An easy-to-use method of determining launching points to deploy ARGO floats drifting with certain average spacing

Shinya KAKUTA*1　Yasunori SASAKI*1

An easy-to-use method of determining launching points to deploy floats drifting with certain average spacing is proposed. Counting the number of drifting floats within a certain radius from the last launching point, this method determines the next launching point successively. It is easy to adopt this method even on cruise tracks curved or broken. In the areas where floats converge or diverge, the above-mentioned radius should be extended or reduced proportionally to the rate of convergence or divergence.

Keywords : ARGO, float, drift, launch, deploy

ARGO漂流フロートを満遍なく展開させる簡便な投入点決定法

角田　晋也*2　佐々木保徳*2

漂流ブイを満遍なく展開させる場合の簡便な投入点の決定法を提唱する。直前の投入点からある半径内で漂流しているフロートの数を数えることにより，次の投入点を逐次決定する。この手法は航路が曲線や折線であっても適用可能である。また，フロートが収束または発散する海域では，収束あるいは発散率に比例して上記半径を大きくあるいは小さくすればよい。

キーワード：アルゴ，フロート，漂流，投入，展開

＊1　Japan Marine Science and Technology Center
＊2　海洋科学技術センター

Introduction

ARGO is an international project that is conducted under the cooperation of international meteorological and oceanographic organizations, such as the World Meteorological Organization (WMO), the Intergovernmental Oceanographic Commission of UNESCO (IOC), and other institutions including related governmental agencies of Japan. During the period of the ARGO project, approximately 3,000 ARGO profiling floats (profiling devices, Photo 1 and Figures 1 and 2) are to be deployed into the world ocean with average spacing of about 300km (Roemmich, D. and W. B. Owens, 2000). Recent distribution of floats is shown in Figure 3. Floats are launched by ships while this paper is being written. Since ship time is limited, ships cannot always deploy floats with such spacing of 300km. Moreover, in most cruises, float launching is not the first-priority mission. Thus, launching points should be chosen on a beforehand determined cruise track. Another aspect to which attention must be paid is that floats are drifting. Thus, evolution of spatial intervals and displacements of floats during their life span must be considered. This paper proposed an easy-to-use method of choosing launching points to deploy floats with certain average spacing, for example, for ARGO.

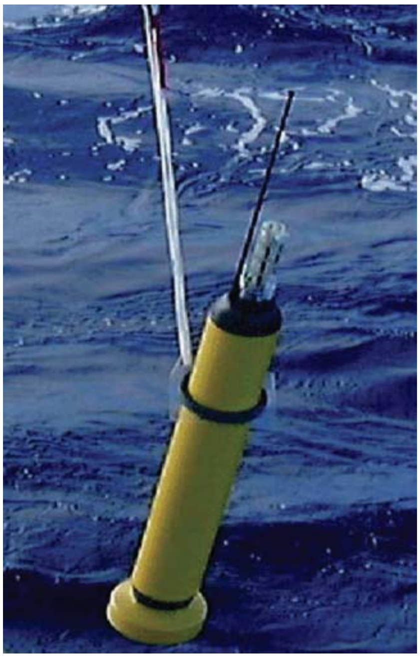


Photo 1 An example of ARGO floats.

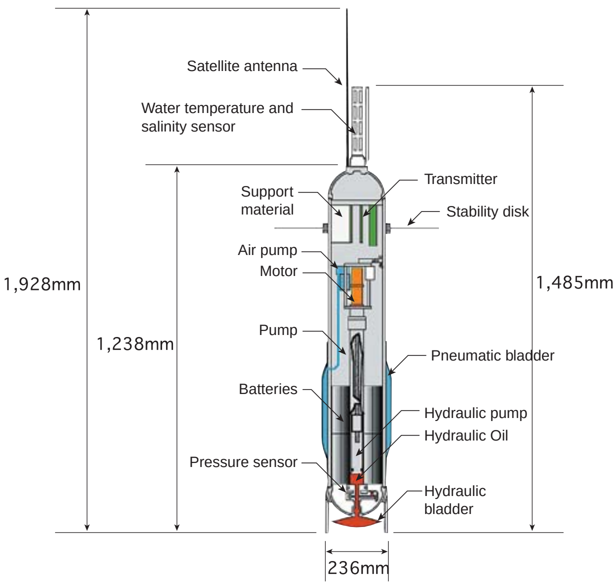


Fig. 1 Schematic figure of an ARGO profiling float.

Objective

Objective is to deploy drifting floats with average spacing of about 300km. It may be supposed that, ideally, floats are located on square grids with intervals of 300km. However, it is not practical to realize such even spacing owing both to limitation of ship time and to

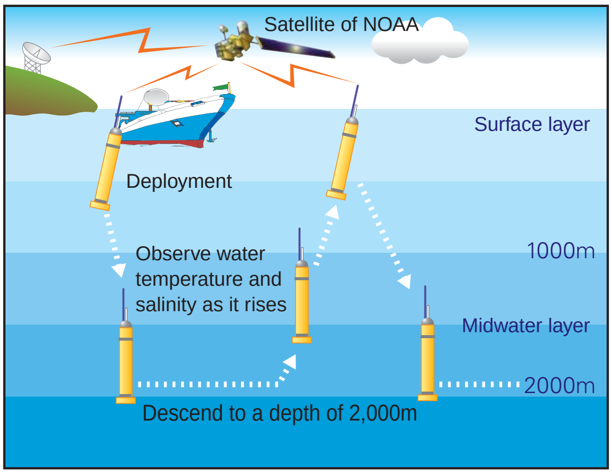


Fig. 2 Schematic figure of an ARGO profiling cycle.

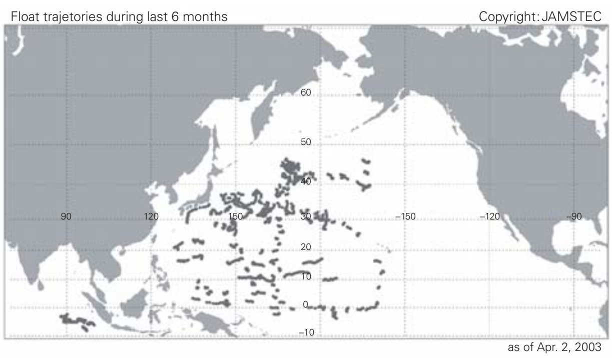


Fig. 3 Distribution of Japanese ARGO floats.

drift of floats. To accomplish the objective, thus, 'average spacing of about 300km' should be defined. This definition is discussed in the following section.

Method

Counting the number of drifting floats within a certain radius from the last launching point, this method determines the next launching point successively. For practical use, we propose to define 'average spacing of about 300km' as in Figure 4. Suppose that a ship is now launching a float at Point A, the center of a circle with 3L/2 of radius. Here, L is desired average spacing, for example, 300km for ARGO. The area of the circle is $9\pi L^2/4$, nearly equal to $7L^2$. Thus, the number of floats in the circle is desired to be 7. In Figure 4, only 5 floats, including one just now launched at Point A, are drifting in the circle. Thus, another 2 floats are desired to be launched in the circle. Launching points of those next 2 floats and Point A are desired to be apart from each other. Thus, the launching interval AB is determined by dividing the radius by 2. When a float has been launched at Point B, the succeeding launching point is similarly determined with Point B centered.

In the above description, the area of the circle $9\pi L^2/4$ is approximated as $7L^2$, for simplicity of explanation. However, it is not necessary to round $9\pi/4$ to an integer number. More generally speaking, the interval AB can

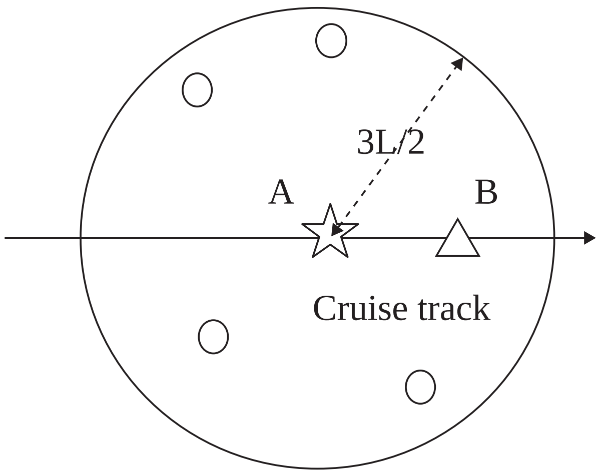


Fig. 4 Schematic figure of determining an interval of launching points. An arrow shows a cruise track and a ship direction. Small circles indicate drifting-float locations. A star indicates the last launching point named A. A triangle indicates the next launching point named B. A ship is on the way from Point A to B. L is desired averaging spacing, for example, 300km for ARGO.

be determined by dividing the radius by $(9\pi/4\text{-}5)$.

Since this method determines distance between Points A and B, the cruise track is allowed to be curved or broken. This is an advantage in practice because cruise tracks are not always straight.

Discussion

Intervals of floats are about 300km. Life spans of floats are about 3 years. In 3 years, floats drift about 1000km far away (Oka, 2001). These lifelong displacements are about 3 times larger than the float intervals. Thus, the intervals are rather large in terms of the life spans. In other words, the relative positions among floats are rather well conserved; namely, the life spans are too short or the intervals are too large for mixing-like rearrangement of floats.

The radius of the large circle in Figure 4 is rather arbitrary. If the radius is too large, a float to be launched will not be able to reach float-spare portions in the circle. On the other hand, if the radius is too small, the 'average' in the term 'average spacing' does not make sense because of too small number of floats. In this paper, the radius is set to 3L/2, where L = 300km: desired average spacing. The radius is also about half of the order of lifelong displacements. Thus, a float to be launched is expected to reach a float-sparse portion within the circle within a half of its life span, wherever the portion is located in the circle.

Of course, intervals among floats within the circle may evolve to take any value during their life span; namely, some floats may get closer while others apart. Such detailed motion is not predictable because of oceanic eddies. As a result, it is also unable to predict where float-sparse portions will appear in smaller scales than the radius in the future, for example, one and a half year later. Thus, it is meaningless to worry about future local convergence or divergence of drifting floats in such small scales in advance. As seen in Figure 5, even floats launched at the same point at once has been drifting as far as 200km apart from each other only one year. Thus, roughly speaking, it is impossible to predict evolution of distance between a pair of floats with a higher resolution than 200km even for a year. Thus, it is also appropriate to consider that a radius within which average should be taken is 300km (desired average spacing) + 200km (eddy-related fluctuations), namely, 500km.

This is also close to 3L/2 (450km).

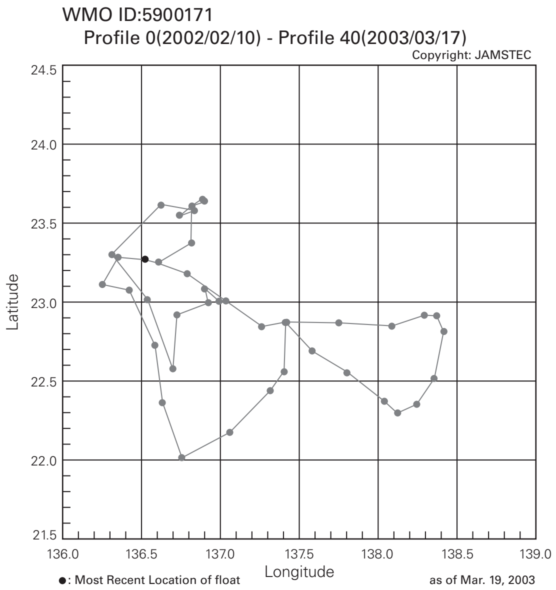
Oka (2001) showed float convergence and divergence zones in the Pacific. Especially, convergence is so intense in the zone of 20 to 30 degrees N that the number of floats becomes over-one-and-half times larger in 3 years there. In such zones, launching intervals should be larger than shown in Figure 2 by simply making the radius larger proportionally to a convergence rate, while the desirable float number $9\pi/4$ remains the same. In such zones as of divergence, the radius should be reduced proportionally to a divergence rate.

What if there is no or little drifting floats in the circle? If there is no drifting floats in the ocean, this scheme gives 3L/14 of interval. To understand more easily, 3/14 is approximately 0.21. Successively, intervals are given as 0.25L, 0.3L, 0.375L, 0.375L, 0.375L... If the radius is set larger than 3L/2, intervals determined in the same way become smaller. The larger the radius, the less likely it is to find no drifting floats in the circle.

What if there are already too many, namely, 7 or more drifting floats in the circle? Natural conclusion is that no float is to be launched in the circle.

In the above discussion, choice of an initial Point A remained to be arbitrary. However, an initial Point A should not be set when there are too many, namely, 7 or more floats are drifting within 3L/2 from a ship.

As above described, no complicated computation but only simple arithmetic is required for this method. This user-friendliness is also advantage.



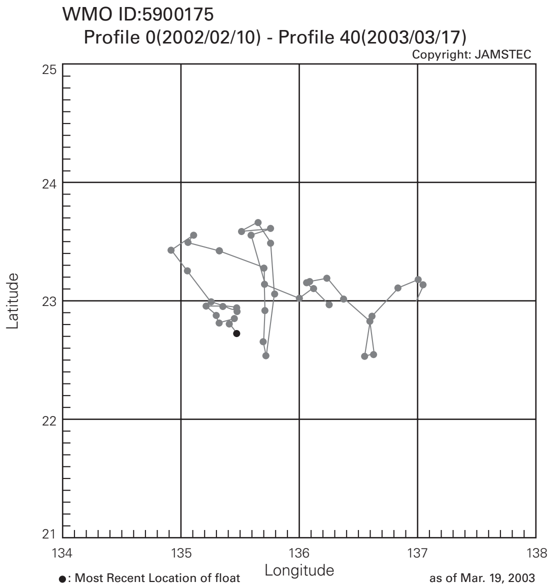


Fig. 5 Trajectories of 2 ARGO floats launched at 23N-137E on 31 January 2002.
Only one month later after their launch, they had already gone 50km apart from each other.

Conclusions

The proposed method of determining launching points to deploy floats drifting with certain average spacing is easy to use. No computation is required even on cruise tracks curved or broken.

References

Oka E., 2001: A simulation for deployment of ARGO floats. JAMSTECR (Report of Japan Marine Science and Technology Center), 44, 9-16 (in Japanese with English abstract and legends).

Roemmich, D. and W. B. Owens, "The ARGO project: global ocean observations for understanding and prediction of climate variability," Oceanography, 13, 45-50 (2000).

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