PROVOR : A HYDROGRAPHIC PROFILER BASED ON MARVOR TECHNOLOGY

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Abstract : IFREMER has developed, through industrial partnership with TEKELEC/MARTEC company, a lagrangian subsurface float, named MARVOR. While drifting at depth, MARVOR can be located using the RAFOS technique and comes up to the surface at regular intervals to transmit via ARGOS all gathered data, including pressure, temperature, time of arrival of acoustic signals. Most of the floats are programmed to drift at depth for two or three months and spend two or three days at the surface but some others are deployed inside eddies and surface every month. As MARVOR is self-ballasted, operating pressure can be decided just before deployment. These floats were designed for an operationnal life of 3 years and about fifty cycles. The first serial equipments were launched at the beginning of 1994, so some of them have already been operating for more than 4 years. This paper presents an evaluation of the global behaviour at sea of the first hundred floats and gives some statistic informations about life duration, causes of failure and drifts of sensors. Moreover, it shows the modifications which have been done to ensure a higher reliability or compensate some aging phenomenas. At least, it presents the characteristics of the PROVOR float which is a hydrographic profiler, based on MARVOR technology.

I - INTRODUCTION

Following the SOFAR and RAFOS float, MARVOR, a multicycle subsurface float, located at depth by acoustics, was designed at the beginning of the nineties, initially within the framework of WOCE program. The development of such an equipment is difficult and it is necessary to take into account the results of the sea experiments to try to improve performances. This paper draws up an evaluation of the results of the MARVOR which have been cycling for more than 4 years and presents the PROVOR CTD profiler which is based on the same technology.

II - OPERATIONNAL PROGRAMS

The first MARVOR floats were launched through operationnal cruises at the beginning of 1994 and the global amount of floats at sea at the end of 1997 was about 160. Three scientific programs are using most of these floats :

- SAMBA is a contribution to WOCE in South Atlantic. This IFREMER program aims at describing the absolute general circulation of the Antartic Intermediate Water (AAIW) as it spreads northward, around 800 m, in the Brazil Basin.
- ARCANE associates IFREMER and the Hydrographic Service of the French Navy to investigate the circulation of Mediterranean Water in the eastern North Atlantic Ocean.
- EUROFLOAT is focussed on the Labrador Sea Water as well as Mediterranean Water in the interior only, east of the Mid-Atlantic Ridge. EUROFLOAT project is a partnership of european scientists.

Figure 1 shows the trajectories of some of these floats. Most of them are programmed to drift at depth for 2 or 3 months and the duration of the data transmission is 2 or 3 days each time they surface.

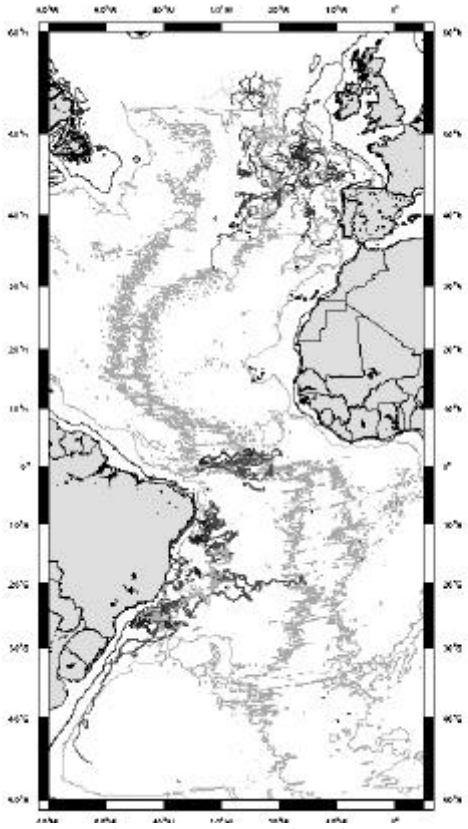

Fig. 1 - MARVOR trajectories

Figure 2 shows the movements of a MARVOR float which was launched inside a meddy. As its speed is quite high, it is located by acoustics every 8 hours and it surfaces every month. The duration of the ARGOS transmission is only 8 hours, using 4 identification numbers.

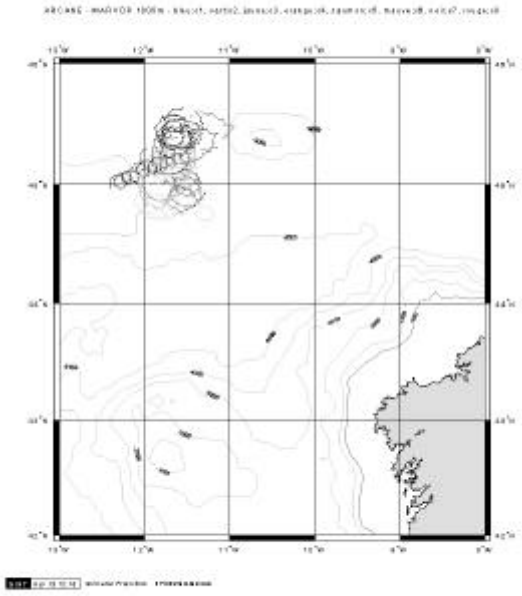

Fig 2 - Trajectory of MARVOR 656 (by courtesy of EPSHOM and ARCANE scientists)

III - SOME TECHNICAL RESULTS

Some of these floats were deployed only a few months ago and their running time are not long enough to be taken into account to get an idea of the global behaviour of the equipments. Figure 3 shows the results of the first 94 deployed floats, 20 in February 94, 29 in November 94, 45 in Summer 96. Each of them was programmed before launching to reach a pressure comprised between 450 and 1750 dbars.

On this figure, it is considered that a running float is cycling and transmitting data regularly via the Argos Satellites System. They are two reasons to explain the high rate of stranded floats. The first one is the circulation of the water in the area of the experiments and the wind when the float is at the surface which draw up the floats to the coasts.

The second one was the control software which, at first, did'nt take into account the processing of stranding risk. This was corrected in 1995 and since then, when a float detects the ground during diving, it comes up back to the surface, transmits via ARGOS some grounding messages and dives again in after a short drifting period at the sea surface.

Stranding risk being discarded, figure 3 shows very good results for the whole MARVOR performances: they are pointed out to about 80 % after 3 years at sea, and more than 60 % after 4 years. It is thought that normal failures occure when battery cells are worn out or, for some of the floats, when some trouble appear on the hydraulic engine. This latest point have been lessened since 1995, when the hydraulic parts of the engine were reduced in order to decrease the leakage risk. Only one valve is used now and the control of the depth is activated more frequently. All these enhancements passed severe qualification tests before being implemented on released floats, in order to assess the reliability improvement.

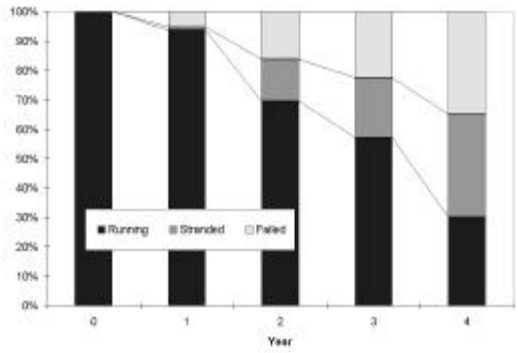

Fig. 3 - Operational Life Duration of MARVOR

An evaluation of the aging of the main components of the float is now in progress. Informations are extracted from technical data which are transmitted when the float is operating or from observation of recovered equipments. MARVOR is fitted with a high precision time base, with a nominal drift of 3 sec/year. The hour of the float and the hour of the satellite can be compared during the transmission phases. This showed the quality of the time base, which is provided by SEASCAN company. The pressure sensor seems to present an offset increasing a few dbars in time : that is corrected by the float itself by taking into account the value of the pressure measured at the surface. Some equipements were recovered after 2 or 3 years at sea : as all the mechanical parts in touch with sea water are anodized, no corrosion is visible.

From another point of view, it is necessary to get a great knowledge of the power supplies and to control the global consumption. The weight of the batteries must be compensated by the volume of the float and the duration of life, including some performances, number of cycles for example, is very long. One can consider that the batteries which are used by a MARVOR float after five

operating years are seven years old. The main consuming parts of MARVOR are the hydraulic system and the Argos transmitter, which are powered by a 14 V lithium battery. Some floats which stranded, coming back the surface very often, made more than 50 cycles.

IV - PROVOR

PROVOR is a free drifting profiler which uses most of the electronic or mechanical parts which were designed for MARVOR, and take advantage of its improvements. When MARVOR drifts at depth for 2 or 3 months, being located very precisely every day, PROVOR has to come up to the surface to permit its localization by the ARGOS Satellite System and the period of emergence is about 10 days. During the trips between the surface and the depth, profiles of temperature and conductivity of the upper layer of the ocean are gathered. the typical operating cycle is shown on figure 4.

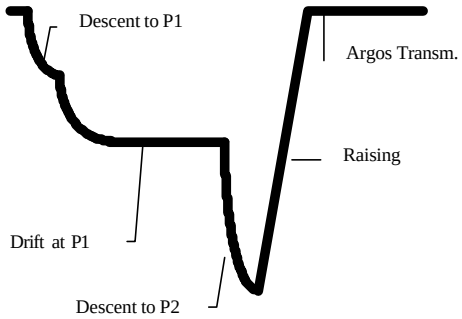

Fig. 4 - Operating cycle of PROVOR float

The float executes identical cycles which are programmed by the user before launching. During the descent phase, the float reaches the drifting level (P1) by light adjustements of the volume of the external ballast, each time the float stabilizes. There is no control of the speed. T or CT measurements can be conducted and the period of data acquisition can be as low as 10 seconds. After the float stabilizes at the desired pressure, it drifts with the surrounding water, until the date of the second descent to the profile pressure (P2), where it stays for a few hours, waiting for the hour of start of profile. The typical duration of the drifting phase is 10 days and the maximum pressure 2000 dbars.

As PROVOR is able to adjust its volume, it can drift at a given pressure to identify the circulation of the water and dives to a higher depth before raising to the surface, to provide CTD informations all over the water column. The speed of the float is controlled during the raising and is typically set to 6 m/mn. After PROVOR reaches the surface, it tranfers the necessary volume of oil to the ballast to provide a sufficient enough stability to ensure good data transmission results. The number of cycles that can be achieved is a function of the operating pressure and the volume of data that is to be transmitted. Taking into account a MARVOR batterie pack, the number of cycles varies between 50 and 100, giving between 100 and 200 CTD profiles. To increase the number of cycles on PROVOR, the battery pack is modified, as there is no acoustic receiver, and the data transmission time restricted, by reducing the volume of useful informations.

V - DATA ACQUISITION

It is necessary to keep the time spent at the surface as low as possible for many reasons :

- the environment is much harsher at the surface than at depth (swell effects in rough sea, risks of collision...),
- the float aims to describe the subsurface water circulation and its drift at the surface must be low, compared with the drift at depth,
- a long stay at the surface means a great energy consumption, as the floats comes up to the surface to transmit data via ARGOS.

For all these reasons, it is necessary to reduce the volume of data to transmit and to choose correctly the most pertinent informations, according to the aims of the final user of the equipments. On PROVOR, CTD measurements are gathered function of time and then processed to extract temperature and conductivity profiles which are functions of the pressure. As the sampling period may be as low as 10 seconds, the number of measurement points over 2000 meters during the raising phase may reach 2000. The resolution of the different measurements is 0.01°C, 0.01 mS/cm and 5 dbar respectively for Temperature, Conductivity and Pressure. That means that the raw data is stored on about 6000 bytes.

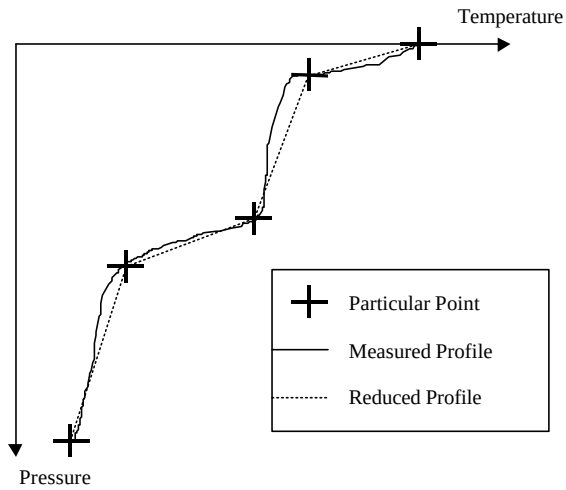

Fig 5 - illustration of the reduction method

Without any treatment, 4 days would be neccessary to transmit all these data. It is possible to reduce the volume of raw data by keeping only some particular points in such a way that, if a stright line is draught between 2 particular points, the difference between the real T or C measurements and the interpolated values is lower than a maximum error which is defined during the programming phase of the float.
This data processing method was already used to reduce the volume of data provided by XBT sensors and is illustrated on figure 5. As the variability of T and C is much higher in the upper layer of the water column, it is possible to define two differents areas with a specific maximum error in each area, for exemple 0.1°C in the upper side and 0.03°C in the lower side.

VI - CONCLUSION

The design of a subsurface equipement needs a lot of work and many sea trials before its use by operational programs. As the operating life is very long, the sea trials can't be sufficient to verify all the expected performances of the equipment and an evaluation is possible only after a few years. More, it is necessary to take advantage of the available basic technology to try to meet others needs. The quality of MARVOR results and the emergence of Operational Oceanography programs explain the development of the PROVOR profiler which will be produced by series in 1999.

ACKNOWLEDGEMENTS

The authors acknowledge the scientific teams who bought the MARVOR floats and permit to use their data. It is fundamental to exploit the technical results of the sea experiments to improve the quality of the equipments, therefore to have access to the data of the operating floats. Thanks go to people involved in SAMBA, EUROFLOAT and ARCANE programs at IFREMER and EPSHOM.

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