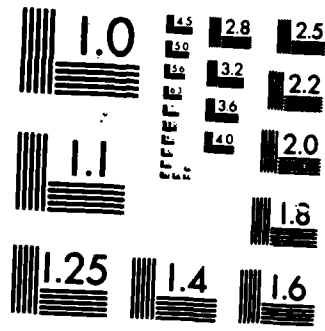MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS-1963-A

AD-A164 364

INVESTIGATION OF ICE DYNAMICS IN THE MARGINAL ICE ZONE

Principal Investigator: Dr. Matti Leppäragta
Contractor: Institute of Marine Research, Finland
Contract Number: DAJA45-83-C-0034
Sixth Interim Report
16 May 1985 - 30 September 1985

DTIC
ELECTE
FEB 1 8 1986
S
D
D

The research reported in this document has been made possible
trough the support and sponsorship of the U.S. Government
through its European Research Office of the U.S. Army. This
report is intended only for the internal management use of
the Contractor and the U.S. Government.

86   1 15 048

Sixth Interim Report

Investigation of Ice Dynamics in the Marginal Ice Zone
Dr. Matti Leppäranta

1. General

The entitled work was commenced by the author on January 24, 1983, at
the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL),
Hanover, NH, and is done in cooperation with Dr. William D. Hibler III
from CRREL. Since March 1984 the author has continued this research at
the Finnish Institute of Marine Research. The work includes both a theo-
retical and an experimental part. This year most of it is involved with
processing the data of MIZEX-83 and MIZEX-84 summer experiments in the
Greenland Sea. The field work has been discussed in earlier reports.

During the time since giving the previous report the research work has
been concentrated in the MIZEX-83 data. This work is now finished and
the processing of the MIZEX-84 data begins next. Dr. Hibler has returned
to CRREL from his sabbatical year at Max-Planck-Institut für Meteorolo-
gie, Hamburg. In the next six months we shall meet on two occasions, at
CRREL and in Finland, discussing mainly on the results of these two
experiments.

2. MIZEX-83

MIZEX-83 was a pilot study program, where ice kinematics data could be
collected for about ten days (see fourth Interim Report). Ocean current
measurements were simultaneously made by the University of Bergen group
who had current recorders beneath the same ice floes as we had transpon-
ders for the ice kinematics at three stations study. (Fig. 1).

The currents were measured with Aanderaa current recorders giving the
mean absolute speed and instantaneous direction at ten-minute intervals.

Availability Codes

Dist	Avail a d/or Special
A-1	

The measurement depths were 2, 10, 20, 40 and 200 meters beneath the ice bottom.

The Bergen group also measured the movement of the ice floes with Argos satellite buoys which are more less accurate than Del Norte microwave transponder system we used.

Our ice kinematics data describe relative motion between the stations. Thus in comparing ice and current kinematics we consider the relative motion, i.e. spatial fluctuations of velocity between two stations and the rate of deformation given by the three stations. It is worth emphasizing that the relative motion provides a more sensitive and discriminating test to theories and model calculations than ice trajectories.

Currents and ice motion

The east-component of the absolute currents and ice drift at Polar-bjørn is illustrated in Fig. 2. The absolute motion is the motion with respect to the earth, and it varies within ± 25 cm/s. The governing periodic variations in the velocities were caused by diurnal tide, semi-diur-nal tide and inertial oscillations. Note that in the high latitudes the semi-diurnal tide and inertial oscillations have nearly the same fre-quency. During the period of the experiment there were no strong winds which would have destroyed this nice picture of a sequence of waves. In the spatial scale of our measurement array, 10 km, the currents and ice motion are naturally highly coherent. Hence the differential velocities between the measurement sites are small (Fig. 3.). It is the most im-portant feature that for the ice this differential velocity is nearly one order to magnitude smaller than for the currents. However, it is seen that also some connection exists between the velocities of ice and water in Fig. 3. The current at 2 m beneath the ice may be locally dis-orted due to ice underside features such as ridge keels. This magnitude dif-ference means that the ice is not a passive tracer of ocean current

structure but has an active role in damping velocity variations. The cause of this damping effect is the internal friction in the ice floe system, i.e. interaction between ice floes. The role of this ice interaction has not yet been well understood or accepted by a number of scientists working on polar ocean problems. In particular, it has been argued that in the marginal ice zone, where the open ocean boundary is nearby, the ice should drift free of internal stresses. MIZEX-83 combined ice motion and current observations are maybe the best data set so far to show the importance of internal friction within the ice in the marginal ice zone.

The active role of ice in the ice - ocean system has a consequence that an ocean dynamics model for the ice margin problems should have an advanced ice dynamics model coupled with it. Such modeling work has not yet been done.

Argos buoys

The Bergen group measured the ice motion with Argos satellite buoys. They are very good for measuring trajectories. In this connection we could compare the measurements of the differential ice motion between the Argos and Del Norte systems.

Fig. 4 shows the time-series of the Argos-measured absolute motion at the four sites BI-BIV (see Fig. 1). They seem to have a similar behaviour, but here one should note that in reality the differential ice motion was typically about 1 cm/s or less. Thus the random errors in the Argos system are much larger than the real differential motion. This is well illustrated in Fig. 5. We can conclude that the best way to use the data of these four Argos buoys would be to average them spatially to get the best estimate of the absolute motion of the measurement array.

When ocean currents are measured from ice floes, the motion of the floes themselves should be measured very accurately. This is especially

true as one tries to observe the differential current field. For
frequencies up to about two cycles per hour our microwave transponder
system is accurate enough. There is no use of Argos satellite buoys
in measuring differential ocean kinematics in the scales of 10 km or
less.

3. Modeling

Our modeling manuscript discussed in the previous report has been accept-
ed for publication in Journal of Geophysical Research. It should come
soon out.   •

The study of the role of floe collisions in sea ice rheology has been
continued jointly by Prof. Hayley Shen, (Potsdam, N.Y.), Dr. Hibler and
the present writer. My part has been dealing with the calculations from
MIZEX-83 data needed to compare the theory with the real world. A report
of this work is under preparation with Prof. Shen as the primary author.

ANNEX

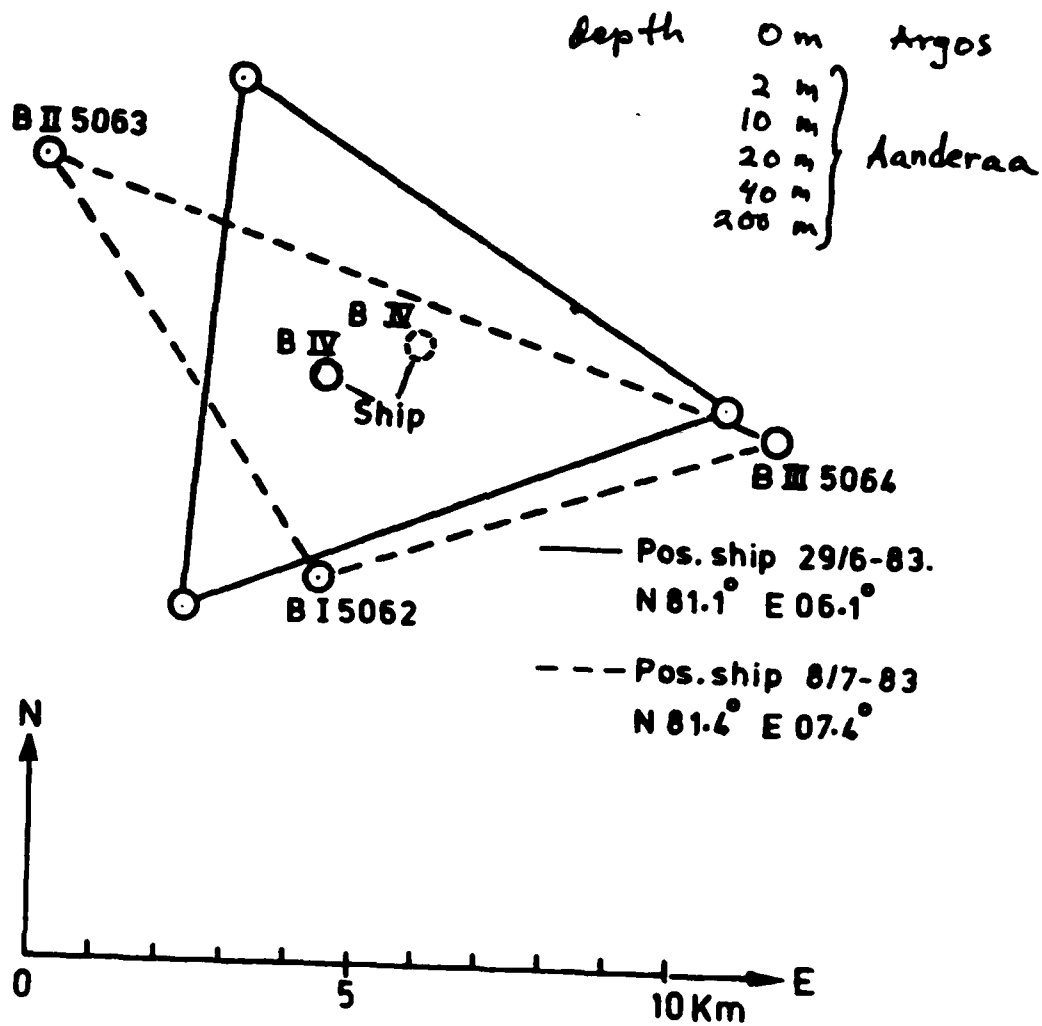a. The amount of unused funds: none
b. Important property required: none

Depth   0 m   Argos
         2 m ⎫
         10 m ⎪
         20 m ⎬ Aanderaa
         40 m ⎪
         200 m ⎭

B II 5063

B IV
B IV
Ship

B III 5064

——— Pos. ship 29/6-83.
N 81.1° E 06.1°

B I 5062

– – – Pos. ship 8/7-83
N 81.6° E 07.6°

N

0   5   10 Km   E

Fig. 1. Configuration change of the Bergen measurement array in MIZEX 83. Del Norte transponders were located at BI, BII and BII
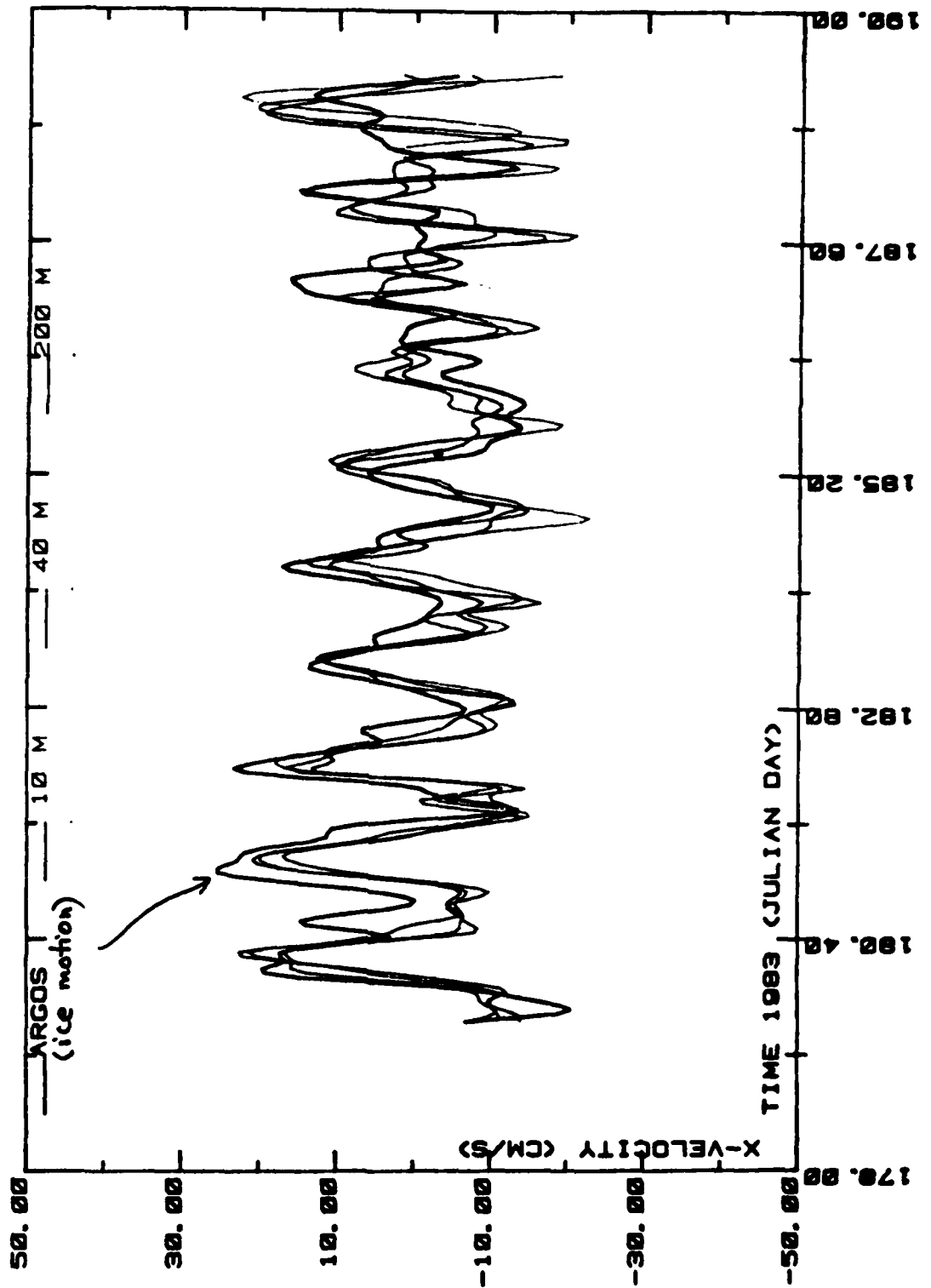
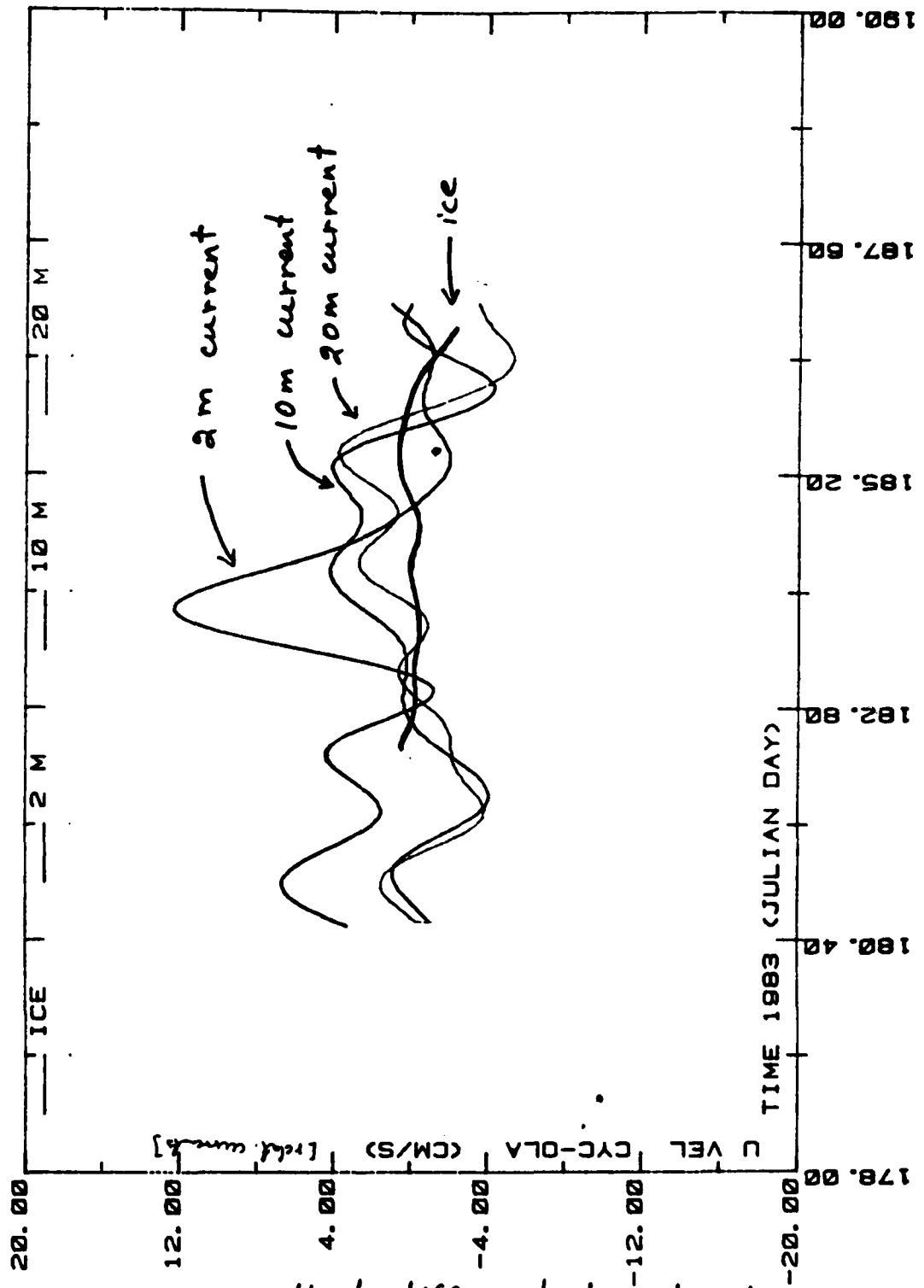FIG.2. ABSOLUTE ICE DRIFT & CU;
AT POLARBJØRN (X-component).

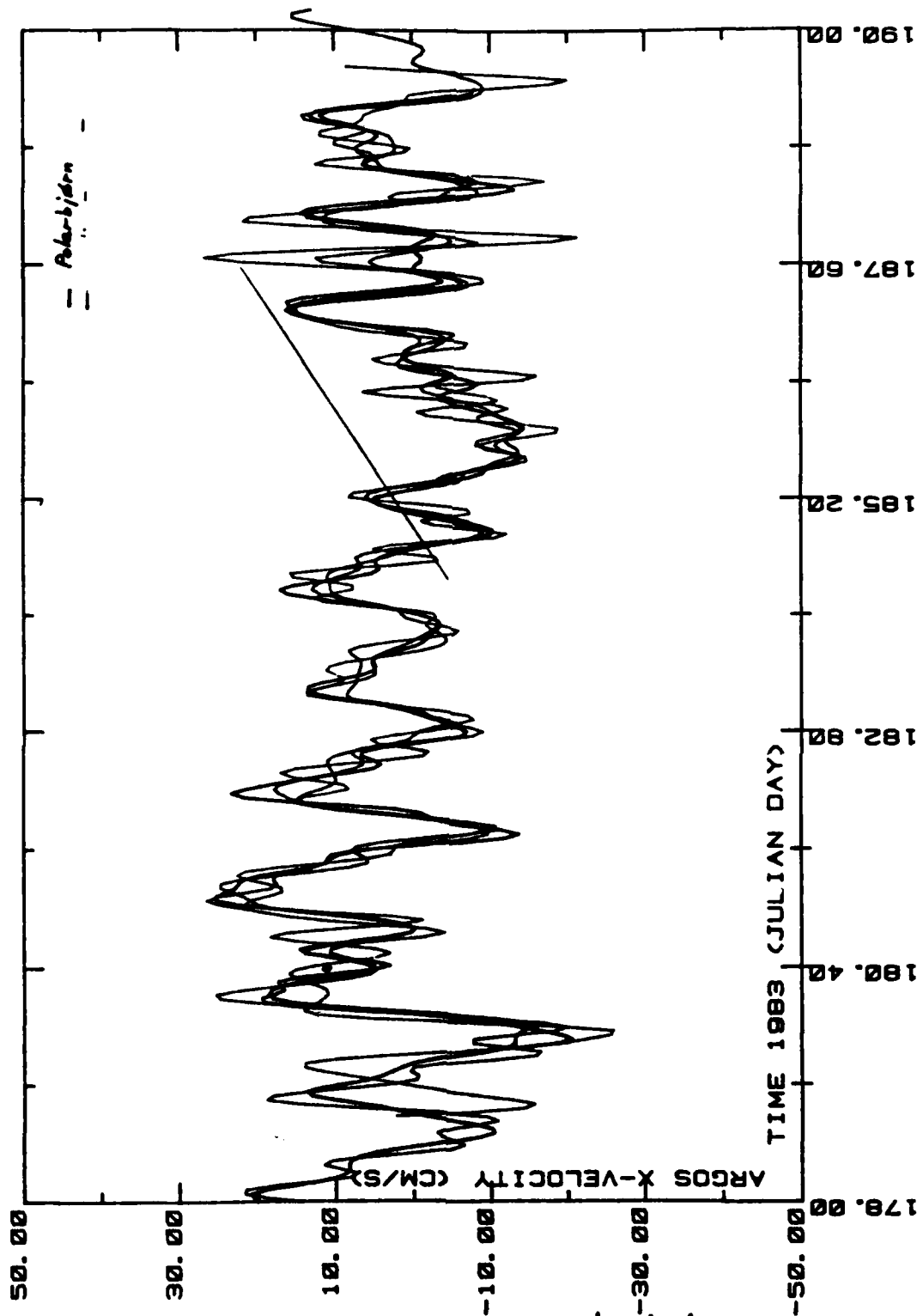Fig.3. Smoothed differential velocity between the sites BⅡ and BI (see Fig.1).

Fig 4. Argos-measured absolute ice motion (east component) at the sites B I - B II (see Fig. 1).
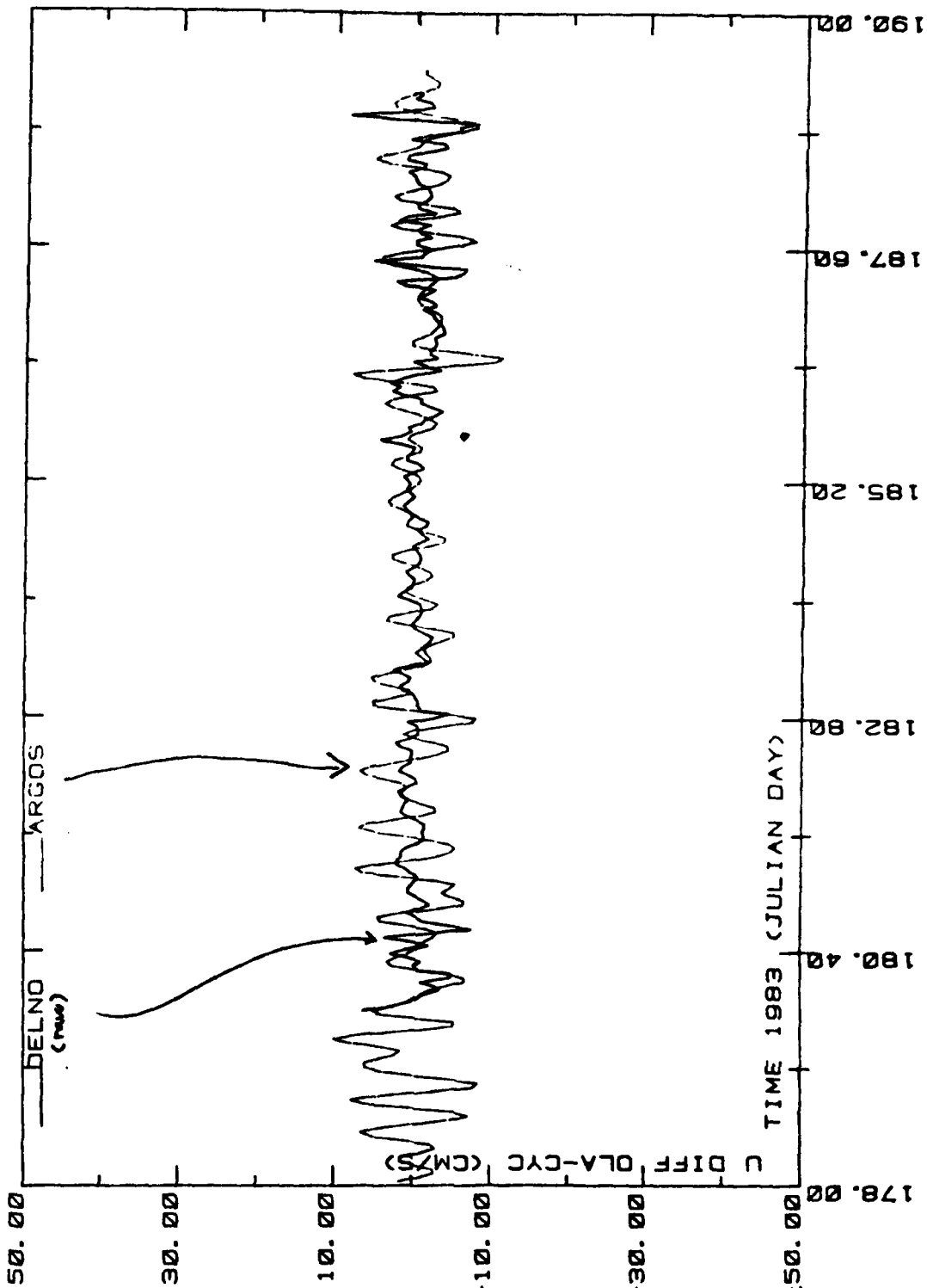
Fig.5. Differential motion between the sites
B Ⅱ and B Ⅰ (see Fig. 1) measured with
Argos and Del Norte systems.

END

FILMED

3-86

DTIC