1. Publication Nº INPE-3793-PRE/888

2. Version

3. Date February 1986

5. Distribution ☐ Internal ☒ External ☐ Restricted

4. Origin DME/DAM

Program OCEMAR/MEDICA

6. Key words - selected by the author(s)
OCEANOGRAPHIC BUOY
DRIFTING BUOY
BRAZILIAN ANTARCTIC PROGRAM

7. U.D.C.: 551.46:551.508.825(99)

8. Title INPE-3793-PRE/888

DEVELOPMENT OF A SATELLITE-TRACKED OCEANOGRAPHIC DRIFTING BUOY FOR THE BRAZILIAN ANTARCTIC PROGRAM (PART I)

10. Nº of pages: 23

11. Last page: 19

12. Revised by

Yelisetty Viswanadham

9. Authorship Merritt R. Stevenson
Eduardo M.B. Alonso

Responsible author

13. Authorized by

Marco Antonio Raupp
Director General

14. Abstract/Notes One of the objectives of the project Measurement of the Antarctic Current (MEDICA) is to develop, build and launch drifting oceanographic buoys, located by System ARGOS, in Antarctica. Previously such national buoy technology did not exist in Brazil. The basis of the drifting buoy was to use a Data Collection Platform (DCP), already developed by INPE for land use and certified by the Centre National d'Études Spatiales (CNES), in France. Consideration was given to using nationally made materials to the maximum extent possible. A biconic geometry was used for the buoy hull to provide good vertical stability and resistance to entrapment by ice. Fiberglass was used for its high strength to weight ratio, as well as the facility to use molds for production of the hulls. Sandwich construction was incorporated by a commercial firm (producing the hull) and provided for outer and inner hulls of fiberglass with polyrethane foam between the walls. Within the hull, the DCP unit and its interface box are mounted within a metal conical rack. The transmitting antenna is mounted on a metal base-plane disc and, in turn, is secured atop the rack. A power supply, consisting of several hundred alkaline dry cells, suitably interconnected and sealed within a plastic housing, resides below the rack for maximum buoy stability. The sensor cable was developed in collaboration with the Institute for Naval Research (IPqM) and consists of a 10m long oil filled hose containing 2 thermistors, at 0,5m and 10m from the top of the cable. An additional thermistor is mounted in a housing on the conical cover of the buoy and provides air temperature readings. The physical specifications and measuring capabilities of the sensors, as well as some results, are reviewed in the presentation.

15. Remarks This work is being submitted to Revista Brasileira de Geofísica.

DEVELOPMENT OF A SATELLITE-TRACKED OCEANOGRAPHIC DRIFTING BUOY FOR THE BRAZILIAN ANTARCTIC PROGRAM (PART I)

Merritt R. Stevenson and Eduardo M.B. Alonso

Instituto de Pesquisas Espaciais - INPE
12200 - São José dos Campos - SP - Brasil

DEVELOPMENT OF A SATELLITE-TRACKED OCEANOGRAPHIC DRIFTING BUOY FOR THE BRAZILIAN ANTARCTIC PROGRAM (PART I)

Merritt R. Stevenson and Eduardo M.B. Alonso

Instituto de Pesquisas Espaciais
C.P. 515 - 12200 - São José dos Campos - SP - Brasil

ABSTRACT

One of the objectives of the project Measurement of the Antarctic Current (MEDICA) is to develop, build and launch drifting oceanographic buoys, located by System ARGOS, in Antarctica. Previously such national buoy technology did not exist in Brazil. The basis of the drifting buoy was to use a Data Collection Platform (DCP), already developed by INPE for land use and certified by the Centre National d'Études Spatiales (CNES), in France. Consideration was given to using nationally made materials to the maximum extent possible. A biconic geometry was used for the buoy hull to provide good vertical stability and resistance to entrapment by ice. Fiberglass was used for its high strength to weight ratio, as well as the facility to use molds for production of the hulls. Sandwich construction was incorporated by a commercial firm (producing the hull) and provided for outer and inner hulls of fiberglass with polyrethane foam between the walls. Within the hull, the DCP unit and its interface box are mounted within a metal conical rack. The transmitting antenna is mounted on a metal base-plane disc and, in turn, is secured atop the rack. A power supply, consisting of several hundred alkaline dry cells, suitably interconnected and sealed within a plastic housing, resides below the rack for maximum buoy stability. The sensor cable was developed in collaboration with the Institute for Naval Research (IPqM) and consists of a 10m long oil filled hose containing 2 thermistors, at 0,5m and 10m from the top of the cable. An additional thermistor is mounted in a housing on the conical cover of the buoy and provides air temperature readings. The physical specifications and measuring capabilities of the sensors, as well as some results, are reviewed in the presentation.

DESENVOLVIMENTO DE UMA BÓIA OCEANOGRÁFICA DE DERIVA LOCALIZADA POR SATÉLITE PARA USO NO PROGRAMA ANTÁRTICO BRASILEIRO (PART I)

Merritt R. Stevenson e Eduardo M.B. Alonso

Instituto de Pesquisas Espaciais
C.P. 515 - 12200 - São José dos Campos - SP - Brasil

RESUMO

Um dos objetivos do projeto Medição da Corrente Antártica (MEDICA) é desenvolver, fabricar e lançar bóias oceanográficas de deriva, localizadas pelo Sistema ARGOS, na Antártica. Anteriormente, a tecnologia nacional para a fabricação de bóias não existia no Brasil. O ponto básico do desenvolvimento de bóias foi usar a Plataforma de Coleta de Dados (PCD), já desenvolvida pelo INPE para uso em terra e homologado pelo Centre National d'Études Spatiales (CNES), na França. Para a construção destas bóias foi dada preferência, o máximo possível, para o material nacional. Para o casco da bóia fornecer boa estabilidade vertical e resistência ao gelo, foi usada uma geometria bi-cônica. Foi utilizada fibra de vidro por causa da sua alta razão força ao peso do material, e também pela facilidade do uso de moldes para confeccionar os cascos. Uma construção do tipo "sandwich" foi utilizada por uma firma comercial (que está confeccionando o casco), que consistiu em paredes internas e externas de fibra de vidro com espuma de poliuretano entre elas. Dentro do casco, a PCD e sua caixa de interfaces são montadas dentro de um "rack" cônico metálico. A antena de transmissão está montada sobre um disco ("base-plane"), o qual está também montado acima do "rack". A fonte de força consiste em algumas centenas de pilhas alcalinas que estão interconectadas e seladas dentro de uma caixa plástica, que fica abaixo do "rack", para estabilidade máxima da bóia. O cabo de sensores foi desenvolvido em colaboração com o Instituto de Pesquisas da Marinha (IPqM) e consiste em uma mangueira de 10m de comprimento cheia de óleo, que contém dois termistores, um a 0,5m e o outro a 10m abaixo do ponto superior do cabo. Um termistor adicional está montado dentro de uma pequena caixa na tampa cônica da bóia, e fornece leituras da temperatura do ar. As especificações físicas e as capacidades dos sensores para obter medidas, bem como alguns resultados, são examinados na apresentação.

Introduction

This is the first of three reports on results from the first test and use of INPE's drifting oceanographic buoy in Antarctica. The second report (Stevenson et al., 1985a) describes oceanographic conditions during the buoy test; the third paper discusses some results from the buoy and a comparison with shipboard observations (Stevenson et al., 1985b)

One of the objectives of the project, Measurement of the Antarctic Current (MEDICA), is to develop, build and launch drifting oceanographic buoys, located by System ARGOS, in Antarctica. Previously such national instrumentation did not exist in Brazil. The basis for developing the buoy was to use a Data Collection Platform (DCP), already developed by INPE for land use and certified by the Centre National d'Études Spatiales (CNES), in France.

Drifting oceanographic buoys normally contain one or more sensors and process data in one of two modes: data recording systems and data transmitting systems. We selected the data transmitting mode because it is less expensive and also is capable of greater flexibility in the field. Because of the inhospitable coastal terrain and large distances involved in Antarctica, the ARGOS System, a satellite receiving system, was adopted as the most efficient and practical system for INPE.

The ARGOS System, whereby data from a drifting buoy is received and relayed by satellite, is shown in Figure 1. The buoy transmits a signal containing sensor data, at approximately one minute intervals, through an omnidirectional antenna. TIROS-N satellites, in polar orbits (for example NOAA-7 and -9), passing over the local horizon of the buoy, receive the buoy's signal with their ARGOS Systems. Two satellites are normally in operation at a time. Buoy messages are stored aboard the satellite and retransmitted to the Wallops Island station (USA) during its overflight of that station. The ARGOS data are separated from other satellite data received at Wallops and are retransmitted to ARGOS Center in Toulouse, France via geostationary satellite. There, Service ARGOS, an automated computer system, enters buoy data into special computer files, by country, experiment, etc. For a buoy where several transmissions were received during the same satellite overflight, buoy position is calculated in latitude and longitude, with an error of about 300m. The number of satellite overflights obtainable per day is a function of latitude and whether one or two satellites are operating (Figure 2). For research in Antarctica, about 12 positions per day can be obtained, along with associated buoy sensor data. After processing each data set with the ARGOS computer, the buoy data may be received 1 1/4 - 3 1/2 hours after satellite passage, via telex from the ship in Antarctica. Later, copies of the data on magnetic tape or printer listings are received in Brazil from Service ARGOS.

To assist in the development of national oceanographic instrumentation, the buoy construction used nationally made materials to the maximum extent possible. The buoy is made of a number of components (Figure 3), and these units will be individually considered.

FIGS. 1, 2 and 3

Buoy Components

- Buoy Hull

A biconic geometry was selected for the buoy hull in order to provide good vertical stability and resistance to entrapment by ice. The buoy hull design is seen in Figure 4. The hull consists of the reinforced lower section and an upper lid that is secured to the lower section with 1/2 inch diameter stainless steel bolts. Two rubber "O" rings are placed between the mating surfaces to keep out seawater and moisture. Buoy height is 1.87 m and is 70 cm in diameter at its widest point.

FIG. 4

Fiber glass fabrication was used due to its high strength to weight ratio. Also, molds made from fiberglass may be readily used in the production of the fiberglass hulls. Sandwich construction was incorporated by the commercial firm producing the hull, and provides for outer and inner hulls of fiberglass with 2 cm of polyurethane foam between the 5 mm thick walls. The wall of the upper section (buoy cover) is 6 mm thick.

- Data Collection Platform (DCP), Rack and Antenna

Within the hull, the DCP is supported by a conical metal rack.- The DCP which transmits in the UHF frequency range (401 MHz) is supported by a conical metal rack. Sensor input signals are received from an interface box, also mounted on the rack. The power source for the sensors and signal conditioning are provided from the interface box.

The transmitter antenna is a compact, quadrifilar type and is fixed to a metal disc, which in turn is mounted atop the conical rack. The antenna design was prepared by the department of telecommunications at INPE, and was fabricated by INPE's mechanical shop.

- Power Supply

The power supply consists of more than 600 alkaline dry "D" cells, suitably interconnected. The batteries are housed within a plastic container that is then filled with polyurethane foam to seal out water. Due to the weight of the supply (~82 kg), it resides below the rack for maximum buoy stability.

- Sensor Cable and Sensors

The sensor cable was developed in collaboration with the Institute for Naval Research (IPqM). The cable consists of an oil filled, nylon-reinforced plastic hose 10 m long and 1.5 cm in diameter which contains 2 thermistors. The thermistors are located 0.5 m and 10 m, respectively, from the top of the cable. Each thermistor is embedded in a small brass cylinder to provide a reasonable time constant. A small-diameter steel cable runs through the hose to provide additional strength.

The top of the sensor cable is connected to the bottom of the buoy with a brass connector that allows the sensor wires and supporting steel cable to enter the buoy. The sensor cable is in turn loosely wrapped around the heavy duty steel cable supporting the drag element, and is connected to the bottom of this cable.

A third thermistor is embedded in a small brass "finger", mounted inside a fiberglass housing on the conical cover of the buoy, and provides air temperature readings. The sensor cover has perforations on the sides and bottom to allow for air flow, and water drainage in case of heavy seas.

- Drag Element

A drogue or drag element is used with a buoy when it is desired to "couple" the drifting buoy to subsurface water. A rectangular or window shade drogue was selected for use with our buoy. The window shade is made from rip resistant nylon fabric and measures 3 m by 2 m. A fiberglass tube at the top and bottom of the nylon material is filled with ballast, to improve the water coupling characteristics of the drogue. The drag element is connected to the bottom of the buoy with a 10 m long, steel cable by means of a swivel.

Results of Test in Antarctica

A test of the buoy was made during 9-12 March 1985, in Bransfield Strait. During the test sensor data were transmitted by the buoy to NOAA satellites passing overhead, while buoy positions were subsequently determined by Service ARGOS.

- Buoy Positions

Geographic positions were determined by Service ARGOS for the buoy over the 3-day period (Figure 5). An evaluation of adjacent position fixes shows the fixes to be consistent with each other to within about 300m. Additional information on the buoy trajectory will be presented separately in this Meeting (Stevenson et al., 1985b).

During transmission from the buoy, four 8-bit channels (0-255 counts) were used: three for temperature sensors and one for the power supply voltage. Since acceptable voltage level is critical for all of the electronic components, this channel will be considered first.

- Voltage Level

The buoy DCP was turned on when the buoy and Oceanographic Support Vessel *Barão de Teffé* were still in proximity to the Brazilian Base, Capitão Ferraz (Figure 6). During the interval of 12-19 hours (GMT) on 9 March, the buoy was transmitting while the ship was en route to the launching site. The arrow and "B" in Figure 6 indicate when the buoy was launched.

FIGS. 5 and 6

During each overflight of the NOAA-7 and NOAA-9 satellites, up to 16 buoy transmissions were received by the satellites. These data sets, separated by one minute intervals, represent the upper frequency limit for data sampling, during the test. The solid curve (Figure 6) represents the mean values of all these transmissions (ca. 730 observations). The voltage range 12.5 - 16.0 V corresponded to 0-255 counts, or 0.0137 V/CNT. The straight line is the linear regression curve of the observations for the test period. The regression equations

$$V = -0.031\,t + 15.25 \quad \text{and}$$

$$CNT = -2.29\,t + 200.68\ ,$$

where t is time in days, indicate that the power supply voltage decreased by 0.03 V/day (or 2.3 CNT/day). For a one year period, the power supply is projected to lose about 1.1 V, well within the operating range of the DCP and associated electronics. The variability in voltage or counts for each transmission (i) is given by the broken curves for $\pm 1\sigma_i$. The mean of the variability of these sets of voltages ($\overline{\sigma}_i$) was ± 0.0198 V, and the overall variability of voltage ($\sigma(\sigma_i)$) was ± 0.0102 V. Since the digital resolution was set at 0.014 V/CNT, the power supply appears to have been quite stable during the three day test.

- Temperature Sensors

Air temperature data were also received continuously from the buoy during the 9-12 March period (Figure 7). The solid curve again represents the mean temperature for each of the transmissions, during each overflight; the broken curves correspond to $\pm 1\sigma_i$ about the mean curve. The mean variability ($\overline{\sigma}_i$) was ± 0.154 C and the overall variability in the fluctuations ($\sigma(\sigma_i)$) was ± 0.132 C. The thermal resolution was 0.157 C/CNT for air temperatures of -30 C to 10 C. The small value for $\overline{\sigma}_i$ compared to the digital thermal resolution indicates that the air temperature channel was functioning well.

Water temperature data were also received, but in limited quantity, due to electrical problems in the sensor cable. Temperature data for the sensor 0.5 m and 10 m below the buoy are shown in Figures 8 and 9. For the transmission of good data (small σ_i), the mean variability ($\overline{\sigma}_i$) was ± 0.05 C and ± 0.067 C respectively for the shallow and 10 m sensors. The overall variability ($\sigma(\sigma_i)$) was ± 0.042 C and ± 0.0478 C, respectively. The $\pm 1\sigma$ envelopes are not shown in these 2 figures. Since the digital resolution was 0.059 C/CNT, these sensors (when not being shorted out) and associated digital circuitry are considered stable.

FIGS. 7, 8 and 9

Comments on the accuracy of the sensor data and comparison with other data will be presented in another report in this Meeting (Stevenson et al., 1985b) and hence will not be included herein.

Conclusions

Several conclusions may be drawn from the 3-day field test of INPE's drifting oceanographic buoy.

1. The buoy positions determined by Service ARGOS appeared to be consistent with each other, within about 300 m, and thereby indicated that the PCD was functioning correctly.

2. The power supply voltage decreased by 0.03 V/day, sufficient to provide autonomy for more than 1 1/2 years; better than the 1 year predicted for autonomy of the buoy.

3. Mean voltage variability ($\overline{\sigma}_i$) was ± 0.0198 V and overall variability ($\sigma(\sigma_i)$) was ± 0.0102 V. The digital resolution was 0.014 V/CNT. These values indicate that the power supply was stable and that the digital circuitry was functioning well.

4. Mean air temperature variability ($\overline{\sigma}_i$) was ± 0.154 C and overall variability ($\sigma(\sigma_i)$) was ± 0.132 C. Digital resolution was 0.157 C/CNT. These values indicate that in terms of precision, the sensor and digital circuitry were functioning well.

5. Water temperature sensors provided only limited data, but the mean variability ($\overline{\sigma}_i$) was ±0.05 C and ±0.067C for the sensors 0.5 m and 10 m below the buoy, respectively. Overall variability ($\sigma(\sigma_i)$) was ± 0.042 C and ± 0.0478 C, respectively, for the shallow and 10 m sensor. Because the digital resolution was 0.059 C/CNT,

it is concluded that when these sensors were functioning correctly, the digital circuitry provided data with acceptable stability.

Acknowledgments

The authors acknowledge the technical assistance of the firm Composite Tecnologia of São José dos Campos, SP, in the development and construction of the buoy hull and drag element. Thanks are also given to the Institute for Marine Research (IPqM) and Cdr. Carlos E. Parente for assistance in the design and fabrication of the sensor cable. Support for Project MEDICA (Measurement of the Antarctic Current) - Nº 9571) was provided by the National Antarctic Program (PROANTAR), of the Inter-Ministerial Commission for Marine Resources (CIRM).

References

ARGOS Users Guide. SERVICE ARGOS, Centre National D'Études Spatiales, Toulouse, France, 1984.

STEVENSON, M.R.; INOSTROZA V., H.M.; STECH, J.L. "Variations in temperature, salinity and density in the Strait of Bransfield during 9-14 March, 1985" In: Proceedings of I Encontro Regional de Geofísica, SBGF, Divisão Regional Sul, 27-29 de novembro de 1985a. São José dos Campos, SP (no prelo).

STEVENSON, M.R.; INOSTROZA V., H.M.; STECH, J.L.; ALONSO, E.M.B. "Comparison of some estimates of circulation and winds, based on data collected aboard ship and by satellite in Bransfield Strait, 9-14 March, 1985. In: Proceedings of I Encontro Regional de Geofísica, SBGF, Divisão Regional Sul, 27-29 de novembro de 1985b. São José dos Campos, SP (no prelo).

DEVELOPMENT OF A SATELLITE-TRACKED OCEANOGRAPHIC DRIFTING BUOY FOR THE BRAZILIAN ANTARCTIC PROGRAM

Merritt R. Stevenson and Eduardo M.B. Alonso

9 Figures

Figure Captions

Figure 1 - SYSTEM ARGOS, a system for the transmission and processing of buoy data.

Figure 2 - Number of overflights by NOAA satellites and number of location fixes per day for SYSTEM ARGOS.

Figure 3 - Diagram of INPE's drifting oceanographic buoy, tracked by SYSTEM ARGOS. A, B and C represent thermistors to measure air and water temperatures, respectively.

Figure 4 - View of INPE's prototype drifting buoy. Buoy height is 1.87 m and construction is of fiberglass. Vertical cable connects buoy and rectangular drag element.

Figure 5 - Drifting buoy trajectory in Bransfield Strait during 9-12 March, 1985. Circles represent position fixes; triangles represent oceanographic stations. Hours, minutes and days are in GMT.

Figure 6 - Voltage output of buoy power supply during field experiment. B indicates time of buoy launch. Straight line represents linear regression of data; solid curve is mean volts (or counts) per transmission; and broken curves represent 1 standard deviation about mean curve.

Figure 7 - Solid curve represents mean air temperatures from the sensor atop the buoy. Broken curves represent $\pm 1\sigma$ variability about the mean curve. B indicates the time of buoy launch.

Figure 8 - Solid curve represents mean water temperatures from the sensor 0.5 m below the buoy (1 1/2 m below the water surface). B indicates time of buoy launch. Triangles and circle represent ship temperatures and isolated buoy temperature, respectively.

Figure 9 - Same as Figure 8, but for the sensor 10 m below the buoy (11 m below the water surface).

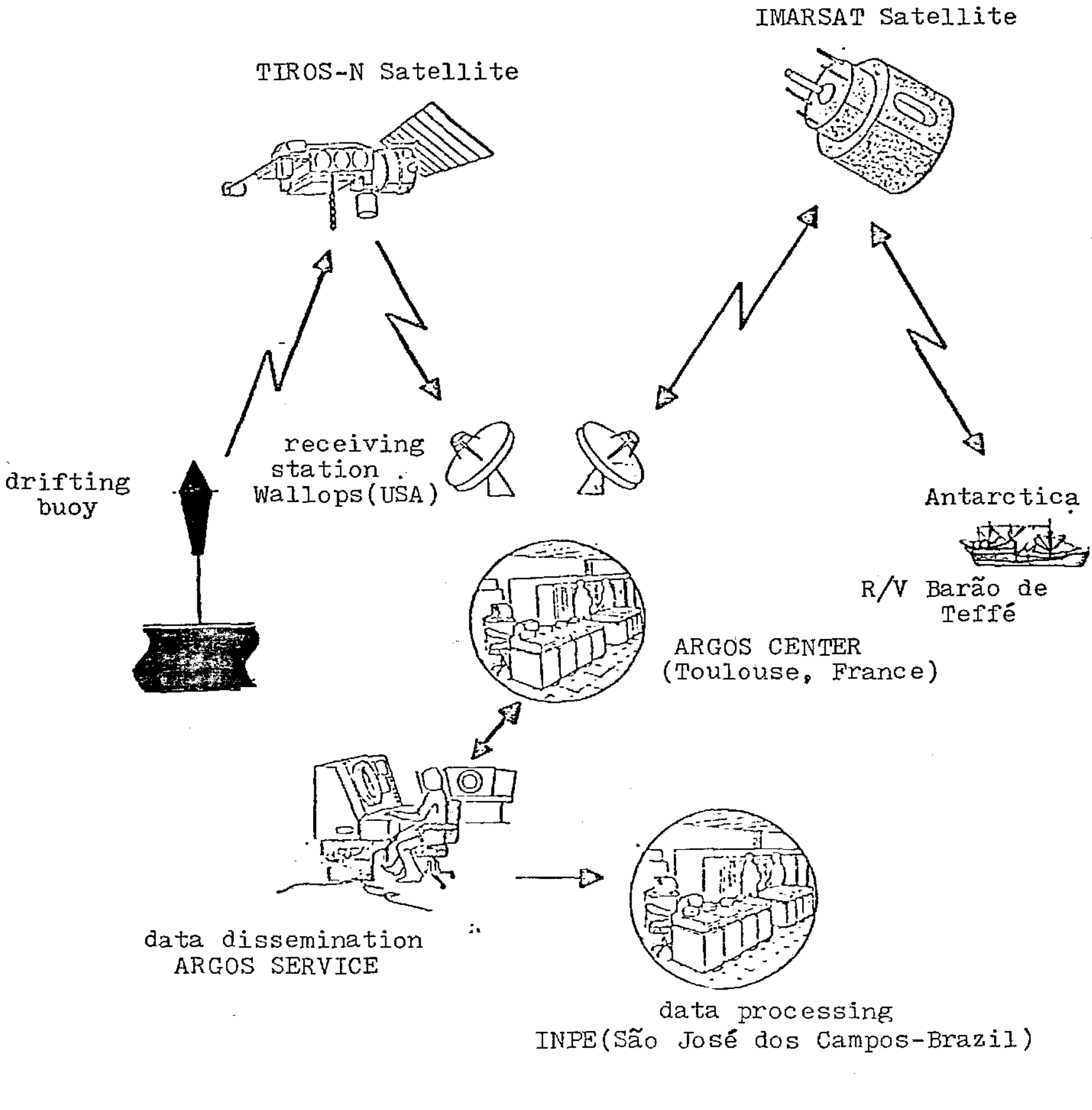

IMARSAT Satellite
TIROS-N Satellite
receiving station Wallops(USA)
drifting buoy
Antarctica
R/V Barão de Teffé
ARGOS CENTER (Toulouse, France)
data dissemination ARGOS SERVICE
data processing INPE(São José dos Campos-Brazil)

Figure 1

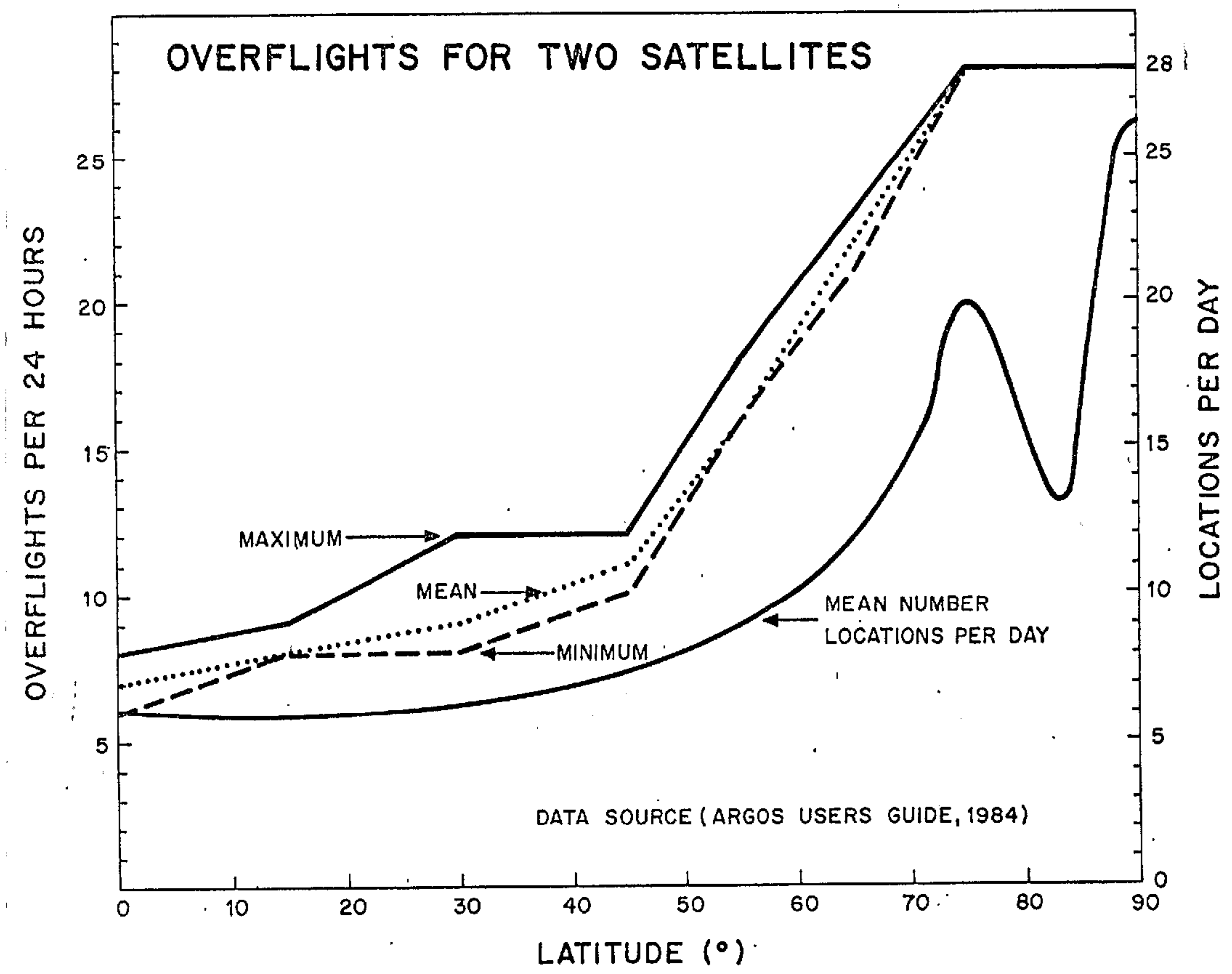

OVERFLIGHTS FOR TWO SATELLITES
MAXIMUM
MEAN
MINIMUM
MEAN NUMBER
LOCATIONS PER DAY
DATA SOURCE (ARGOS USERS GUIDE, 1984)
OVERFLIGHTS PER 24 HOURS
LOCATIONS PER DAY
LATITUDE (°)
0
10
20
30
40
50
60
70
80
90
5
10
15
20
25
28

Figure 2

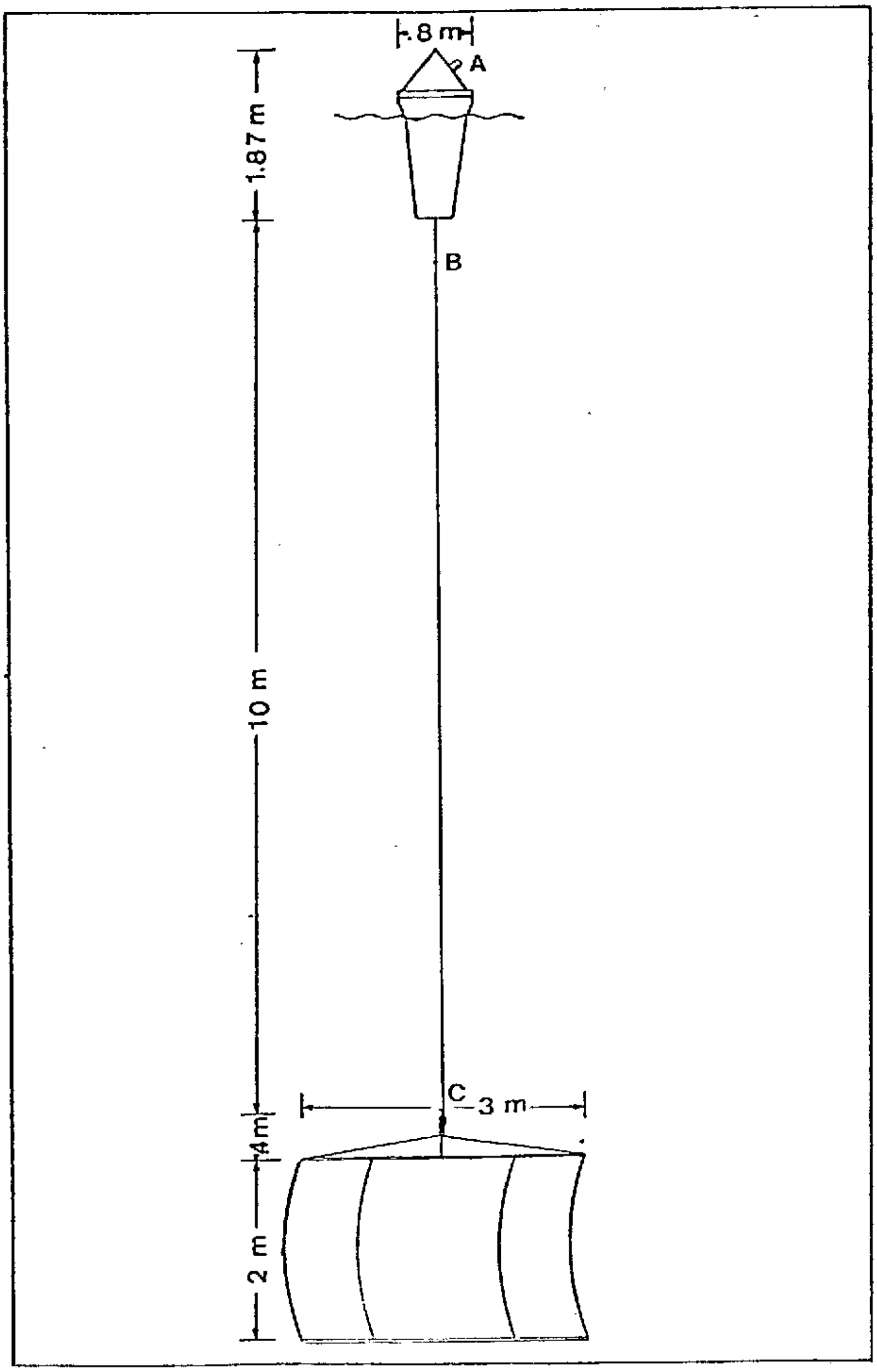


Figure 3

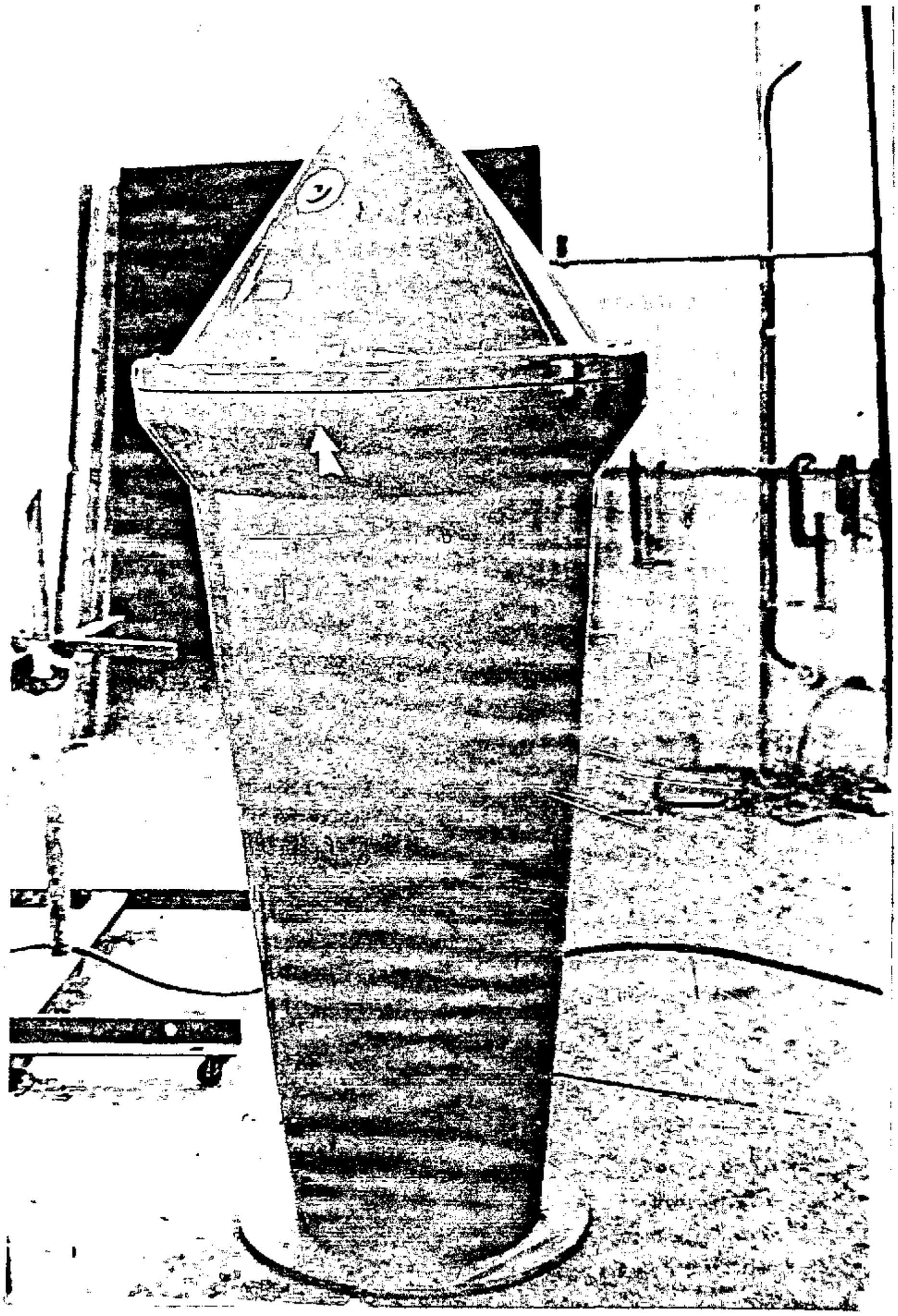


Figure 4

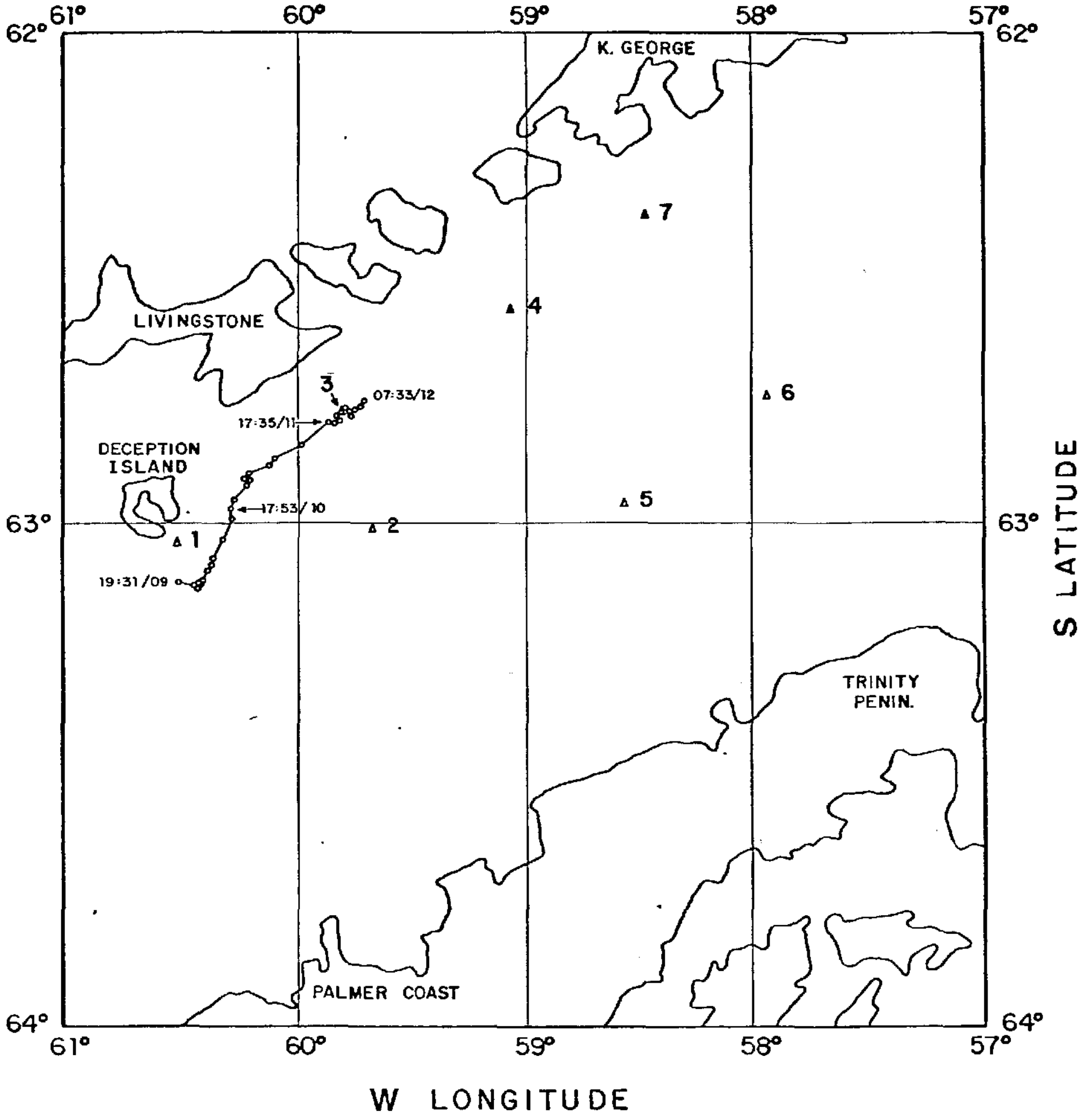

K. GEORGE
LIVINGSTONE
DECEPTION ISLAND
TRINITY PENIN.
PALMER COAST
07:33/12
17:35/11
17:53/10
19:31/09
1
2
3
4
5
6
7
61°
60°
59°
58°
57°
62°
63°
64°
W LONGITUDE
S LATITUDE

Figure 5

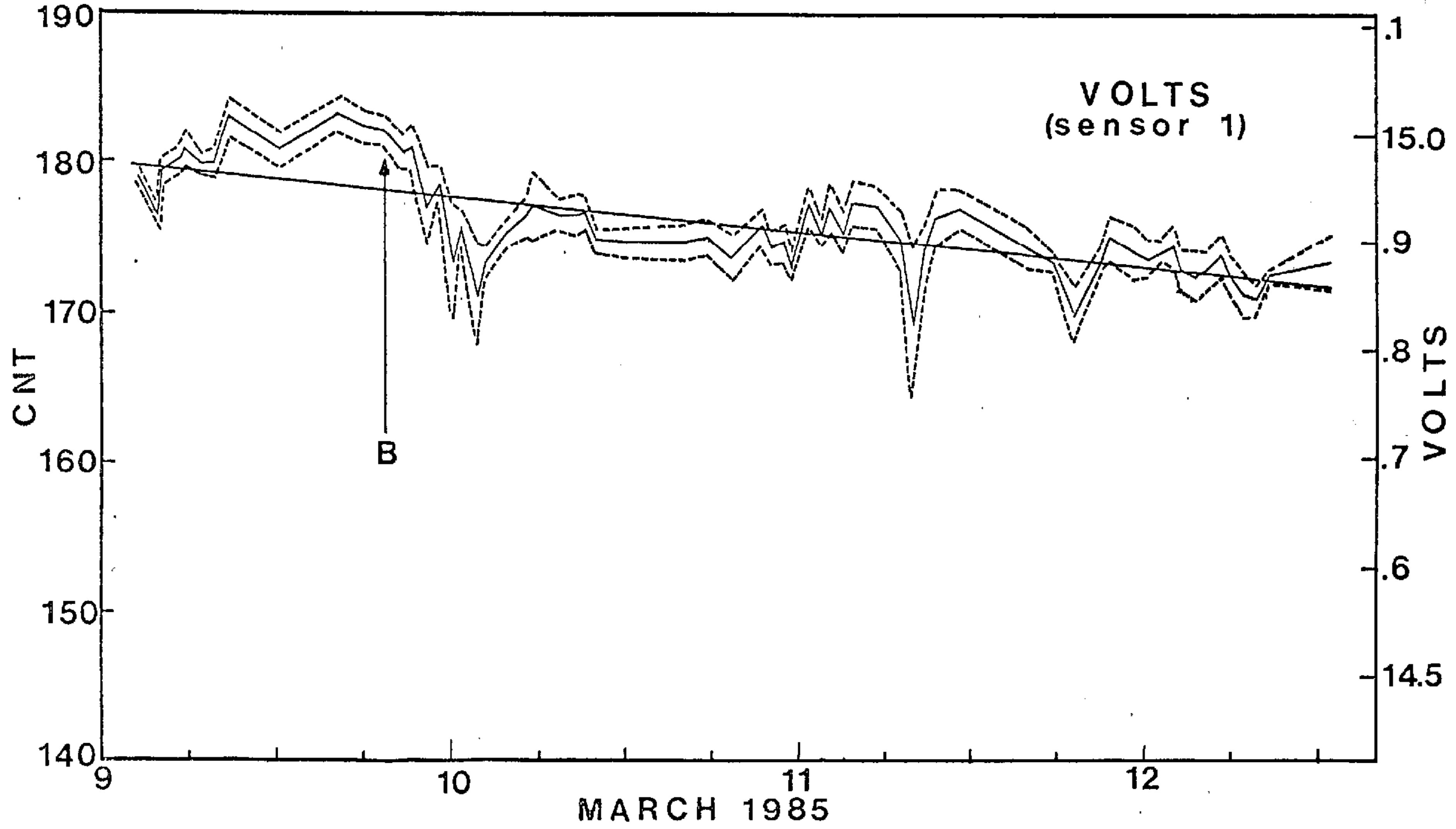

VOLTS
(sensor 1)
B
CNT
VOLTS
MARCH 1985
190
180
170
160
150
140
9
10
11
12
.1
15.0
.9
.8
.7
.6
14.5

Figure 6

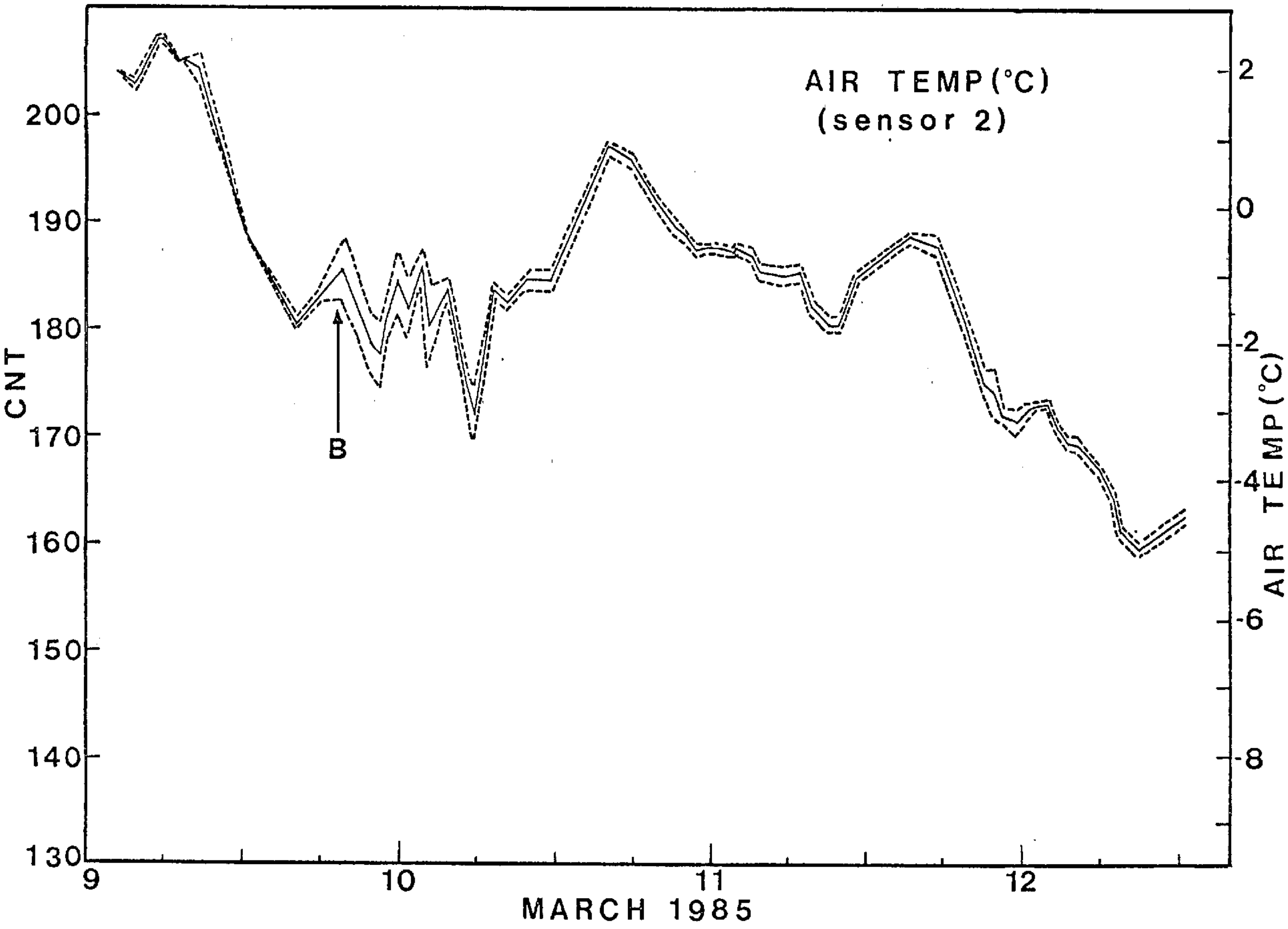
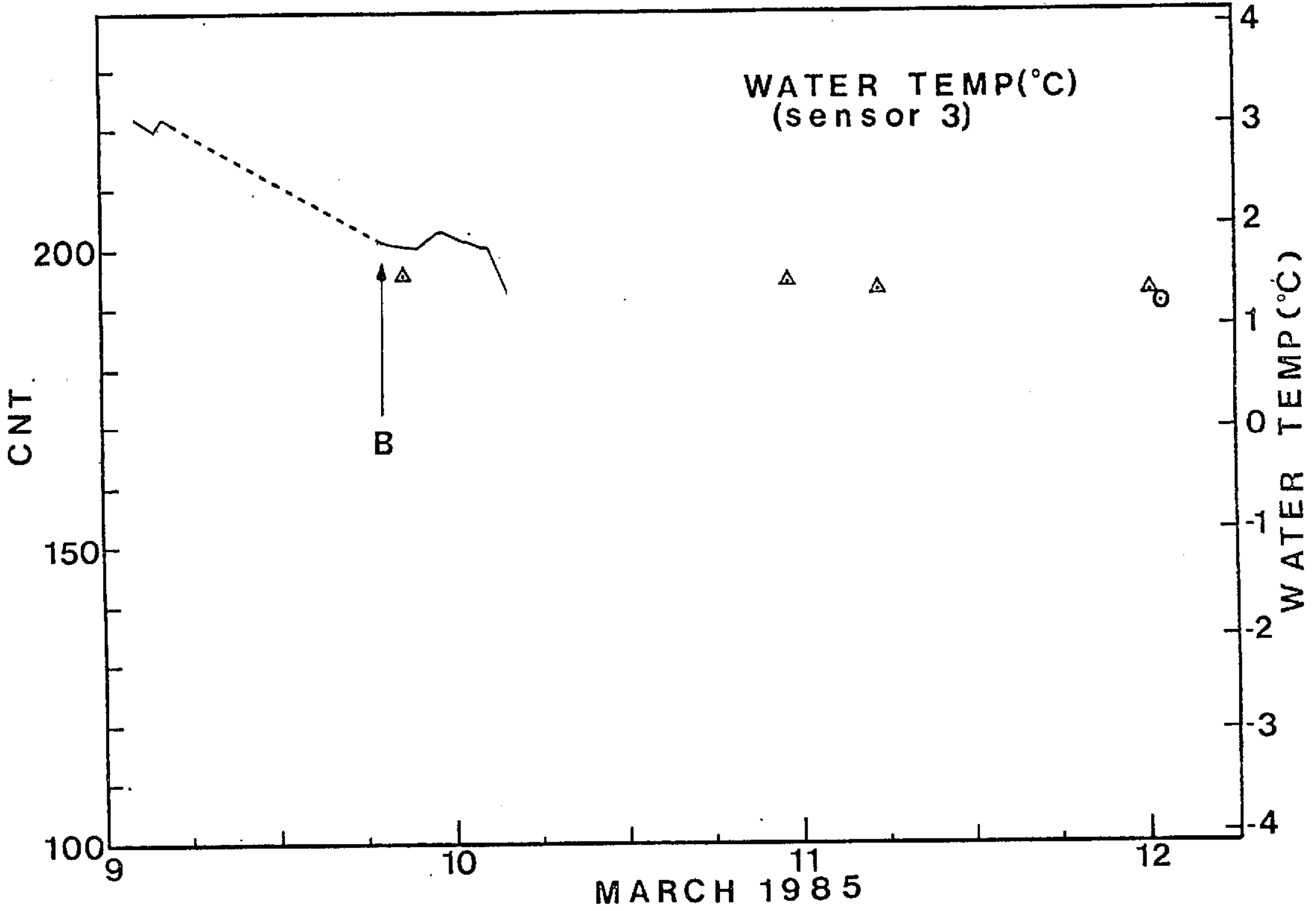

AIR TEMP(°C)
(sensor 2)
B
CNT
200
190
180
170
160
150
140
130
2
0
-2
-4
-6
-8
AIR TEMP(°C)
9
10
11
12
MARCH 1985

Figure 7



WATER TEMP(°C)
(sensor 3)
B
CNT
200
150
100
9
10
11
12
MARCH 1985
4
3
2
1
0
-1
-2
-3
-4
WATER TEMP(°C)

Figure 8

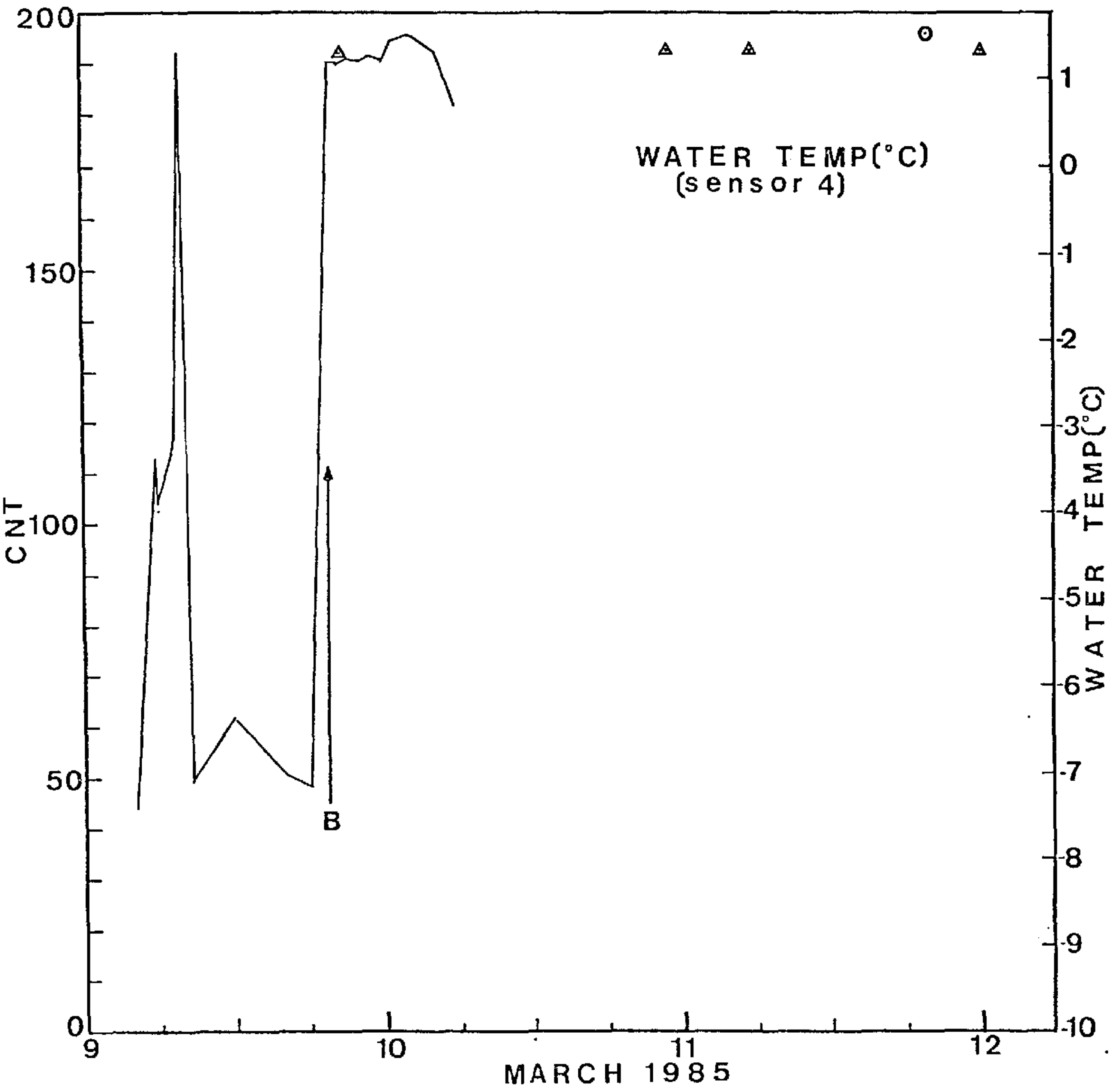


Figure 9