meteo-France after one year operation in the Bay of Biscay.

Figure 9. Main view of the SVP-BTC temperature-profiling drifter, which was recovered after one year operation in the Bay of Biscay.

The buoy has much more load applied to the “wire” connections and drogue as a whole. This is because the drogue has lower ring, the design of which is same with upper ring. Temperature chain is connected with buoy via lower “wire” connection, so drogue is under influence of two oppositely directed forces: float’s positive buoyancy, directed upward and gravity force of the chain directed down. In spite of this twice effect, the connections and drogue did not have damages after one year in operation, as that is obviously from the Figure 10, which shows the view of drogue after it was cleared from biology fouling.

Figure 10. The view of SVP-BTC drifter’s drogue after it was cleared from one-year biology fouling.

This buoy was the prototype, which was developed as a result of study why previous prototypes of temperature-profiling drifters had drogues and chain attached not longer of 2-3 months. The results of this study can be applied to SVP-B and SVP-B mini drifters.

The breaking load for 4-6 mm rope, used as a tether for SVP-B and SVP-B mini drifters, is much more in contrast with static and dynamic load applied to tether of buoy in operation. We guess that there are two possible variants to get a drogue lost. The first event could take place within 3 months after deployment. For second variant the loss could be on some day during 300-450 days interval. The matter of these variants is presented on the Figure 11.

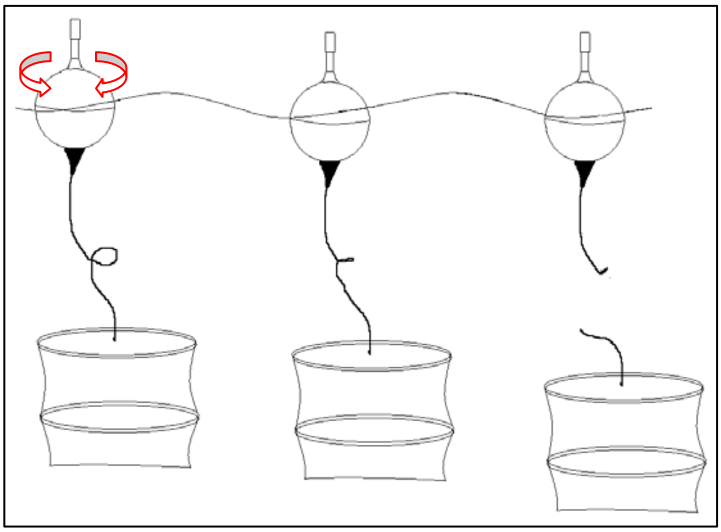

Figure 11. Creation of loops on tether and bidirectional rotation of float, which are the main reasons to get the drogue lost.

The first event could be a consequence of "weak place" creation on tether during deployment of drifter, when bad weather conditions. The "weak place" means that small loop could be formed at some point of tether during submergence of drogue. Because float can "jump" under wave influence, this loop can be shrunk with creation of fissure on tether. The rupture of tether in this place can be within 3 months.

We study a few buoys beached in the Black Sea and it became visible that more often the "weak place" can be closer to drogue (lower part of tether).

If deployment takes place without creation of the "weak place" on tether, the buoy could keep its drogue attached during longer time. Of course, the situation during strong storm could be unexpected and "weak place" can appear under storm influence. Nevertheless, we guess that probability of "weak place" under storm influence is smaller in contrast with situation during deployment.

To avoid appearance of those two events for temperature-profiling drifters the 6-mm outside diameter tether between float and upper ring of tether is inserted now in hydraulic hose with 14-mm outside diameter. Creation of loops for this tether is unlikely and influence of bidirectional rotation become smaller. The buoy, shown on the Figures 9 and 10, was the device, built on basis of this design, and it demonstrated one-year reliable operation in rough Bay of Biscay.

This variant can be used only for quasi Lagrangian SVP-BTC drifter and it is inapplicable variant for Lagrangian buoys, because the DAR (Drag Area Ratio) for SVP-B drifter decreases up to DAR =20-25. Thus, another technical solution should be found for SVP-B and SVP-B mini drifters.

To decrease a probability of first variant appearance to get the drogue lost, we started using for two last years the spiral packaging of tether in the clips, attached to radials of upper ring. This packaging allows keeping a tension of tether during submergence of drogue after drop of buoy to water. This variant of packaging is used since 2010 and we see that more buoys kept drogues attached longer. The view of tether’s spiral packaging is shown on Figure 12.

Figure 12. Spiral packaging of tether line in the clips, fixed to radials of “wire connection” to decrease probability of loops creation on tether during submergence of drogue after drop of buoy to water.

The packaging is used since 2010 and a few SVP-B mini buoys with 4-mm OD rope got its drogues attached longer than 400 days. On the other hand in isolated instances the buoys lost their drogue within 100 days and approximately 50% within 200-350 days. Thus, the spiral packaging is not a perfect decision of this problem.

Since 2012 we started application of swivels inserted into tether below float. We think that swivel should prevent the influence of float’s bidirectional rotation on tether. And second positive thing here could be to prevent or additionally decrease a probability of "weak place" creation on tether. The view of swivel, inserted in tether is shown on Figure 13.

Figure 13. Swivel, inserted in tether below float to decrease influence of float’s bidirectional rotation on tether.

Packaging of a drifter for safety deployment.

The problem to build drifter to be safety deployed is close to the item above about drifter with drogue attached for long time as well as to get drifter ready for automatic self-deploying capability after drop to water from 20-m height and velocity of deploying ship is up to 25 knots.

The 2012 prototype of SVP-B mini drifter, which has design shown on Figure 14, is next approach for decision of this the DBCP requirements.

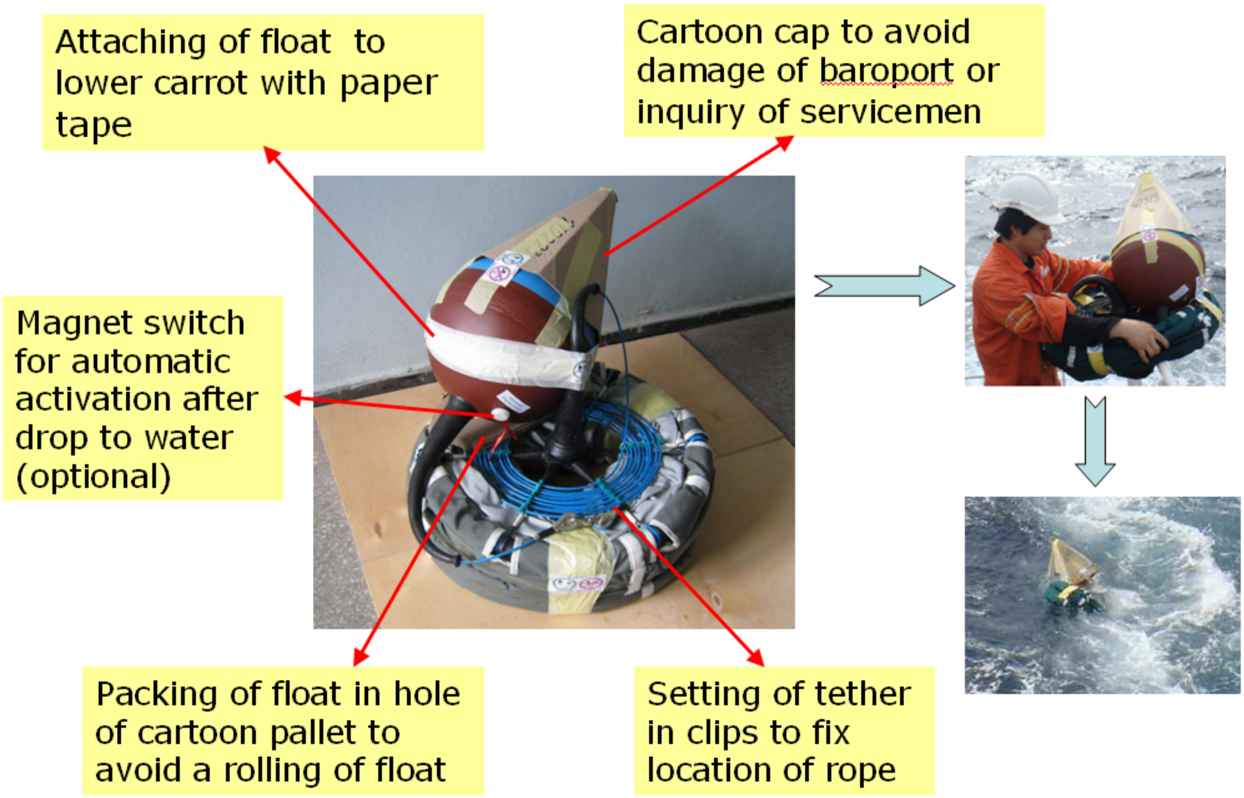

Figure 14. 2012 prototype of the SVP-B mini drifter, the design of which is next approach to get the buoy ready for self-deploying after drop from 20-m height when deploying ship runs with 25-knots velocity.

The buoy has the setting of tether in clips to fix location of rope and prevent possible catch of deploying person's hand during drop of buoy. The float is laid in the hole of cartoon pallet to avoid a rolling of the float on ship's deck, which could be a reason to damage float or injure servicing person. Additional fixing of float to keep its location during drop is made with paper tape, which attach float to drogue's carrot. The cartoon cap is used to avoid damage of barometric port, when blow of water, or to inquiry of servicemen. At last, according to a user's request the buoy can be equipped with magnetic switch for automatic activation after drop to water. The SVP-B mini drifter of this prototype can be safety deployed by one person.

More than 30 SVP-B mini were successfully deployed under following conditions: Vship~20 Knots, Hdrop~20 m. SVP-B mini drifters with shortened lifetime can be mainly used in central areas of the Ocean, where there is a larger probability to get failure of buoy because of beaching or sea vandalism, but on the other hand there is capability to support density of drifter network by means deployment form ships of opportunity.

Since 2012 the standard SVP-B drifter has similar packaging. This prototype of buoy is shown on the Figure 15.

Figure 15. Main view of standard SVP-B drifter with 41-cm float and 92-cm drogue, prepared to be ready for self-deployment after drop to water.

Safety deployment of this type of the drifter has to be carried out by two servicemen as it is shown on the Figure 16.

Figure 16. Deployment of the standard SVP-B drifter by means of drop to water from deploying ship.

Three buoys of this prototype were successfully deployed by New Zealand MetService in the Tasman Sea in June-August 2012. The drops were carried out under following conditions: Vship = 8 Knots, Hdrop=5 m, Vwind=44 knots, Hwave=6-7 m.

Main area of standard long-living SVP-B drifters with reliable AP data under any weather conditions is difficult of access high latitudes and South Ocean in particular.

Argos-3 PP drifters

Five Argos-3 SVP-B mini drifters with 34-cm hulls and 61-cm drogues from 6-buoy cluster were successfully deployed by NZ MetService in the Tasman Sea in August-October 2010. One buoy got failure on 15th day after deployment. Current operational status of the buoys is presented in the Table 4.

Table 4

Current operational status of the Argos-3 SVP-B mini drifters, deployed in the Tasman Sea

ID	WMO	Depl.	Beaching		Re-deployment		Last location	Days (total)
			Date	Days	Date	Days		
41803	55962	30.09.10					in operation	711
41882	55963	01.10.10	16.07.11	288	04.02.12	219	re-deployed	507
42957	55961	31.10.10					21.03.12	507
42961	55644	02.09.10	19.11.11	443	04.02.12	219	re-deployed	662
42973	55645	02.09.10	12.12.11	466			12.12.11	466

The deployments in the Tasman Sea are more interest in contrast with deployments in the Black and Mediterranean Seas, made in 2010, because fast beaching in these basins with limited areas could not be a basis for determination of real lifetime.

The Argos-3 SVP-B mini drifters had 40 D-size alkaline cells, packaged in 5 blocks. This is standard number for mini drifters with 34-cm hull independently of the telemetry link used (Argos-2, Argos-3, Iridium). More number is impossible because of limited buoyancy of the float.

Three buoys in green in the Table 4 continue to be in operation. Two buoys from this cluster (ID41882/WMO55963 and ID42961/55644) were beached on NZ coast, but because they were operational, NZMS re-deployed them. However, because they were beached on sand coast and had some time here before to be picked up, the membranes of barometric ports were closed with sand and AP got failure. Only SST is operational for both.

Buoy ID41803/WMO55962 kept permanent operational status for 711 days after deployment. We compare this buoy with intercomparison Argos-2 SVP-B mini drifter ID43869/WMO13600, which were deployed approximately at the same time to determine the power consumption. The result is presented on the Figure 17.

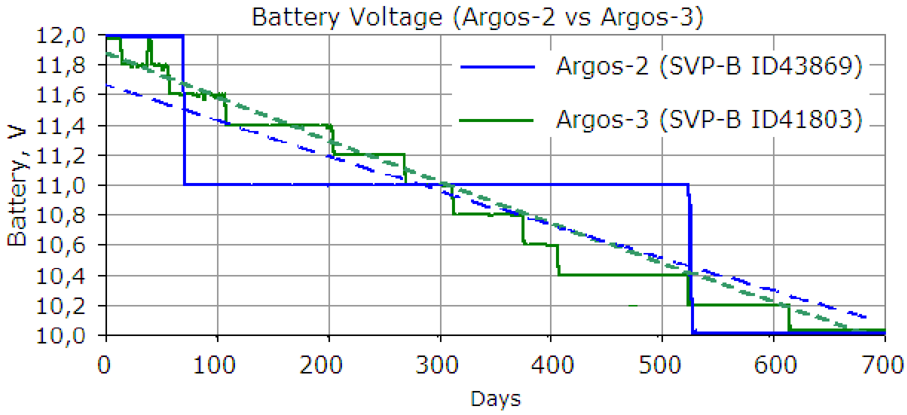

Figure 17. Battery Voltage decreasing for Argos-3 and Argos-2 SVP-B mini drifters, deployed approximately at same time.

Data formats for Argos-2 and Argos-3 telemetry links have different resolution, i.e. 1V and 0,2V correspondingly. Nevertheless, the approximation of battery voltage falling on 700-day interval allows making a preliminary conclusion about approximately same power consumption for both versions of SVP-B mini drifters. The buoys have a remainder of battery power to be in operation for 6 months at least. Thus, final conclusion could be ready to next the DBCP meeting.

Iridium and Iridium/GPS drifters

Three Iridium SVP-B drifters with 41-cm hulls and 92-cm drogues, equipped with 64 alkaline D-cells, were deployed by SAWS in South Atlantic in late 2009 and early 2010. All had perfect status of AP and SST on Sep 10, 2012. One buoy without GPS from Iridium cluster, built for the SAWS, was deployed much later at the end of 2011. The buoy is operational, but it is too previous to discuss its capabilities here. The status of the drifters is shown in the Table 5.

Table 5

Status of Iridium PP SVP-B drifters with GPS and without GPS, deployed by SAWS in the South Ocean

WMO	GPS	Depl.	Drogue loss (days)	Status	Days
17526	hourly	15.11.09	562	In oper.	1030
16551	hourly	13.04.10	587	In oper.	881
17572	no	15.12.09	124	In oper.	1000
14602	no	14.12.11	94	In oper.	231

Two SVP-B drifters (WMO17526 and 16551) had GPS receivers with hourly samples. The buoy WMO17526 had 1030 days (2.8 years) in operation and buoy WMO16551 – 881 days (2.4 years) correspondently. Full trajectory WMO17526 in South Ocean and detailed its fragment, built on basis of GPS fixes, is presented on Figure 18.

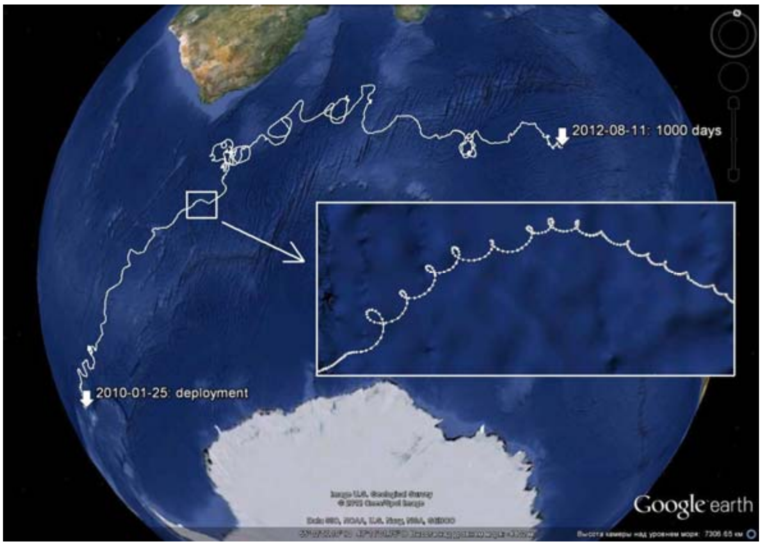

Figure 18. Full trajectory of the Iridium SVP-B drifter, equipped with hourly GPS, in South Ocean and detailed fragment of the trajectory built on basis of hourly GPS locations.

The tandem Iridium/GPS provided reliable GPS fixes in this area with rough weather conditions. Continuity of hourly samples and GPS fixes during more than 1000 days is presented on the Figure 19. The figure has three fragments. Upper fragment reflects the situation, when buoy had its drogue attached and cover full lifetime with this status. It is shown that continuity for samples with 1-hour interval is near 99%, while the continuity for hourly GPS fixes is 96.7%.

The fragment in the middle shows the parameters under conditions same to the above, but when level of submergence was more than 20%, i.e. when the worst-case weather conditions took place. In this case the continuity of samples, sent via GTS, did not have difference and had 99%, while the continuity of hourly GPS fixes was near 10% smaller.

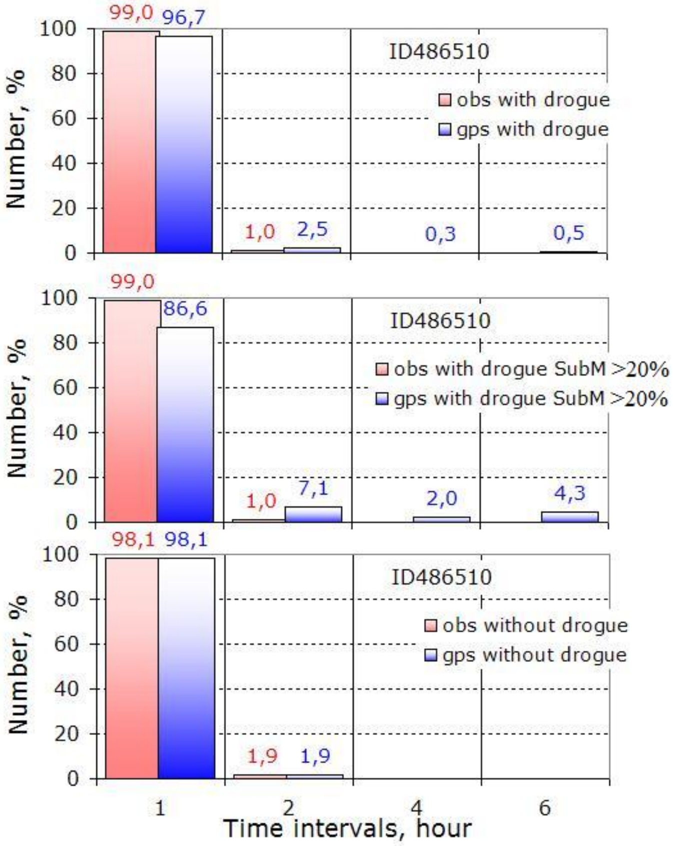

Figure 19. Continuity of hourly samples and GPS fixes for SVP-B/RTC/GPS drifter under following conditions: buoy with drogue during full lifetime; buoy with drogue when level of submergence was more of 20%; and continuity of hourly samples and GPS fixes after the drogue was lost.

At last, lower fragment shows the parameters, when drogue was lost. The continuity of hourly samples became near 98%, while continuity of hourly GPS fixes became larger in contrast with previous fragments. The probable explanation could be that float without drogue had larger amplitude of vertical oscillations that did worse the conditions of communication via Iridium, while GPS link worked perfect.

Third SVP-B drifter without GPS WMO17572 keeps also operation and the current level of battery voltage after 1000 days (2.7 years) allows keeping for a 3.5-year theoretical lifetime at least.

Thus, the Iridium SVP-B/RTC/GPS drifter is the best tool for marine meteorology, the buoy produces high quality communication and GPS fixes with continuity of hourly data close to 100% and small delay of data in the way. All this is valid during three years at least in operation.

New temperature-profiling drifters.

Successful results of the Iridium Pilot Project allowed beginning further development of marine SVP-BTC80/RTC/GPS temperature-profiling drifters. First versions of these buoys had Argos-2 telemetry link, which worked in general satisfactorily. The problem was that much more passing capability needs to transfer large volume of data from this kind of drifter. If full 256 bits capacity of one message was used, this volume was not enough to send full information. 2-page format was developed and tested. However, the capabilities of 2-page format were also small. Moreover if surface waves took place it was a problem to send data completely without holes in data.

First prototype of Iridium SVP-BTC80/RTC/GPS temperature-profiling drifter was developed and successfully tested in 2010-2011. Passing Iridium ability is much more and buoy was equipped with model inserted to process locations of each temperature sensor depending on the chain inclination from vertical. This means that data were sent with paits: Temperature – Depth. The buoy was successfully tested by Meteo-France in the Bay of Biscay and demonstrated one-year reliable operation in this area, known as the place with bad weather conditions.

New step in development of temperature-profiling drifters was carried out in this year. The ice temperature-profiling drifter was developed. The structure of this buoy is shown on Figure 20.

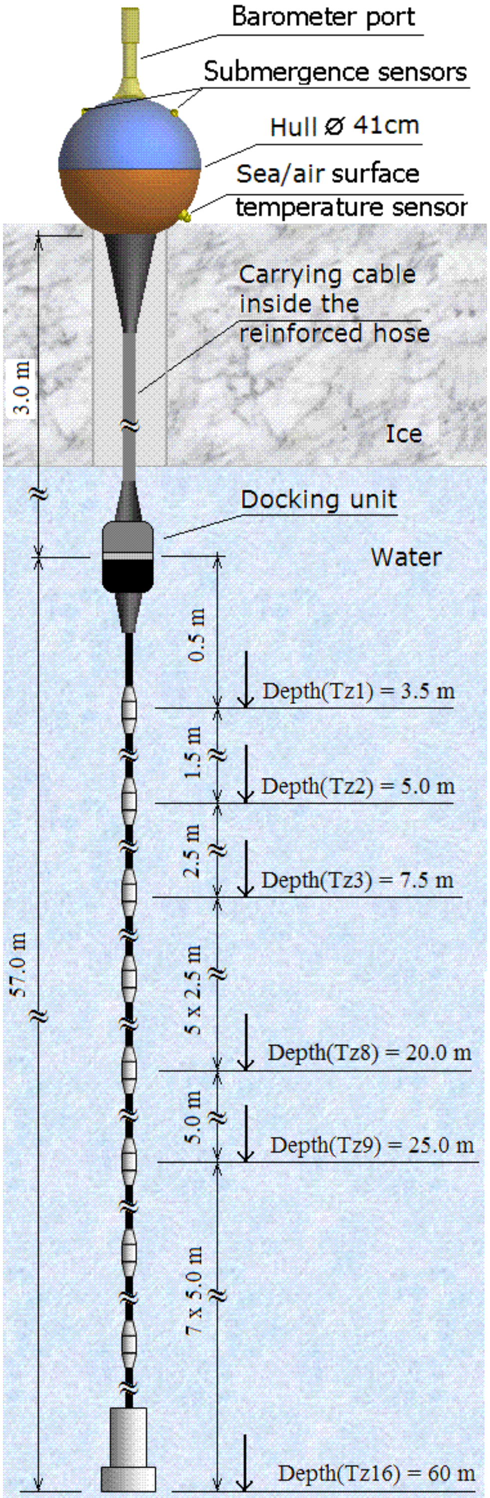

Figure 20. View of the ice temperature-profiling buoy structure.

The design of ice drifter has following differences in contrast with its marine prototype:

- The buoy does not have drogue;
- The float is connected with temperature chain via carrying cable inserted in the piece of reinforced hose. The length of hose depends on the possible maximum thickness of ice. First prototype of ice temperature-profiling drifter had 3-m length;
- The reinforced hose is connected with temperature chain via docking unit, which provides mechanical and electrical connection of the electronics inside float with chain.

First temperature sensor can be fixed close to docking unit and other sensors can be located at depths according to a user's requests.

This decision became possible because ice buoy should operate under conditions, when surface float is placed on ice and there are not vertical fluctuations applied to the chain. Even if the buoy is in water, e.g. when ice melted, the level of surface waves has small amplitude in polar area.

The buoy has set of sensors and main technical parameters same with marine SVP-BTC/RTC/GPS drifter. First ice SVP-BTC60/RTC/GPS drifter was deployed in the Arctic Ocean on Sep. 4, 2012. The point of deployment is shown on the Figure 21.

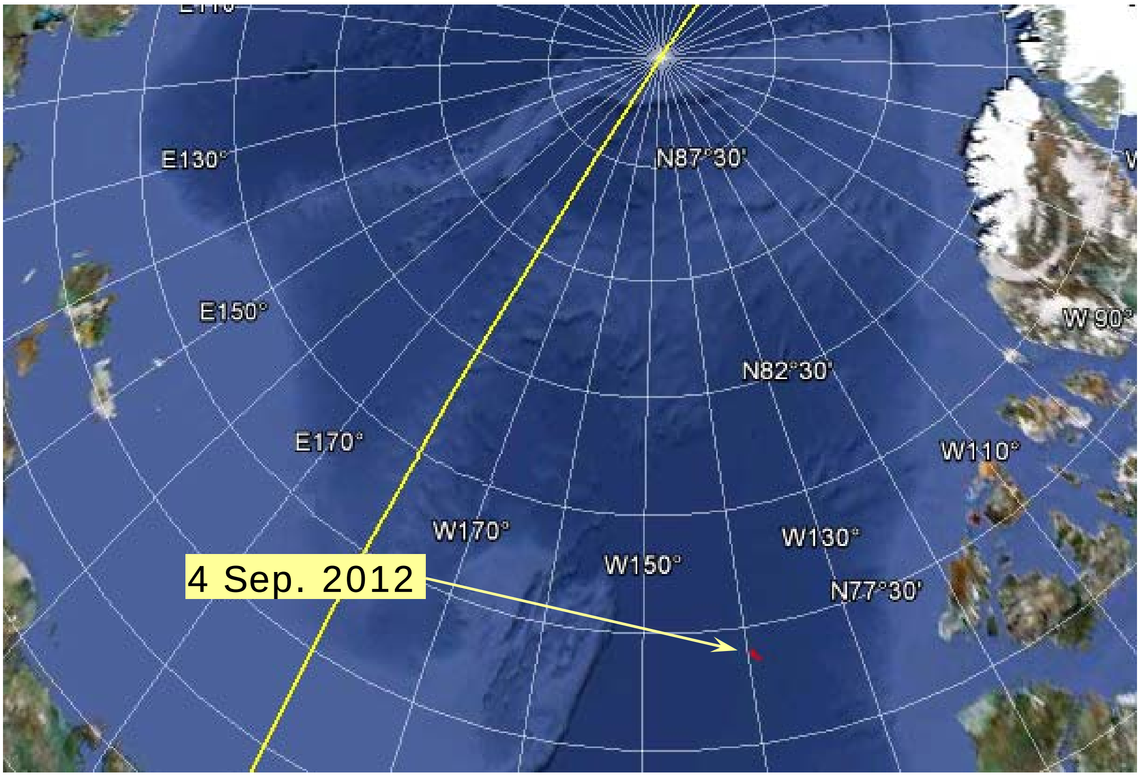

Figure 21. The point of ice SVP-BTC60/RTC/GPS temperature-profiling drifter deployment in the Arctic Ocean.

Figure 22 shows the fragment of the buoy's trajectory from 4 Sep to 15 Sep 2012. The trajectory was built on basis of hourly GPS fixes. The figure has also the vertical temperature profiles for 3 points: at the beginning, in the middle and close to the end of trajectory.

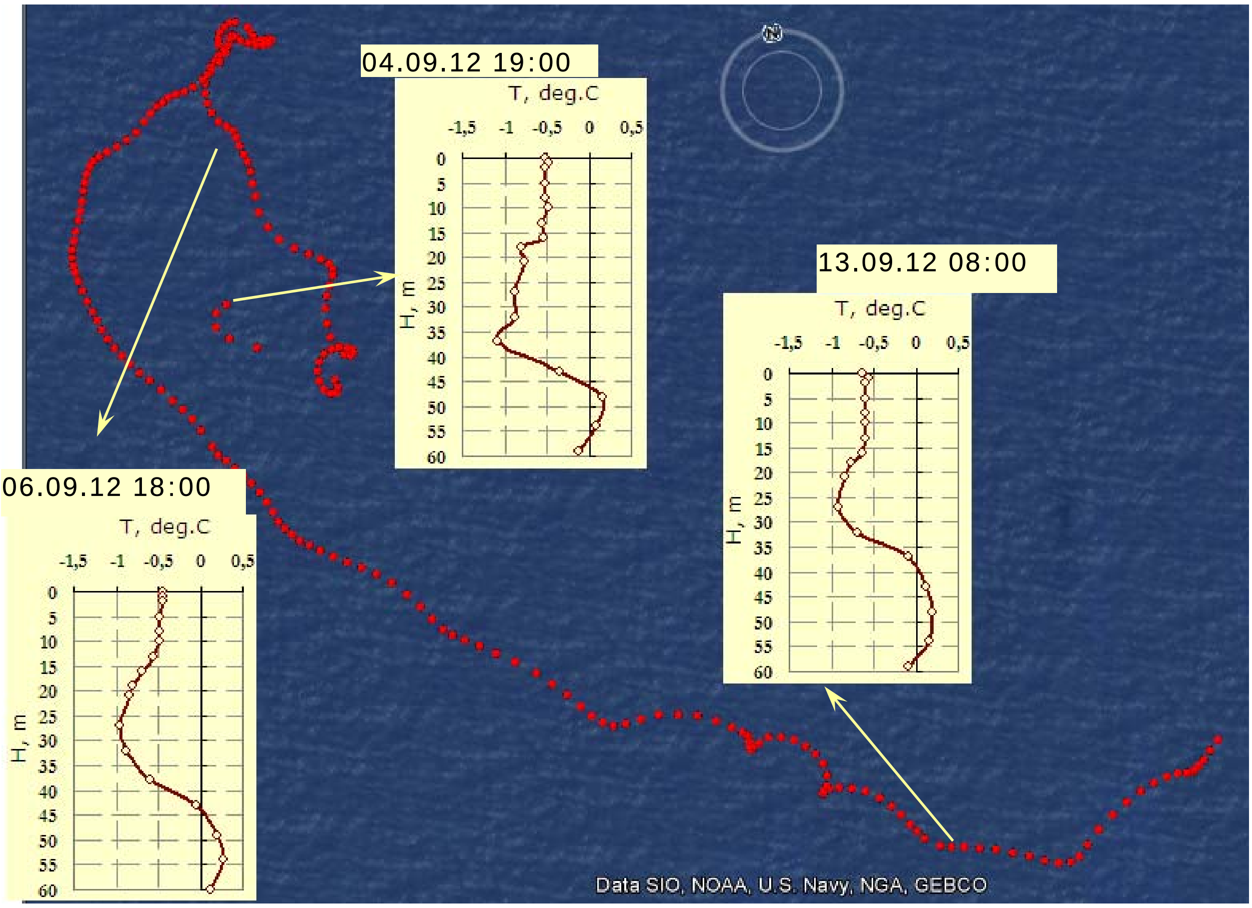

Figure 22. Fragment of the buoy’s trajectory from 4 Sep to 15 Sep 2012, built on basis of hourly GPS fixes, and 3 vertical temperature profiles.

Temperature variability from temperature sensors, fixed at the depths shown on right side, is presented on Figure 23.

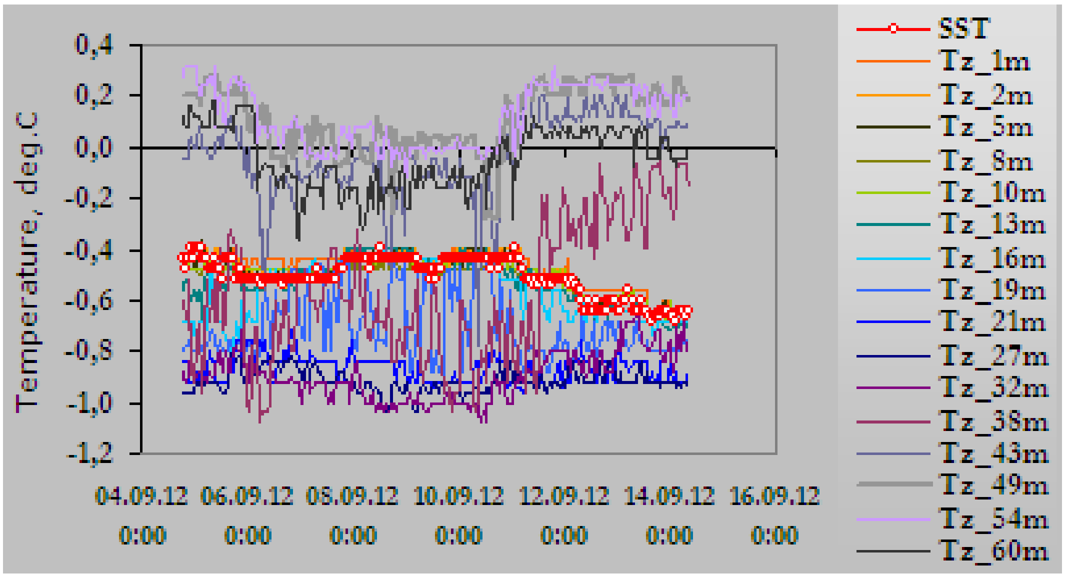

Figure 23. Temperature variability measured by temperature sensors of the chain from 4 Sep to 15 Sep 2012.

This buoy was the first prototype of ice temperature-profiling drifters and further design of this tool depends on the result of long its study in situ.

Argos-2 ice micro buoys with parachute deployment.

New development got the “micro” drifter (ice marker) with 20-cm float. The view of this marker is shown on the Figure 24.

Figure 24. View of micro ice marker, equipped with parachute system to be deployed on ice or snow.

The buoy got the parachute system to be ready for air drops on ice or snow. The parachute is connected with platform, which supports buoy. The connection of platform with parachute is via tip-up spring-supported rods. After contact with ice the rods become free to turn and be aflat fixed. Simultaneously the parachute’s container with parachute attached becomes free. As a result of this the buoy stays at platform, while parachute can be carried with wind or stay near buoy.

In spite of the fact that main application of this buoy is a tracking of ice-floes, the buoy has necessary capacity of positive buoyancy as well as static and dynamic stability of vertical orientation to be used as marine buoy swimming under wave influence. To drop the buoy in water, another prototype of parachute was developed. The parachute is connected with buoy via eyebolt in bottom of buoy as it is shown on Figure 25. Parachute keeps permanent connection with buoy and plays a role of drogue in water. The buoy can be used for tracking of oil patches.

Figure 25. Micro buoy for parachute deployment in water for oceanographic and other applications, e.g. tracking of oil patches.

The test drops on ice and snow of buoy equipped with parachute were carried out from aircraft as well as from helicopter at late 2011-early 2012. Both experiments were successful. Figure 26 shows the opening of parachute after drop from aircraft. Figure 27 shows the buoy with parachute fully opened. Figure 28 shows buoy after landing. The land played role of ice.

Figure 26. Opening of parachute after drop from aircraft.

Figure 27. The with parachute fully opened before landing.

Figure 28. The buoy after landing. The land played role of ice.

The drop of buoy from helicopter is shown on Figure 29 (opening of parachute) and Figure 30 (buoy after fall in snow). There were two doubts before test drops. The first was that air flow from helicopter directed down could close the parachute’s canopy. The second was that platform could not be opened because of small resistance of snow. Nevertheless, all was perfect. If helicopter velocity was 200 km/hour at least the canopy was completely opened. Similar was with fall to snow.

Figure 29. Opening of parachute after drop from aircraft.

Figure 30. The buoy after fall to snow.

We hope that this device could be used for different applications as oceanographic as well as other orientation. In particular, these buoys were used for study of marine animal life.

Water level measuring device.

In August of 2012 it was successfully finished the evaluation of the WLG-100 Water Level Gauge. The device was developed as a transfer of drifter technology with different goals to be applied. Data transfer via Argos-2 allows using of the device in difficult of access areas.

Among the areas of application could be:

- Monitor of subterranean waters level;
- Coastal water level;
- High and low tide;
- Level of flood.

The device has automatic correction of the level depending on barometric pressure. Its measuring parameters are shown in the Table 6.

Table 6

Technical Parameters of the WLG-100 Water Level Gauge

Parameter	Range	Resolution	Accuracy
Water level, m	0 to 100	0.02	±0.1
Air Pressure, hPa	850 to 1054.7	0.1	±1.0
Water temperature, °C	0 to +60.0	0.03	±0.2
Temperature inside the case, °C	Minus 30 to +50.0	0.2	±1.0
Supply voltage, V	7 to 14	1.0	±1.0

The structure of the device is shown on the Figure 31.

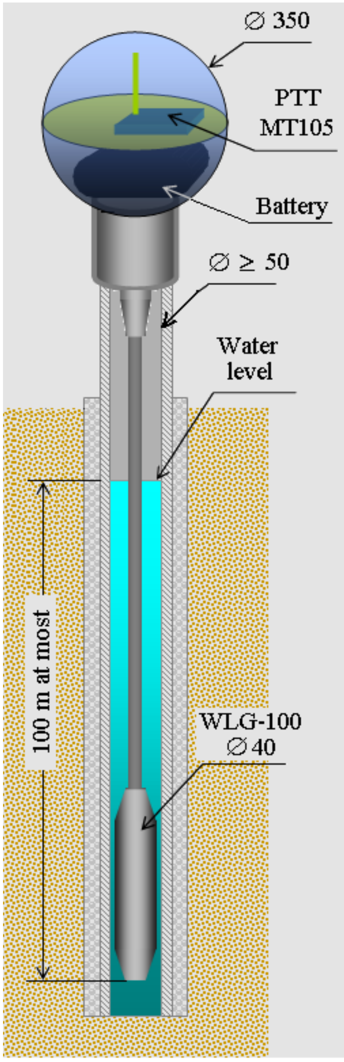

Figure 31. Structure of the WLG-100 Water Level Gauge.

The test prototype of the device was evaluated at the North of Sakhalin Island (Russia) to monitor during one year the level of subterranean waters below gas pipe. The WLG-100 view at the top of drilled hole is shown on the Figure 32.

Figure 32. WLG-100 Water Level Gauge, fixed at the top of pipe liner of drilled hole.

Figure 33 shows fragment of data about water level with fast fall and fast reconstruction of the water level< that took place according to unknown reasons.

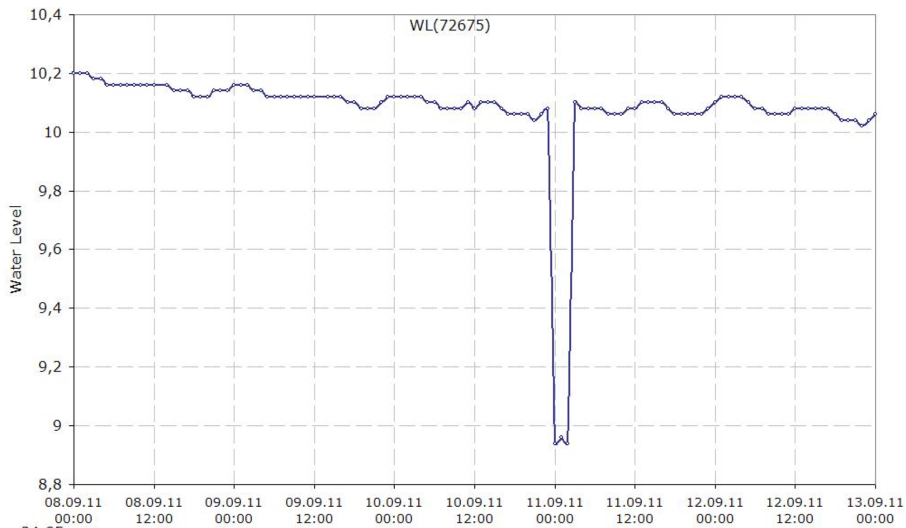

Figure 33. Fragment of data about water level with fast fall and fast reconstruction of the level. The reason of this event is unknown.

Conclusion.

1. Argos-2 drifters can provide more than 6-year tracking of its movement.
2. SVP-B drifters have RMS < 0,6-0,7 hPa under any wave-wind conditions of South Ocean right up to full battery depletion or 3 years at least.
3. SVP-B mini drifters have RMS < 0,7-0,9 hPa and lifetime 2 years at least.
4. Long-living SVP-B drifters can be used in difficult of access South Ocean, while SVP-B mini drifters with shorter lifetime– in low latitude by means of deployments from ships of opportunity.
5. “Wire connection” of tether and drogue as whole are reliable parts of drifter. The problem of fast loss of drogue is wire tether. Fix of tether in clips and use of swivel

below float could keep drogue attached longer.

6. One satellite Argos-3 current configuration does not allow to determine completely the system’s capabilities. Preliminary Argos-2 and Argos-3 SVP-B mini buoys have similar same lifetime.
7. Iridium with hourly GPS SVP-B drifters have 1000 days lifetime at least. Continuity of hourly samples and GPS fixes are near 99% and 90% correspondingly under any weather conditions.
8. Iridium SVP-B buoys without GPS have continuity of hourly samples near 99% under any weather conditions and should provide 3,5 years operation at least.
9. Iridium ice prototype of SVP-BTC/RTC/GPS drifter was developed and deployed for trail. The buoy can be used also as marine drifter.
10. The drifter with 20-cm outside diameter hull, equipped with parachute, was developed and successfully tested from aircraft and helicopter.
11. WLG-100 Water Level Gauge for different applications, connected with monitoring of water level, was developed and successfully tested.