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INVESTIGATIONS ON THE CURRENTS INFLUENCING ICEBERG MOTION

by

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ABSTRACT

Several factors contribute to the natural drift of an iceberg, and among these, currents play an important part on the translation and rotation. Some information exists on surface currents in sub-Antarctic areas, but an iceberg behaves as a current integrator due to its draught and it is assumed to drift under the action of a "mean" current. In order to measure the mean current, five drogued buoys were launched in July-August 1979. These buoys were located by Argos satellite transponders. The drift of the buoys gives the mean current from 0 to 230 m depth in the Southern Ocean. Some corrections must be made on the measured drifting speed of the drogued buoys, due to the influence of the wind on the above-water portion of the buoys.

INTRODUCTION

It is important to distinguish between the contribution of the ocean current to the drift of an iceberg and that of other factors such as wind, swell, and waves. An iceberg behaves as does a current integrator over its depth, and the main driving force for the movement of an iceberg is the integrated effect of the current. If the draught of a typical Antarctic tabular iceberg is assumed to be 230 m, then the speed and heading of an iceberg will approximate the mean direction and mean speed of the current from 0 to 230 m depth.

Surface currents in the Southern Ocean are shown in Figure 1. Deep currents are not well-documented and further investigations are needed to extend our knowledge of them. The use of fixed current meters does not give satisfactory results, since information is obtained on the local behaviour of currents only. A simple method of obtaining an approximate Lagrangian movement, which is basically what was required, was to use drogued buoys, with drogues made up of several floating anchors. Five buoys were launched in July-August 1979, thus equipped to determine the average of the currents from 0 to 230 m depth. This paper presents the drift track analyses of these buoys.

THE BUOYS

The buoys, four of which were still working well eight months later, were launched in July-August 1979 and transmit information by means of the Argos system. This system uses two satellites which receive information transmitted by the beacons of the buoys. The collected data are retransmitted to a computation and processing centre, which distributes them to users. The buoys are equipped with a timer which switches off the emission from the beacons for periods of four days in order to reduce the processing costs and to increase the life of the batteries. The mean error of position is $\approx$ 480 m, with a maximum error of 2.8 km. It was important that the buoys should be lightweight and portable, with shock-resistant hulls, so they were made of polyester strengthened with fibre glass (Fig. 2). Water tightness was ensured by polyurethane foam. The Argos transmitter works at temperatures ranging from -30 to +40°C, and the transmitting antenna was omnidirectional and protected by a hood. The total weight of the equipped buoy was about 80 kg. The planned battery life of the buoys was two years.

The main problems in setting up the drogues were as follows: the drogue had to be constructed in such a way that the effect of wind and swell on the above-water part of the buoy was minimal, the drogue had to remain vertical and taut however the velocity and direction of the current varied, and the repetitive stresses at the junction between drogue and buoy had to be kept to a minimum. To resolve these problems, a drogue consisting of wired cylinders was chosen. These cylinders were attached at intervals of 5 m on a wire which was 200 m long. They offered a very high drag coefficient. The drogue was kept vertical and taut by means of an immersed float and a 50 kg chain used as a weight at the bottom of the drogue. The heave was damped with a catenary curve made of a rope provided with 27 cylindrical floats attached at one side of the immersed float and at the buoy on the other side (Fig. 3). The buoy and the drogue were as independent as possible.

Fig. 1. Generalised surface water movement in the Southern Ocean, from the *Antarctic pilot* (Great Britain. Hydrographer of the Navy 1974).

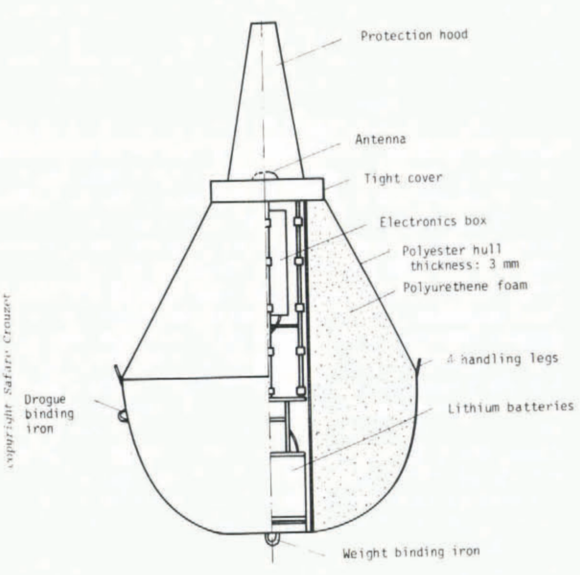

Fig. 2. Buoy.

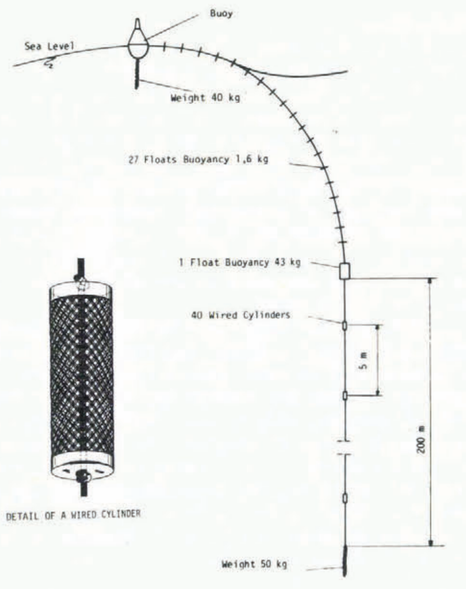

Fig. 3. Drogued buoy launched in July-August 1979.

LAUNCHING OF THE BUOYS

The five launching locations of the buoys were:

Buoy	Date	Launching points	
3 009	24 Jul 1979	44°59'S.,	10°53'E.
3 008	25 Jul 1979	49°43'S.,	10°53'W.
3 007	26 Jul 1979	54°08'S.,	10°28'W.
3 005	31 Jul 1979	52°08'S.,	2°53'W.
3 001	1 Aug 1979	47°17'S.,	1°29'E.

These locations were chosen in order to cover the current field from 45°S. to 55°S. Launching a buoy involved several steps. The buoy, equipped with its drogue, floats, and chain, was arranged on the deck of the ship. When the ship stopped, the buoy was lifted into the water by a crane and when the drogue was fully immersed the 50 kg weight was cast overboard. Unfortunately, the first buoy (3 009), launched at 45°S., broke down on the day following the launch.

The positions of the buoys are transmitted every four days, and are plotted on a Mercator projection chart as well as on a bathymetric chart of the south-east Atlantic and south-west Indian oceans to show the drift in relation to bathymetric features. The last recorded positions of the four functioning buoys were:

Buoy	Date	Positions	
3 008	22 Mar 1980	49°52'S.,	49°09'E.
3 007	23 Mar 1980	51°58'S.,	44°48'E.
3 005	19 Mar 1980	53°34'S.,	53°58'E.
3 001	20 Mar 1980	43°41'S.,	44°30'E.

TRAJECTORIES

The principal features of the trajectories of the buoys may be seen in Figure 4 and are as follows (the Antarctic convergence plotted in this figure is approximate, corresponding to its mean position in winter, as it varies seasonally and from year to year):

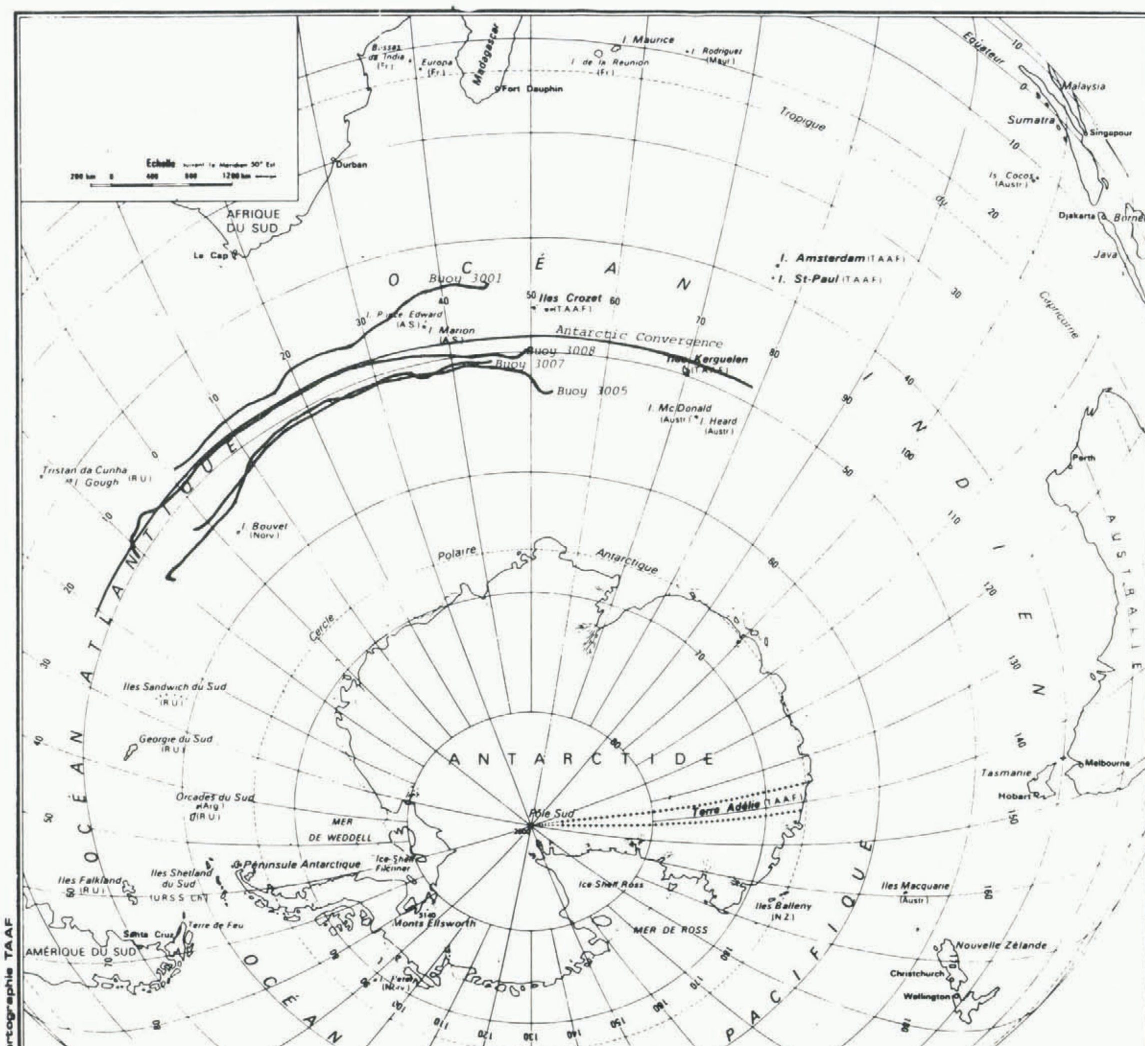

Fig. 4. Trajectories of buoys.

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1. Buoy 3 001 kept its launching latitude from nearly 0° to 30°E. From longitude 30°E., its mean heading was about 081° and thus it passed north of Marion Island. The distance of drift was about 3 800 km in 231 days. During the first two months, the trajectories of 3 001 had a sinusoidal shape with an amplitude of nearly 1° and a period of about 15 days (Fig. 5). This may be due to a tidal effect, to alternating passages of cyclones and anticyclones, to the influence of seamounts, or to the influence of eddies at the northern edge of the convergence.

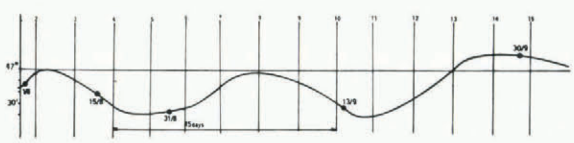

Fig. 5. Sinusoidal shape of the trajectory of buoy 3 008.

2. Buoy 3 008 travelled furthest from its launching point, drifting more than 5 000 km. Its trajectory followed the 48°S. parallel to 25°E., from where it was deflected to the south to reach its last recorded point. During the first two months the drift was distorted. This may be because the launching point was on the Antarctic convergence.

3. Buoys 3 005 and 3 007 were launched at nearly the same latitude, but 10° apart in longitude. The difference corresponds to a drift of about one month. This separation was still evident after eight months of drift. Their trajectories were very similar and crossed on five occasions.

The mean heading of the four buoys between 5°E. and 40°E. was as follows:

Buoy	Mean heading
3 001	082°
3 008	094°
3 005	090°
3 007	091°

VELOCITIES

The velocity was obtained by dividing the rhumb line distance by the time between two positions, and the direction by the rhumb line heading between two positions. The velocities of different buoys were compared by calculating from positions at 5°E. to positions at 40°E.

To obtain the mean zonal speed, the mean speed was multiplied by the sine of the mean heading. Thus the variation with latitude of the mean zonal speed is calculated. The average speeds of the buoys for the whole period were:

Buoy	Average speed (knots)
3 001	0.40
3 008	0.52
3 005	0.39
3 007	0.41

In order to correct for the influence of wind on the drogued buoy, practical tests were carried out and theoretical calculations made. From these, it was concluded that the true mean speed of the current was about 95% of the speed of the drogued buoys.

The mean zonal speeds between 5°E. and 40°E. were as follows:

Buoy	Means zonal speed (knots)	Corrected speed (knots)
3 001	0.32	0.30
3 008	0.40	0.38
3 005	0.37	0.35
3 007	0.37	0.35

Figure 6 shows the average zonal current speeds compared with those obtained from drifting buoys launched in 1976 by South Africa (Harris and Stavropoulos 1978).

CONCLUSIONS

1. The hull and the electronic equipment worked satisfactorily. It seems that the loss of drogues was mainly due to the heave of the buoy. The use of a floating line to reduce wear at the junction of drogue and buoy increased the efficiency of the buoys.

2. Comparison of the trajectories of the buoys gives interesting results on the general field of the integrated current to 230 m depth and from 0° to 45°E. It was noticed that buoy 3 001, launched north of the Antarctic convergence, was deflected to the north, and that the other three buoys, launched south of the convergence, kept to the same latitude except for 3 008 which moved slightly south. This confirms the influence of the convergence on the drift of icebergs which tend to stay to the south of the convergence.

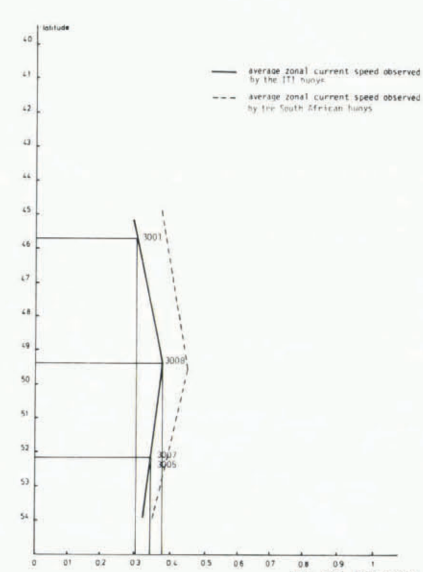

Fig. 6. Variation with latitude of zonal drift speeds.

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Icebergs sighted further north could be those which drifted across the 50th parallel north of South Georgia.

3. The importance of the Antarctic convergence was further seen when the mean speeds of the buoys were analysed. The greatest average speed was observed for buoy 3 008 which was nearest to the convergence. The variations of the average zonal current velocity of the buoys and those obained in 1976 were similar. The average velocities of the buoys represented 80% of the average velocities of the buoys launched in 1976. If the current fields were identical in 1976 and 1979, then this indicates that the average zonal speed of the current integrated from 0 to 230 m represented 80% of the surface current.

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