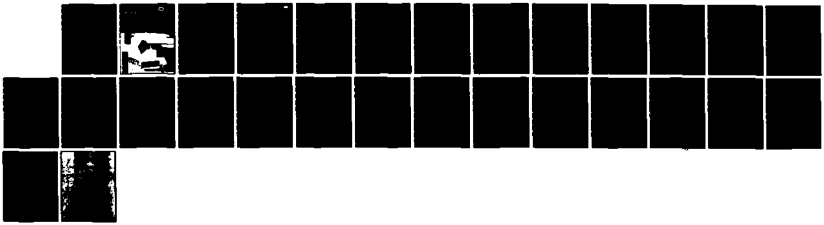
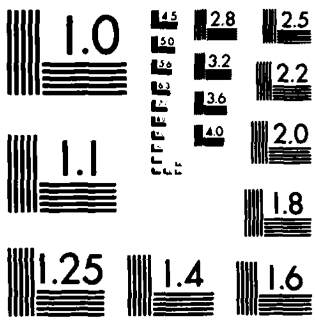
AD-A144 953 SEA ICE DATA BUOYS IN THE WEDDELL SEA(U) COLD REGIONS RESEARCH AND ENGINEERING LAB HANOVER NH S F ACKLEY ET AL. MAY 84 CRREL-84-11 NSF-DPP80-06922 1/1

UNCLASSIFIED F/G 8/3 NL





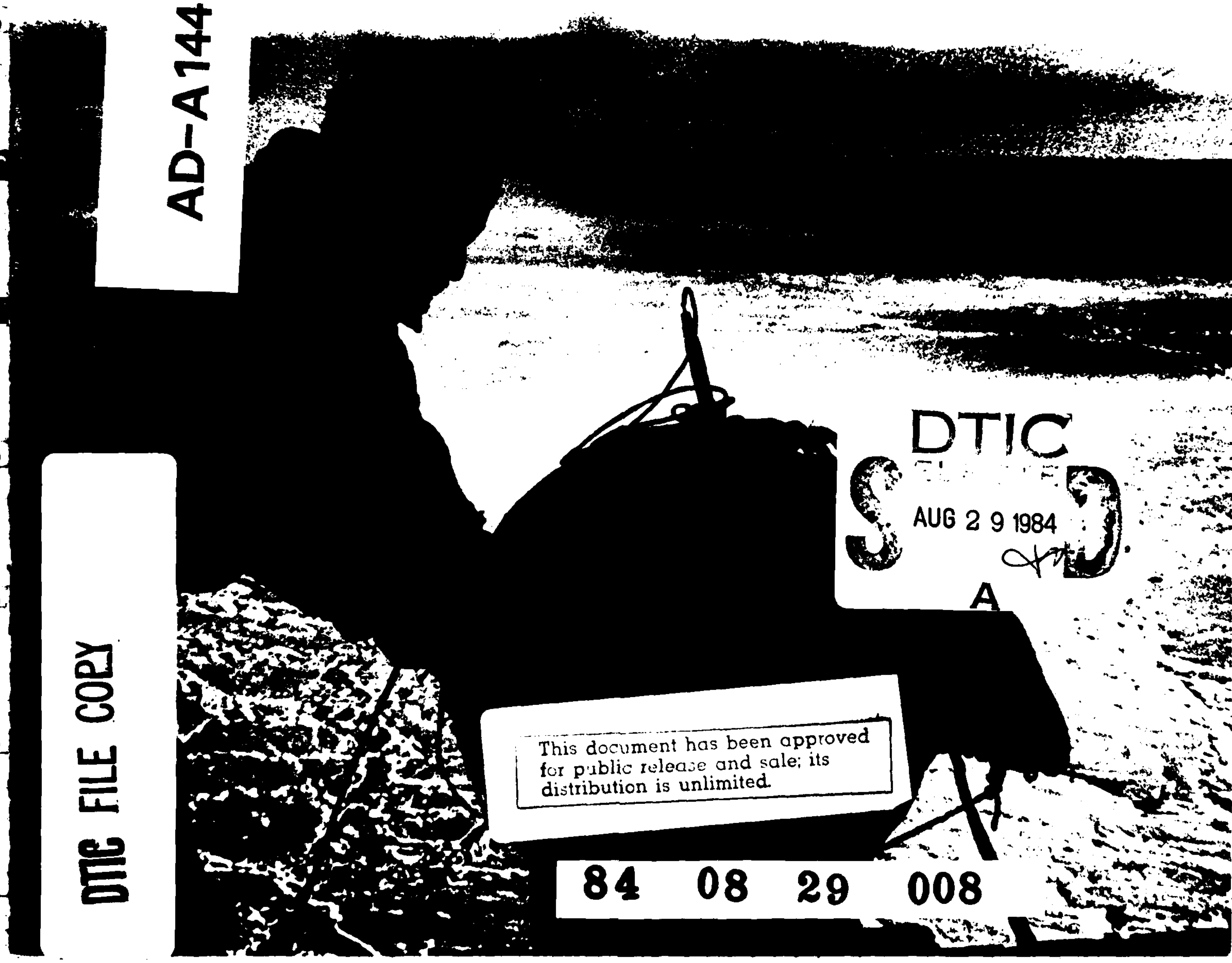
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

CRREL
REPORT 84-11

US Army Corps
of Engineers
Cold Regions Research &
Engineering Laboratory

(12)

Sea ice data buoys in the Weddell Sea



For conversion of SI metric units to U.S./British customary units of measurement consult ASTM Standard E380, Metric Practice Guide, *published by the American Society for Testing and Materials, 1916 Race St., Philadelphia, Pa. 19103.*

Cover: *Data buoy equipped with parachute about to be dropped from the rear cargo door of a C-130 aircraft flying at about 600 m over pack ice in the western Weddell Sea, December 1978.*

CRRELl Report 84-11

May 1984

Sea ice data buoys in the Weddell Sea

Stephen F. Ackley and Elizabeth T. Holt

Prepared for
NATIONAL SCIENCE FOUNDATION

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER CRREL Report 84-11	2. GOVT ACCESSION NO. AD-A144 953	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* SEA ICE DATA BUOYS IN THE WEDDELL SEA		5. TYPE OF REPORT & PERIOD COVERED
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Stephen F. Ackley and Elizabeth T. Holt		8. CONTRACT OR GRANT NUMBER(s) NSF DPP 80-06922 NSF DPP 77-24528
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Cold Regions Research and Engineering Laboratory Hanover, New Hampshire 03755		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS National Science Foundation Division of Polar Programs Washington, DC		12. REPORT DATE May 1984
		13. NUMBER OF PAGES 21
14. MONITORING AGENCY NAME & ADDRESS *(if different from Controlling Office)*		15. SECURITY CLASS. *(of this report)* Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Antarctic regions
Buoys
Drift
Pack ice
Pressure
Sea ice
Temperature

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

Data obtained from two sets of data buoys either air-dropped or deployed by ship onto the Weddell Sea pack ice during the period from Dec 1978 to Nov 1980 are presented. The buoy data include position, pressure and temperature information and to date represent the most complete combined weather and pack ice drift records for the ice-covered Southern Ocean regions. The buoys tended to drift north initially and then to turn east generally between latitudes 62°S and 64°S. Buoy 1433 turned east farther south at approximately 67°S but at about the same time as buoy 0527, implying that the westerly wind belt was farther south than usual in 1979. The range of air pressures from about 950 mb to about 1020 mb is typical of the circumpolar low pressure trough in the Southern Hemisphere. All buoys were equipped with an internal or compartment temperature sensor. The 1980 buoys also contained an external air tempera-

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

20. Abstract (cont'd).

ture sensor in a ventilated, shielded can at 1-m height. Although differences of 10°C or more between recorded air and compartment temperatures are common, the correlation between the two measured temperatures is generally very good. The compartment temperatures are higher probably because the buoy is radiationally heated. We found that subtracting 3°C from the average daily compartment temperature yielded a good estimate of the average air temperature for any given day. This technique can be used to construct average daily air temperature records for the 1979 buoys which only contained the internal or compartment temperature sensor.

PREFACE

This report was prepared by Stephen F. Ackley, Chief, Snow and Ice Branch, Research Division, U.S. Army Cold Regions Research and Engineering Laboratory, and Elizabeth T. Holt, Physical Science Aide, Snow and Ice Branch. Funding for the research described in this report was provided by the National Science Foundation in Grants DPP 80-06922 and DPP 77-24528.

Walter Tucker and Diane Clarke of CRREL technically reviewed the manuscript of this report.

The authors wish to thank the reviewers for their comments and E. Perkins and M. Pacillo who drafted the figures. The support of U.S. Navy Squadron VXE-6 and the crew of USCGC *Polar Sea* is gratefully acknowledged for assistance in deploying the data buoys.

A1

CONTENTS

ILLUSTRATIONS

TABLES

SEA ICE DATA BUOYS IN THE WEDDELL SEA

Stephen F. Ackley and Elizabeth T. Holt

INTRODUCTION

During the AIDJEX (Arctic Ice Dynamics Joint Experiment) program, unmanned reporting stations (data buoys) were developed which provide ice velocities, pressure and temperature information for the calculation of wind fields over experimental areas. The original buoys used high frequency radio for data transmission, and later buoys were developed that transmit data through the NIMBUS satellite's Random Access Measurement System (RAMS). This system greatly expands the range of the buoys and employs the satellite's position measurement capability, from which the ice velocities may be calculated. In addition, buoys were developed that could be deployed by parachute drop, allowing their use in regions beyond the range of helicopters and where fixed-wing aircraft could not land because of rough ice or fuel limitations. These buoys, designated ADRAMS (air-droppable RAMS), are described in detail by Brown and Kerut (1979).

This report provides preliminary data analyses of the information obtained from two arrays of buoys which were either air-dropped or deployed by ship onto the Weddell Sea pack ice. The first set of six buoys was deployed in December 1978. Two of these survived only a few days, while buoys 0511, 0527, 1121 and 1433 survived from 3 to 11 months. A second set of buoys was deployed in February 1980 (Ackley et al. 1980). Buoy 0621 survived until May 1980, while buoys 0003, 0035 and 1405 transmitted into October, August and November 1980, respectively.

METHODS AND INSTRUMENTATION

The ADRAMS buoy consists of two foam-insulated Lexan plastic hemispheres bolted together which contain a transmit terminal (transmitter), a pressure transducer accurate to ±1 mb and an internal temperature sensor (thermistor) accurate to ±0.5°C absolute and ±0.25°C relative. The thermistor provides a temperature correction for the pressure sensor and a measure of ambient thermal conditions. Concern that the records from the thermistor were adversely affected by the sensor's position within the buoy's compartment prompted the addition of an external temperature sensor to the 1980 buoys. This sensor is in a shielded can, open at both ends, designed to be about 1 m above the ice surface. Lithium batteries provide nominal power equivalent to 0.25 W continuous on a 1:60 on/off time cycle and last about 8 months at full power. The buoy transmits once a minute in a one-second burst that the satellite receives when within sight of the buoy. Buoy positions are calculated by computing the Doppler shift of the signal received by the satellite from knowledge of the satellite's position relative to a reference geoid. Because NASA ground-receiving and data-handling personnel have commitments to several satellite systems, reception and processing of the buoy data were restricted to every second day at best. Several longer data gaps also occurred.

RESULTS

Drift tracks

Tables 1 and 2 list the stop and start dates (Julian days) and positions (degrees latitude and longitude) for each buoy. Figures 1 and 2 show composite tracks for each set of buoys, while Figure 3 depicts the tracks of the longer-lived buoys. Data gaps are indicated by dashed lines.

Initially the buoys all tended to drift almost directly north and then to turn east between latitudes 62° and 64°S. The only exception was buoy 1433 which turned east at approximately 67°S.

Table 1. Start and stop dates and positions for 1979 buoys (Julian days, Day 1 = 1 January).

	Date		Position			
			Start		Stop	
Buoy	*Start*	*Stop*	*Lat.(°S)*	*Long.(°W)*	*Lat.(°S)*	*Long.(°W)*
0511	1978, Day 355	1979, Day 121	72.9	58.2	69.8	55.9
0527	1978, Day 355	1979, Day 336	69.5	49.7	59.8	27.0
1121	1978, Day 355	1979, Day 94	70.4	57.7	69.6	56.5
1433	1978, Day 355	1979, Day 291	73.3	48.3	64.3	39.9

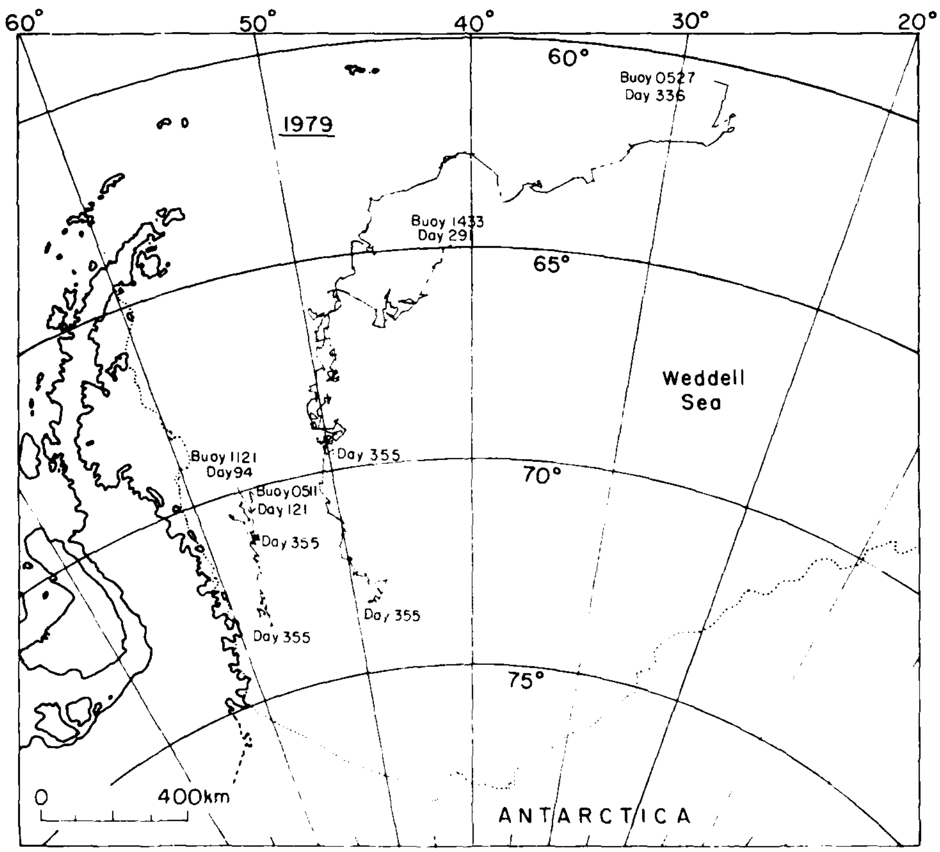


Figure 1. Drift tracks for all 1979 buoys.

Table 2. Start and stop dates and positions for 1980 buoys (Julian days, Day 1 = 1 January).

	Date		*Position*			
			Start		*Stop*	
Buoy	*Start*	*Stop*	*Lat.(°S),*	*Long.(°W)*	*Lat.(°S),*	*Long.(°W)*
0003	1980, Day 49	1980, Day 276	73.8	44.5	60.6	38.5
0035	1980, Day 60	1980, Day 243	70.5	39.7	61.0	34.5
0621	1980, Day 56	1980, Day 134	71.9	42.0	68.5	45.3
1405	1980, Day 56	1980, Day 332	72.9	39.5	59.8	21.1

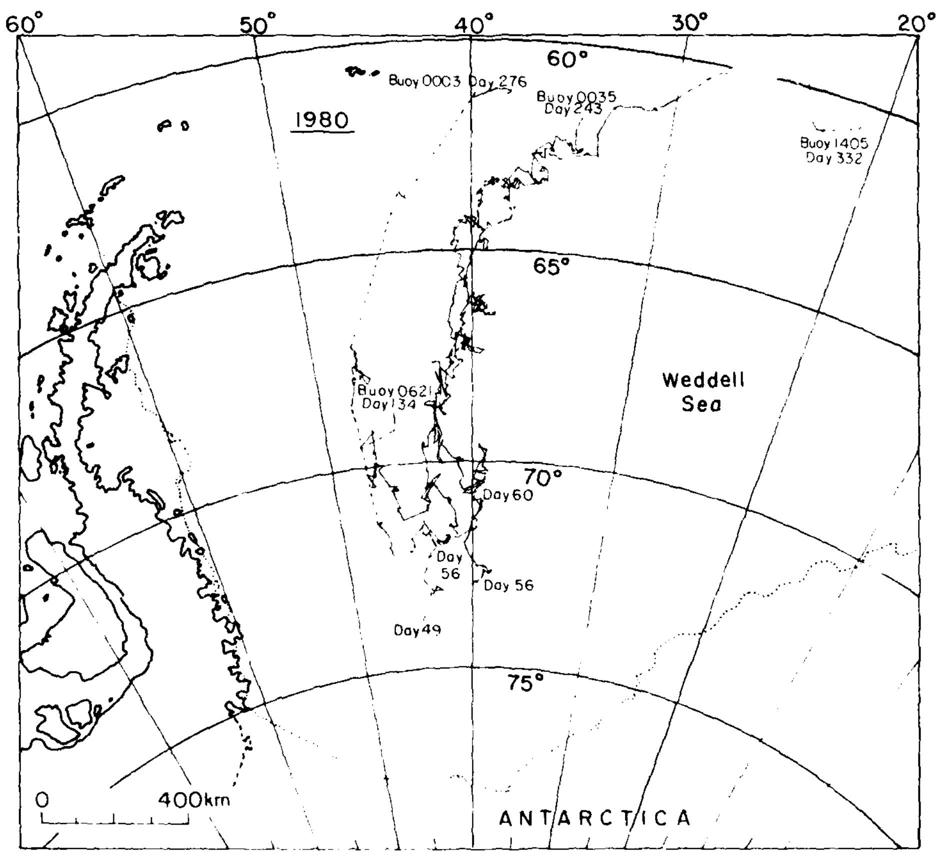


Figure 2. Drift tracks for all 1980 buoys.

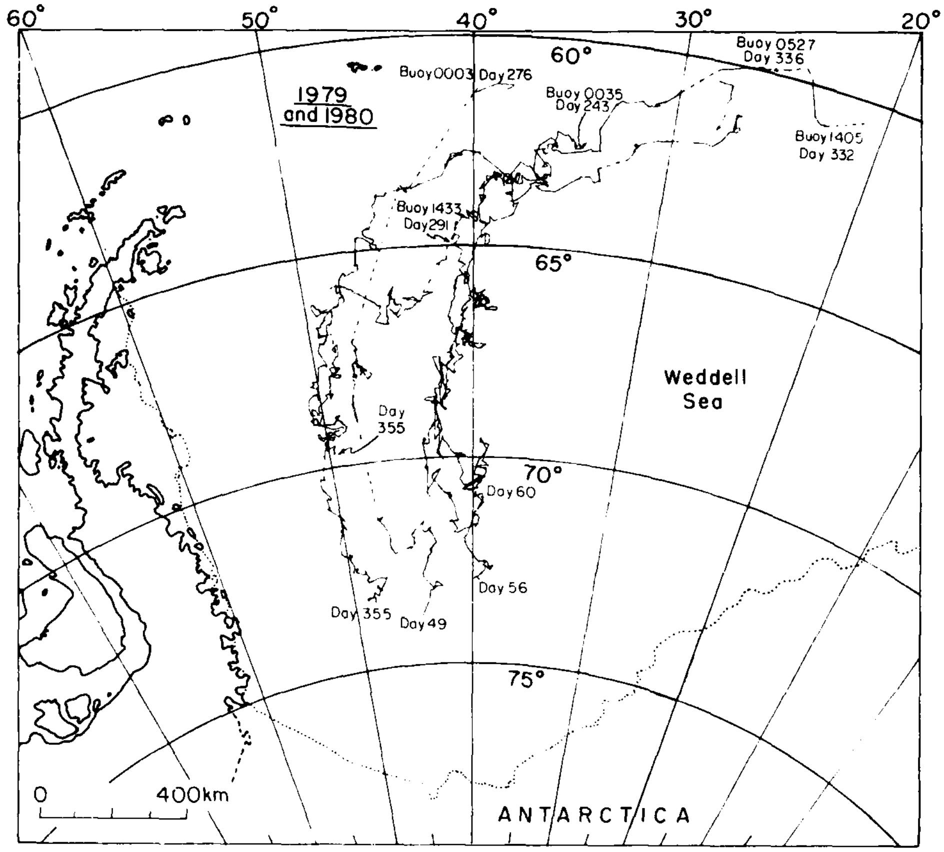


Figure 3. Drift of buoys 0527, 1433, 0003, 0035, and 1405 (1979 and 1980 combined).

Pressure data

Figures 4-11 show the recorded pressures in millibars for each buoy. Data for the 1979 buoys are presented from 1 January 1979 until end of transmission for each of the buoys. The range of pressures, from about 950 mb to about 1020 mb, is low relative to those seen in similar latitudes in the Northern Hemisphere but typical of the circumpolar low pressure trough in the Southern Hemisphere.

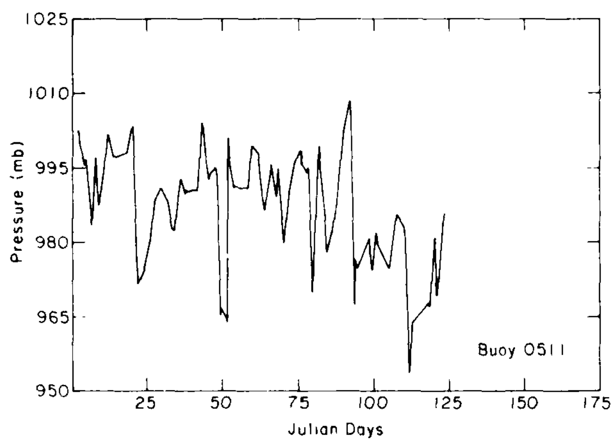
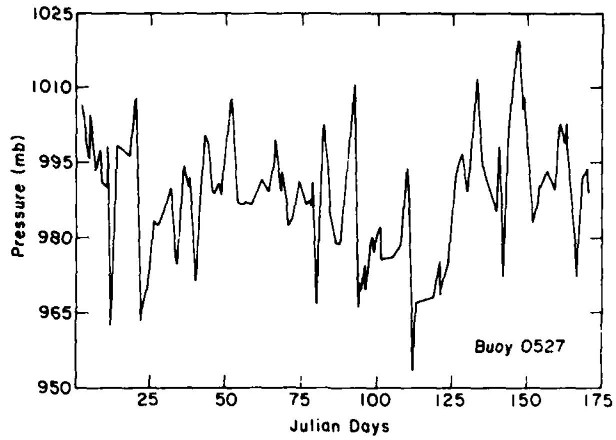


Figure 4. 1979 Pressure record for buoy 0511.



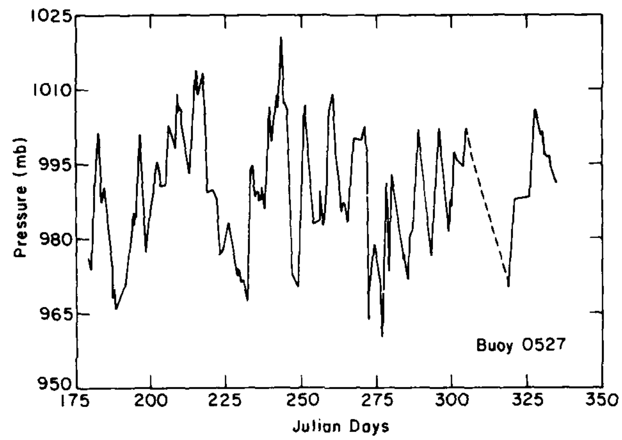


Figure 5. 1979 Pressure record for buoy 0527.

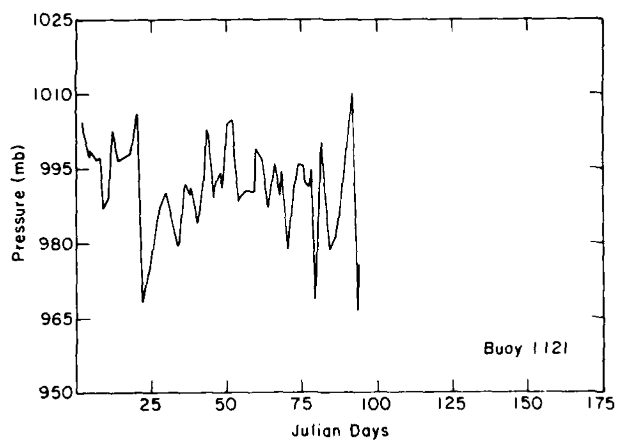


Figure 6. 1979 Pressure record for buoy 1121.

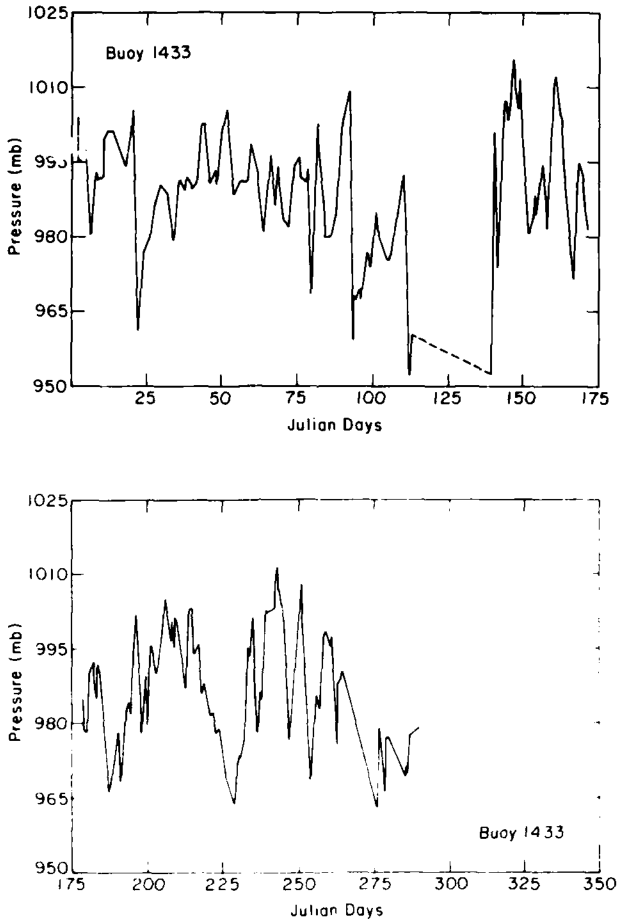


Figure 7. 1979 Pressure record for buoy 1433.

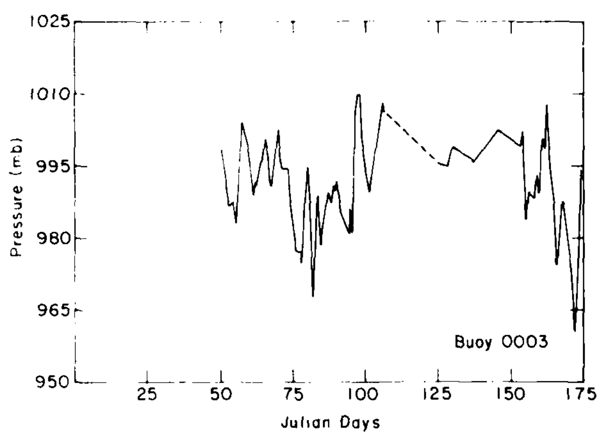


Figure 8. 1980 Pressure record for buoy 0003.

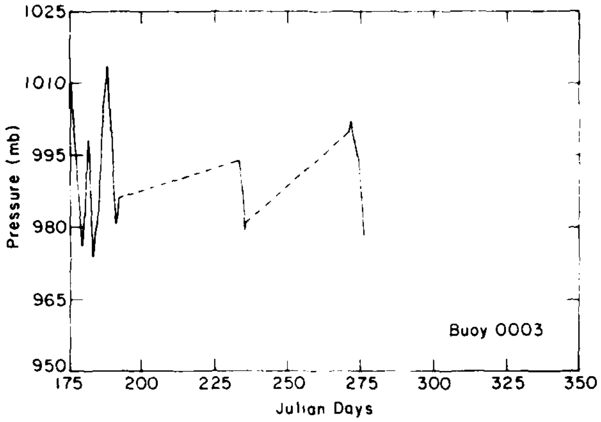
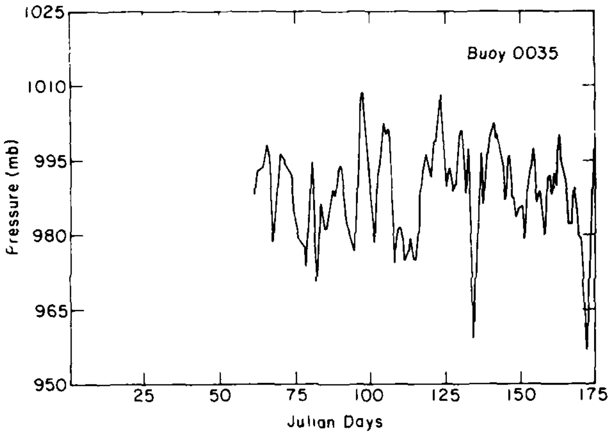


Figure 8 (cont'd).



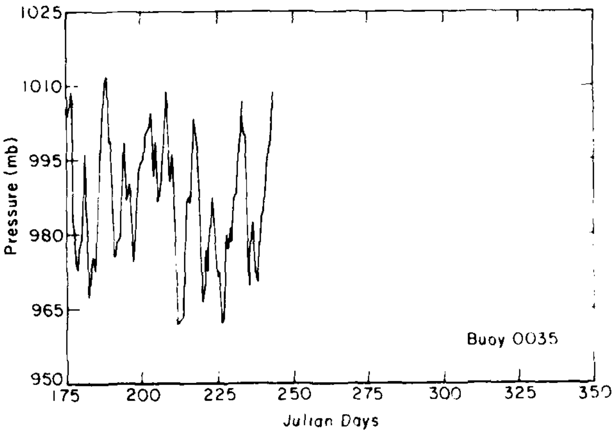


Figure 9. 1980 Pressure record for buoy 0035.

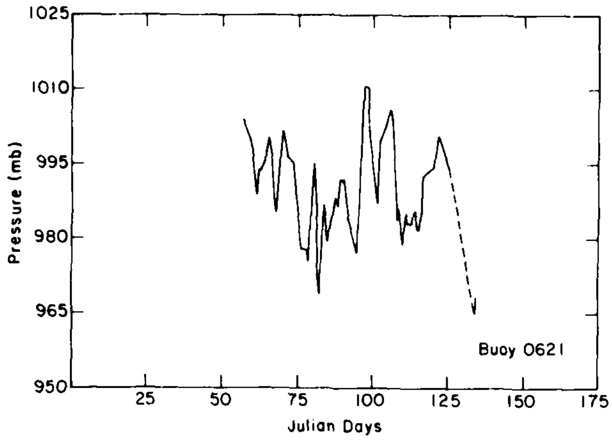


Figure 10. 1980 Pressure record for buoy 0621.

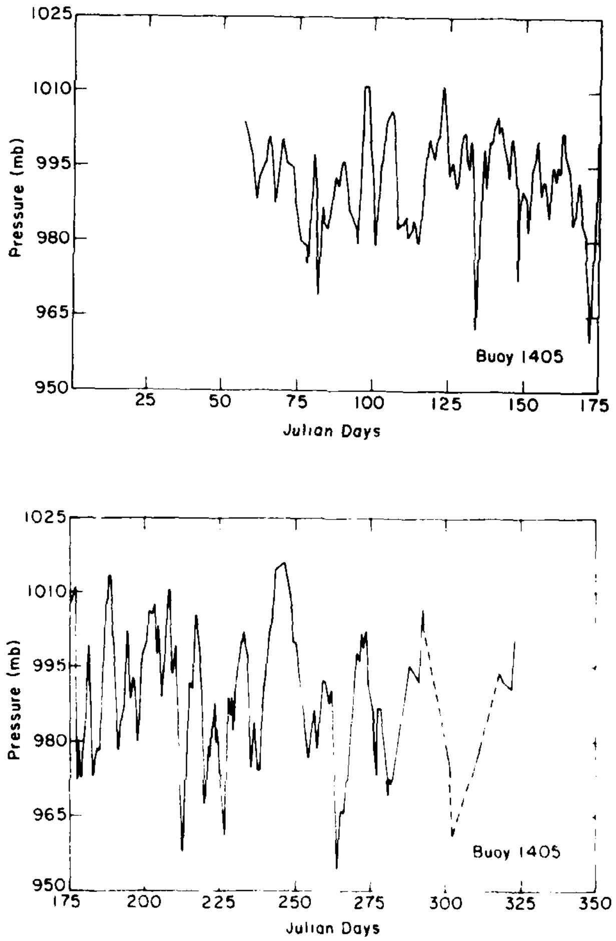


Figure 11. 1980 Pressure record for buoy 1405.

Temperature data

Figures 12-19 show the compartment temperature (thermistor) data for all buoys. Figures 20-22 show the available air temperature records for the 1980 buoys.

For the 1980 buoys with both temperature records, we show the daily records of difference between external thermistor temperature and compartment temperature in Figures 23-25. Figures 26-30 show air vs compartment temperatures and include the best-fit regression line and the perfect fit (45°) line for each of those buoys having both internal and external systems. The differences and correlations between the air and thermistor temperatures

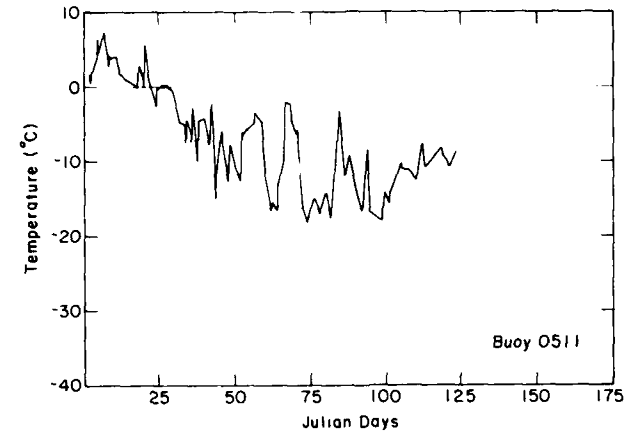
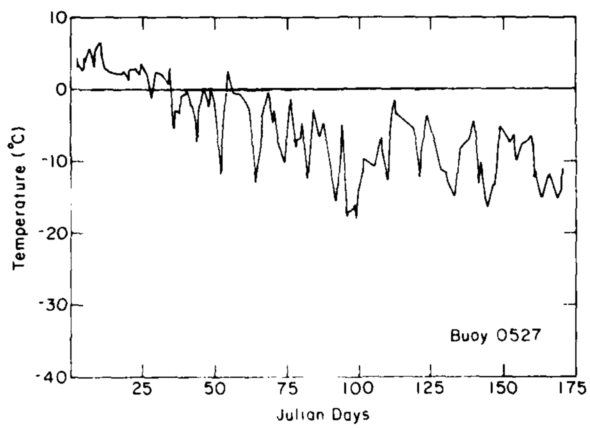


Figure 12. 1979 Compartment temperature record for buoy 0511.



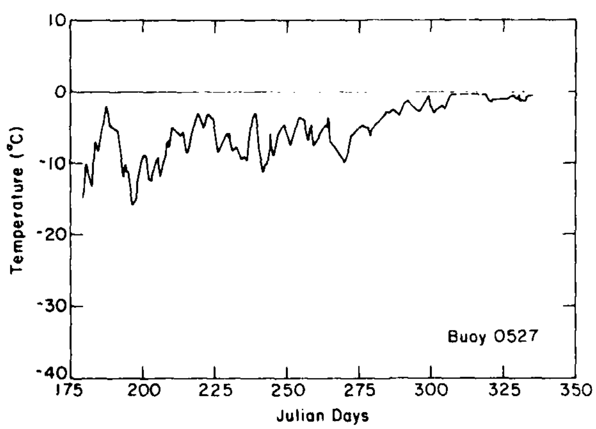


Figure 13. 1979 Compartment temperature record for buoy 0527.

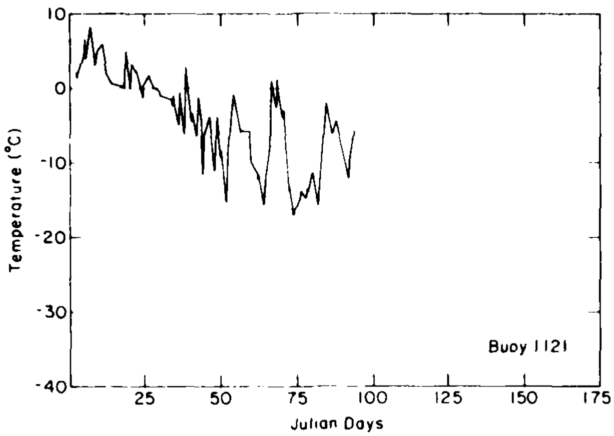


Figure 14. 1979 Compartment temperature record for buoy 1121.

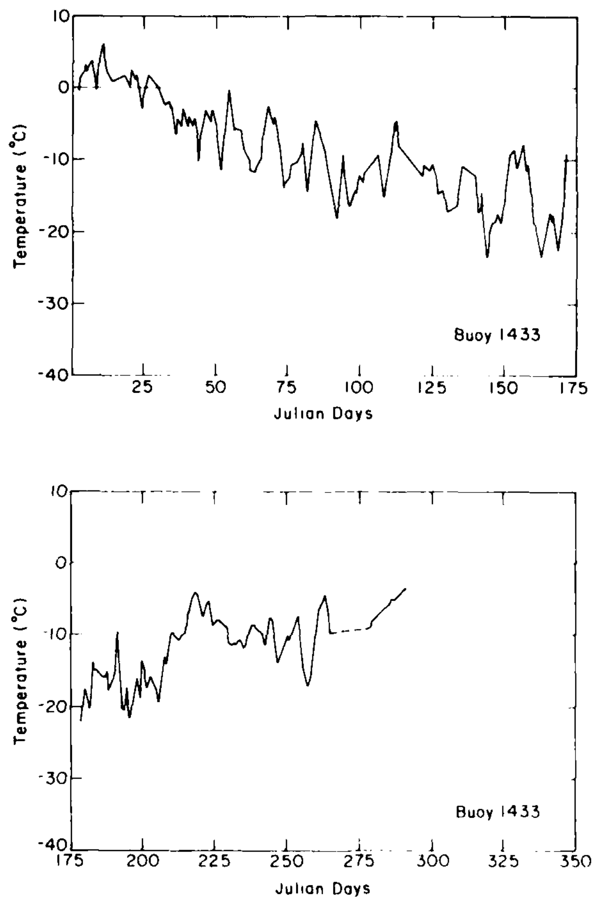


Figure 15. 1979 Compartment temperature record for buoy 1433.

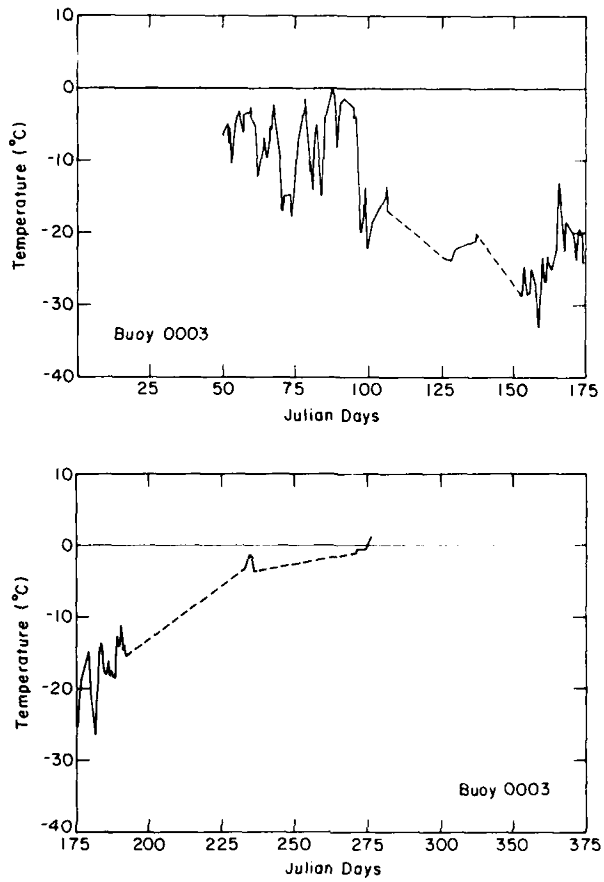


Figure 16. 1980 Compartment temperature record for buoy 0003.

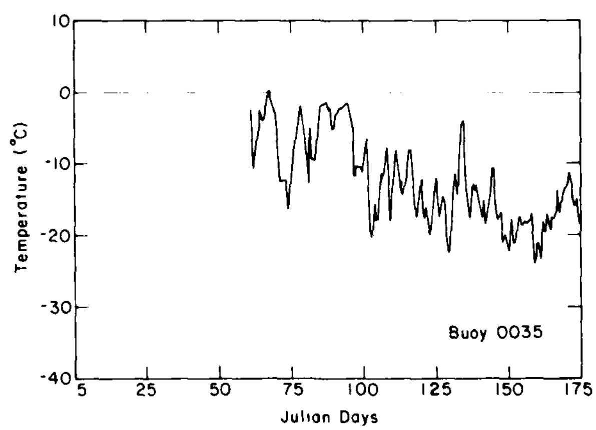


Figure 17. 1980 Compartment temperature record for buoy 0035.

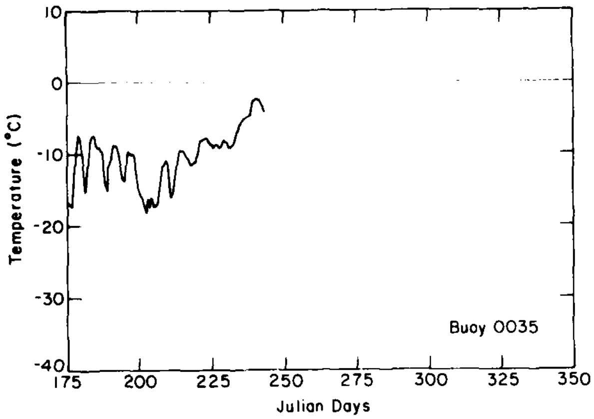


Figure 17 (cont'd). 1980 Compartment temperature record for buoy 0035.

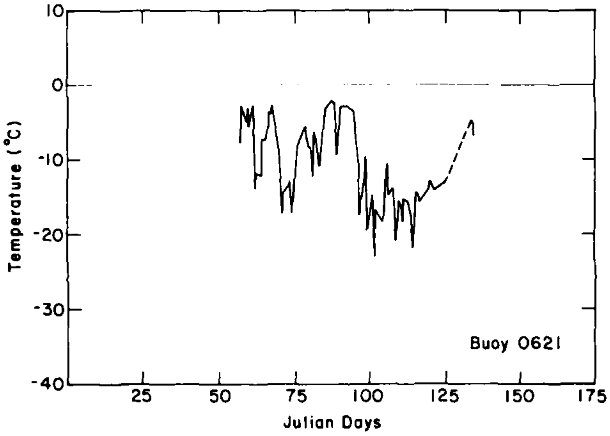


Figure 18. 1980 Compartment temperature record for buoy 0621.

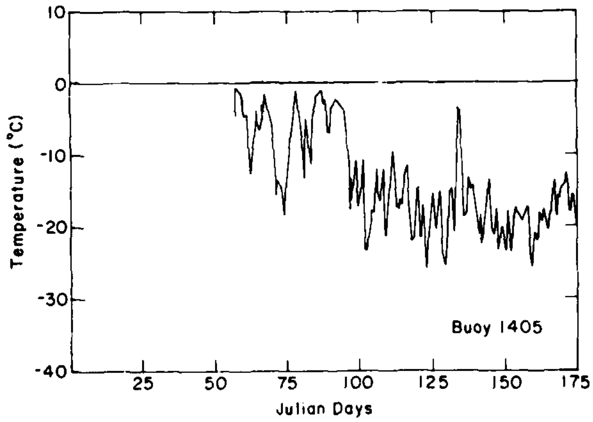


Figure 19. 1980 Compartment temperature record for buoy 1405.

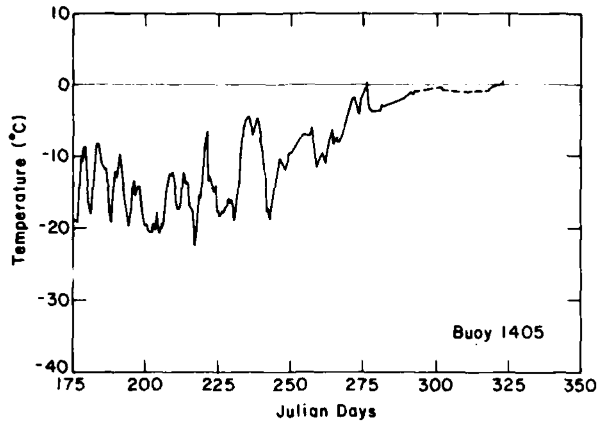
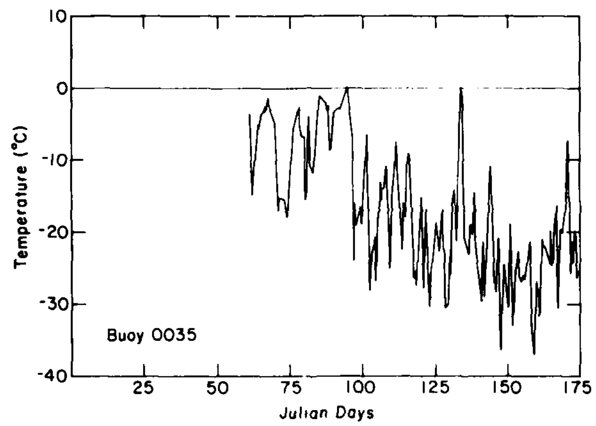


Figure 19 (cont'd).



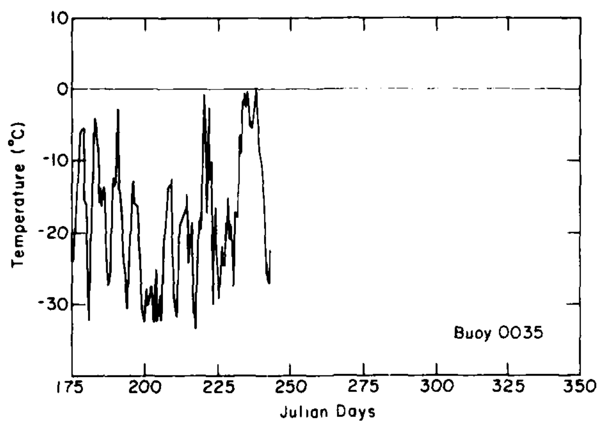


Figure 20. 1980 Air temperature record for buoy 0035.

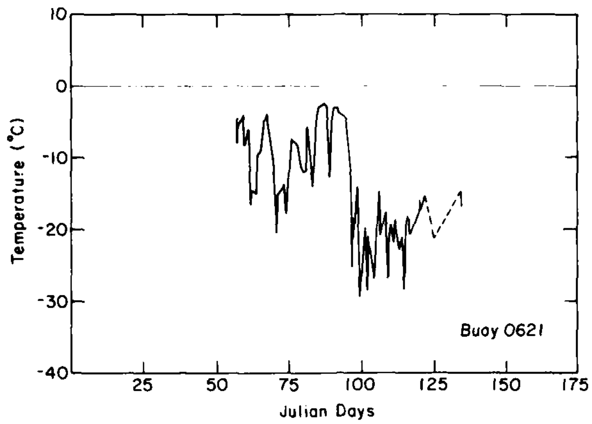


Figure 21. 1980 Air temperature record for buoy 0621.

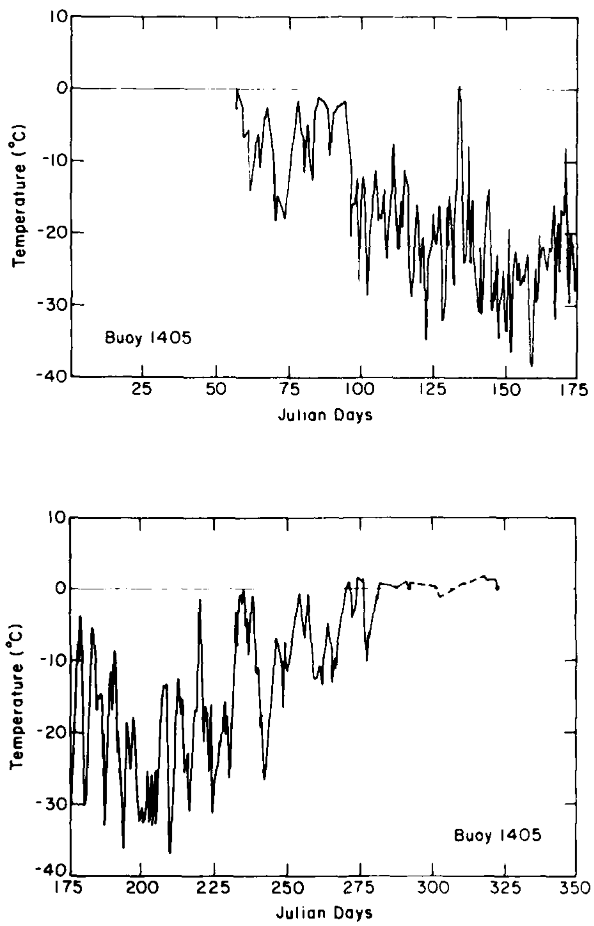


Figure 22. 1980 Air temperature record for buoy 1405.

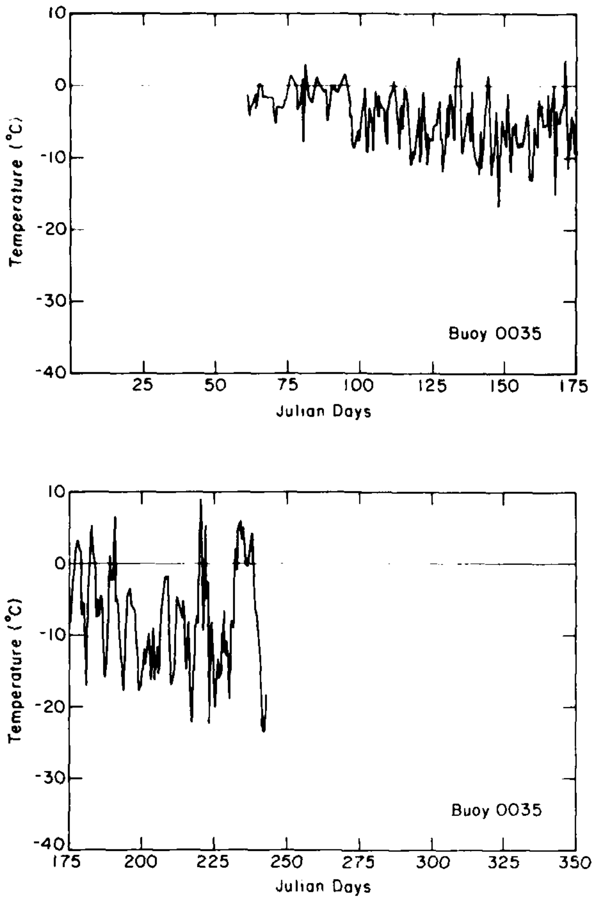


Figure 23. Plots of compartment temperature subtracted from corresponding air temperature, buoy 0035.

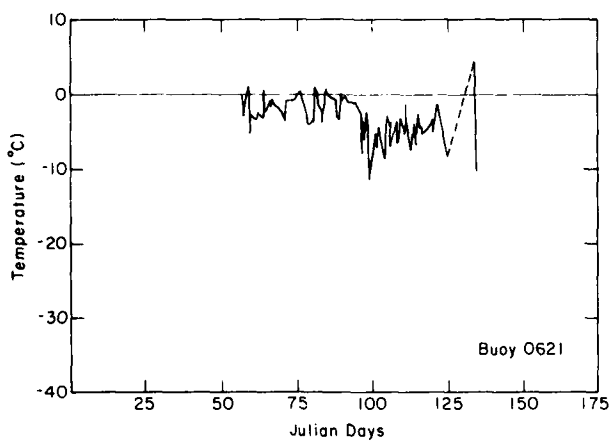


Figure 24. Plots of compartment temperature subtracted from corresponding air temperatures, buoy 0621.

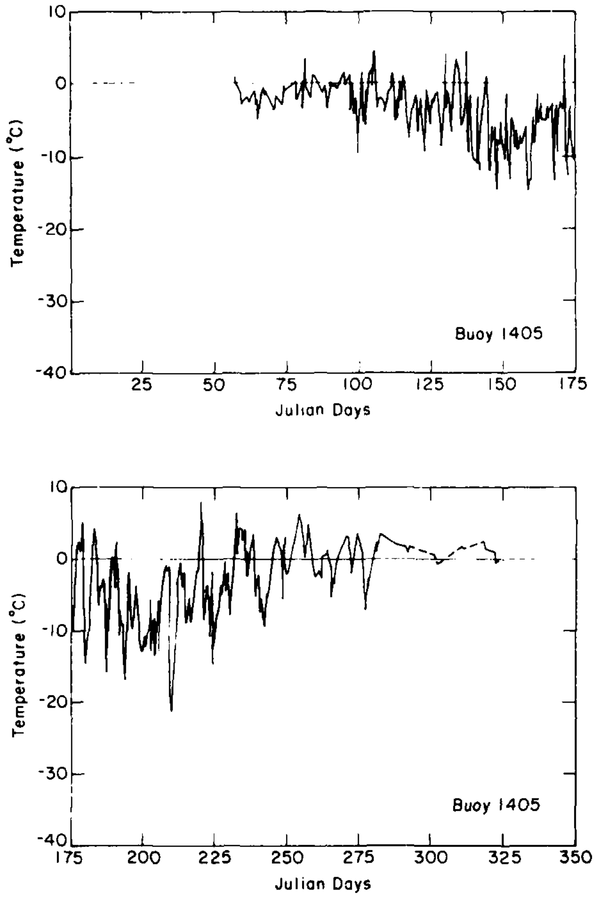


Figure 25. Plots of compartment temperature subtracted from corresponding air temperatures, buoy 1405.

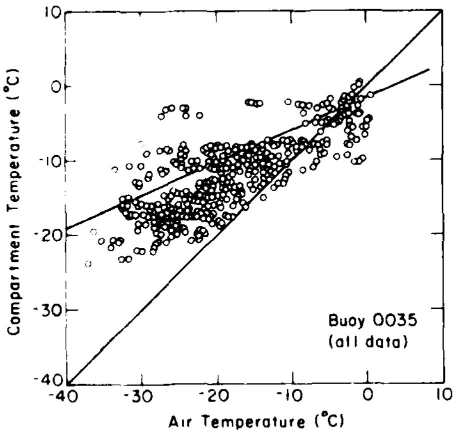


Figure 26. Air vs compartment temperature, buoy 0035 (all data).

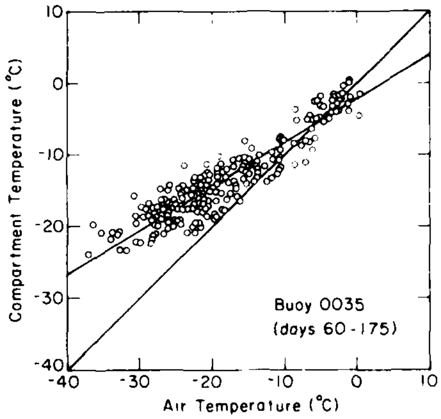


Figure 27. Air vs compartment temperature, buoy 0035 (days 60–175).

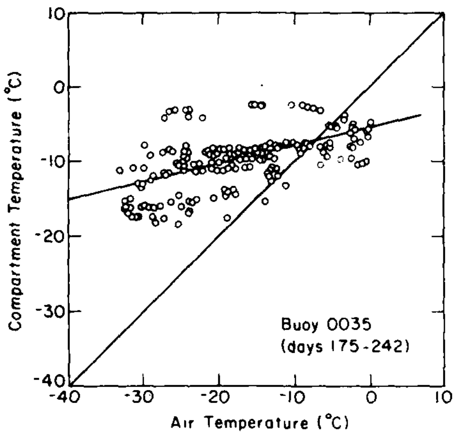


Figure 28. Air vs compartment temperature, buoy 0035 (days 175-242).

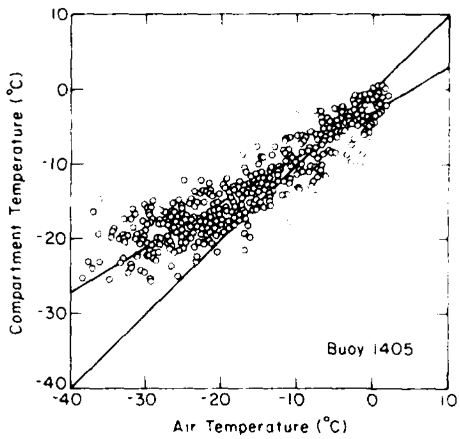


Figure 29. Air vs compartment temperature, buoy 0621.

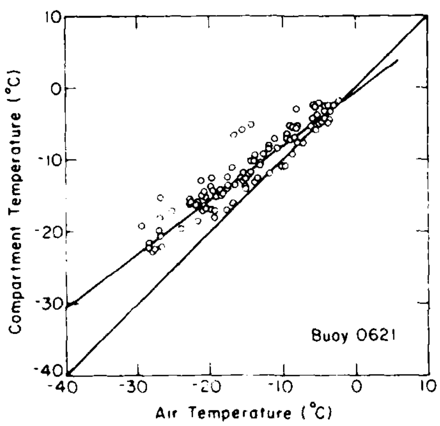


Figure 30. Air vs compartment temperature, buoy 1405.

for the three buoys are summarized in Table 3. Buoys 0621 and 1405 show high correlation (>0.9) between the two sets of readings. For buoy 0035 we find a high correlation for days 60-175 which decreases to 0.57 after day 175. We suspect that the poorer correlation during this later period is due to a malfunction of one of the temperature sensors. For the high correlation periods, Table 3 shows that the air temperatures are 3 to 4°C lower than the compartment temperatures and have a 3 to 4°C greater standard deviation. The largest deviations occur at lower temperatures, while temperatures above -10°C are in reasonable accord.

Table 3. Average values and correlation parameters between air and compartment temperatures.

	Temperature avg. (°C)		Variances (°C)²		Standard deviation (°C)		Correlation	Slope of
Buoy	*Air*	*Compartment*	*Air*	*Compartment*	*Air*	*Compartment*	*coefficient*	*regression line*
0621	-13.511	-10.419	58.821	34.878	7.670	5.906	0.956	0.736
1405	-16.497	-13.497	97.590	41.693	9.879	6.457	0.920	0.601
0035 (Days 60–175)	-17.998	-13.248	78.645	34.447	8.868	5.869	0.933	0.617
0035 (Days 174–242)	-17.366	- 9.634	79.432	14.455	8.912	3.802	0.571	0.244

DISCUSSION

The initial northward drift of the buoys followed by a turn to the east is in accordance with the major winds and ocean currents in the region. The topographic barrier of the Antarctic Peninsula affects the weather systems such that this northward motion is predominant in the region just west of the peninsula. North of approximately 65°S, the mid-latitude southern hemisphere westerly wind belt, one of the more vigorous circulation features of the global weather system, drives ice to the east. Buoy 1433, as mentioned before, turned east at approximately 67°S, but this shift occurred at about the same time as the eastward movement of buoy 0527. The coincidence of these shifts implies that the westerly wind belt was farther south than usual in 1979.

Our temperature results, in respect to the difference between air and compartment temperatures, are similar to those reported by Thorndike et al. (1982) for Arctic Ocean data buoys. Compartment temperatures are probably higher than air temperatures because the buoy is radiationally heated. Differences of 10°C or more between the two measured temperatures are common. The thermal inertia of the buoy because of its mass tends to dampen diurnal and other short-lived temperature "spikes," which contributes to the lower standard deviation of the compartment temperatures. Some of these spikes are due to short-lived outbreaks of cold air from the Antarctic continent, which probably cause the poor correlation of the air and compartment temperatures below -10°C. In addition, the changes in the compartment temperatures lag the changes in air temperatures by several hours, again because of the thermal inertia.

From these comparisons, we conclude that the 1979 and 1980 compartment temperature records are higher than actual air temperatures at the buoy locations. A good estimate of the average air temperature on a given day can be calculated by subtracting 3°C from the average compartment temperature for that day. The resulting estimate may be biased a bit high for temperatures below -15°C.

CONCLUSIONS

These data buoy records represent the most complete combined weather and pack ice drift records for the ice-covered Antarctic Ocean regions. They are therefore a valuable data set for ice modeling. Digital records of the data presented here are available from the authors.

The temperature and ice drift records have already been used in ice modeling studies of the Weddell Sea by Hibler and Ackley (1982, 1983). These modeling results show that air temperature records estimated without these buoys are significantly higher than observed temperatures, suggesting a strong feedback between ice presence and surface air temperature. Ice drift records also verify the model dynamics used in these studies. Ongoing studies are comparing forecast pressures and temperatures with the actual data buoy results from the Antarctic pack ice region.

LITERATURE CITED

Ackley, S.F. (1979) Drifting buoy measurements on Weddell Sea pack ice. *Antarctic Journal of the U.S.*, XIV(5): 106-108.

Ackley, S.F., A.J. Gow, K.R. Buck, and K.M. Golden (1980) Sea ice studies in the Weddell Sea aboard USCGC *Polar Sea*. *Antarctic Journal of the U.S.*, **XV**(5): 83-86.

Brown, W.P. and E.G. Kerut (1979) Air droppable RAMS (ADRAMS buoys). *AIDJEX Bulletin 40*, pp. 15-20.

Hibler, W.D. and S.F. Ackley (1982) On modeling the Weddell Sea pack ice. *Annals of Glaciology*, **3**: 125-130.

Hibler, W.D. and S.F. Ackley (1983) Numerical simulation of the Weddell Sea pack ice. *Journal of Geophysical Research*, **88**: 2873-2887.

Thorndike, A.S., R. Colony, and E.A. Munoz (1982) Arctic Ocean buoy program data report 1 January 1981-31 December 1981. Polar Science Center, University of Washington.

A facsimile catalog card in Library of Congress MARC format is reproduced below.

Ackley, Stephen F.
Sea ice data buoys in the Weddell Sea / by Stephen F. Ackley and Elizabeth T. Holt. Hanover, N.H.: Cold Regions Research and Engineering Laboratory; Springfield, Va.: available from National Technical Information Service.
iii, 21 p., illus.; 28 cm. (CRREL Report 84-11)
Bibliography: p. 18.
1. Antarctic regions. 2. Buoys. 3. Drift. 4. Pack ice. 5. Pressure. 6. Sea ice. 7. Temperature. I. Holt, Elizabeth T. II. United States. Army. Corps of Engineers. III. Cold Regions Research and Engineering Laboratory, Hanover, N.H. IV. Series: CRREL Report 84-11.

END

FILMED