

Naval Oceanographic and
Atmospheric Research Laboratory

Technical Note 40
July 1990



2

AD-A225 857

DTIC FILE COPY

Aircraft Measurements in the Northeast Pacific, Summer 1989

DTIC
ELECTR
AUG 22 1990
S B D
Co

J. D. Boyd
Oceanography Division
Ocean Science Directorate

Approved for public release; distribution is unlimited. Naval Oceanographic and Atmospheric Research Laboratory,
Stennis Space Center, Mississippi 39529-5004.

90 08 20 070

These working papers were prepared for the timely dissemination of information;
this document does not represent the official position of NOARL.

Abstract

Between 25 June - 19 July 1989, an experiment deploying over 800 deep and shallow AXBTs was conducted in the subarctic frontal zone of the Northeast Pacific, between approximately 32° - 43° N, 138° - 151° W. The operation was part of the validation phase of the Naval Oceanographic and Atmospheric Research Laboratory's (NOARL's) Northeast Pacific Modeling Project (NEPAC). This document describes the experimental plan and the data acquisition and processing techniques used for the NEPAC experiment and presents the resulting data in graphical form.

Accession For	
NTIS GFA&I	☒
DTIC TAB	☐
Unannounced	☐
Justification	
By	
Distribution/	
Availability Codes	
Dist	Avail and/or Special
A-1	



Acknowledgments

The 30 research flights during the experimental period were made possible only with the help of a great many people. They included:

The officers and crew of the Naval Research Laboratory (NRL) aircraft #150607, CDR Robert Stephenson, commanding;

The officers and crew of the VXN-8 aircraft "Birdseye," LCDR H.S. Schaffer, commanding; Gary Athey and Leonard Gordon, civilian employees of the Naval Oceanographic Office on board the VXN-8 aircraft;

The officers and crew from patrol squadrons VP-9, VP-46, VP-48, and VP-Mau who flew 9 flights for the experiment;

LT Jim Curtis of COMPATWINGSPAC, our point of contact at Moffett Field, who made many arrangements for our use of facilities and resources there;

LCDR Stephen Ambrose, LCDR Robert Quinn, AWC K. Bales, AOC George Miller and other members of Patrol Wing Ten who helped with aircraft scheduling, replay of mission data tapes, and many logistical matters;

and many others who remain anonymous but without whose assistance the experiment could not have been a success.

Bob Linzell of Neptune Technologies and Shirley Baker of Planning Systems, Inc., did much of the data processing.

This project was sponsored by the Office of Naval Research through the Naval Ocean Modeling and Prediction (NOMP) program (R. Peloquin, program manager) under program elements PE06032707 Project #X2008 (LCDR W. Cook, Space and Naval Warfare Systems Command) and PE0602435N Block ORC2 (CDR L. Bonds, Office of Naval Technology); and the Anti-Submarine Warfare Environmental Acoustic Support (AEAS) program (E. Chaika, program manager) under program element PE0603785N projects #0121 and #2170 (Active Underwater Acoustic Modeling, G. Morris).

Contents

Introduction	1
Experimental Plan and Operations Description	1
<i>Personnel</i>	3
Data Collection and Processing	3
<i>Acquisition</i>	3
<i>Navigation</i>	4
<i>Initial Data Processing</i>	4
<i>Depth Equation Corrections</i>	5
<i>Final Data Processing</i>	6
Results	6
<i>Oceanographic Background</i>	6
<i>Horizontal Planes</i>	7
<i>Vertical Transects</i>	8
<i>GEOSAT Tracks</i>	8
References	8
Appendix A. NEPAC Grid 1 (25 - 28 June 1989). Temperature Contours at Selected Depths.	21
Appendix B. NEPAC Grid 2 (6 - 7 July 1989). Temperature Contours at Selected Depths.	37
Appendix C. NEPAC Grid 2 (6 - 7 July 1989). Inferred Salinity Contours at Selected Depths.	53
Appendix D. NEPAC Grid 2 (6 - 7 July 1989). Computed Sound Speed Contours at Selected Depths.	69
Appendix E.. NEPAC Grid 3 (17 - 19 July 1989). Temperature Contours at Selected Depths.	85
Appendix F. NEPAC Grid 1 (25 - 28 June 1989). Temperature Contours along Selected Vertical Transects. Surface to 300 m.	101

Appendix G. NEPAC Boundary Flight 1 (30 June 1989). Vertical Temperature Contours along All 4 Sides. Surface to 300 m.	115
Appendix H. NEPAC Grid 2 (6 - 7 July 1989). Temperature Contours along Selected Vertical Transects. Surface to 300 m.	121
Appendix I. NEPAC Grid 2 (6 - 7 July 1989). Temperature Contours along Selected Vertical Transects. Surface to 5500 m.	139
Appendix J. NEPAC Grid 2 (6 - 7 July 1989). Inferred Salinity Contours along Selected Vertical Transects. Surface to 5500 m.	155
Appendix K. NEPAC Grid 2 (6 - 7 July 1989). Calculated Sound Speed Contours along Selected Vertical Transects. Surface to 5500 m.	171
Appendix L. NEPAC Boundary Flight 2 (12 July 1989). Vertical Temperature Contours along All 4 Sides. Surface to 300 m.	187
Appendix M. NEPAC Grid 3 (17 - 19 July 1989). Temperature Contours along Selected Vertical Transects. Surface to 300 m.	195
Appendix N. First GEOSAT Underflight, 28 June 1989. Vertical Contours. Temperature: Surface to 300 m and Surface to 5500 m. Inferred Salinity: Surface to 5500 m. Calculated Sound Speed: Surface to 5500 m.	209
Appendix O. Second GEOSAT Underflight, 30 June 1989. Vertical Contours. Temperature: Surface to 300 m and Surface to 5500 m. Inferred Salinity: Surface to 5500 m. Calculated Sound Speed: Surface to 5500 m.	221
Appendix P. Third GEOSAT Underflight, 11 July 1989. Vertical Contours. Temperature: Surface to 300 m and Surface to 5500 m. Inferred Salinity: Surface to 5500 m. Calculated Sound Speed: Surface to 5500 m.	233

Aircraft Measurements in the Northeast Pacific, Summer 1989

Introduction

An extensive set of oceanographic measurements for three major experiments were obtained from research and operational P-3 aircraft during June and July 1989. These experiments were the Northeast Pacific (NEPAC) modeling project of the Naval Oceanographic and Atmospheric Research Laboratory (NOARL), the multi-institutional VAST project and the Downslope Conversion Experiment of the Scripps Institution of Oceanography. Over 1300 deep (nominally 760 m) and shallow (nominally 305 m) temperature profiles from airborne expendable bathythermographs (AXBTs) were obtained for the three experiments, as well as a number of sound speed profiles, current profiles, and drifter tracks from other types of air deployed instruments. This document provides an overview of the data obtained for the NEPAC experiment; data summaries for the VAST experiment and the Downslope Conversion Experiment are given in Boyd and Linzell (1990) and Boyd (1989).

The NOARL NEPAC modeling project is one of several projects which are developing oceanographic prediction systems based upon a hierarchy of nested numerical circulation models. The approach is to have a tactical scale (local scale) model nested within a regional model which is in turn nested within a global model. The NEPAC project has as its specific goal the development of an ocean environmental/acoustic prediction system for the subarctic frontal region of the Northeast Pacific Ocean. The primary objective of the aircraft operations for this experiment was to obtain initialization and validation data for the tactical scale model.

The operations also had three secondary objectives. The first was to acquire temperature transects along portions of tracks of the GEOSAT altimeter satellite so as to investigate the feasibility of using altimetry to monitor the North Pacific subarctic front. These data are included here. The second was to deploy from the aircraft six "minidrifiers" (Pickett, 1989), A-size drifting buoys which transmit position, sea surface temperature, air temperature, and barometric pressure back 6 - 8 times per day via SERVICE ARGOS. The drifting buoy data will be presented in a later NOARL Technical Note. The third objective was to deploy AXBTs and AXCPs (air deployed expendable current profilers) along six tracks crossing the subarctic front for a Naval Postgraduate School/University of Miami experiment. The current profiler data will be reported on elsewhere.

Experimental Plan and Operations Description

The study area lay between about 32 - 43° N, 138 - 151° W. All flights originated from Moffett Field, California. A summary of all flights for the three experiments is given in Table 1, and a composite of all NEPAC drop positions is shown in Fig. 1. The experimental plan was to obtain three near-synoptic realizations of a basically rectangular area, as shown in Figs. 2a, 2c, and 2e. A central portion was designated an intensive study area in which detailed tactical scale modeling was to be attempted; AXBTs were dropped around the boundary of this region between the first and second grids (Fig. 2b) and the second and third grids (Fig. 2d). Spacing between drops in the grids was 20 nmi (37 km) along track and 30 nmi (56 km) between tracks. Spacing between drops on the boundary flights was 20 nmi (37 km). Three flights were flown along GEOSAT tracks (Figs. 3a, 3b, and 3c), with an along-track spacing of 11 nmi (20 km). In general, deep (nominally 760 m) and shallow (nominally 305 m) AXBTs were alternated along the tracks. Table 1 summarizes average speeds and altitudes for the various flights.

Table 1. Summer 1989 NEPAC/VAST/Downslope Aircraft Speed and Altitude Summary

Date 1989	Ft #	Flight Description	Aircraft	True Airspeed, knots	Ground Speed, knots	Altitude kft	Navigation Error, nmi/km	System Used; Comments
25 June	101	NEPAC Grid A1#1	VXN-8	330	330	24.5-26.5	7.1/13.1	Inertial
26 June	102	NEPAC Grid B#1	VXN-8	330	330	24.5	2.1/3.9	I
	1	NEPAC Grid C#1	NRL	200	300	24.5	1.0/1.76	I
27 June								
28 June	301	NEPAC Grid D1 *	VP-9	230	220	12.5-14.4	N/A	
	103	NEPAC GEOSAT#1	VXN-8	230	240	10-10.5	3.5/6.2	I
	2	NEPAC Special Probes#1	NRL	200	190	5.0	0.1/0.2	Omega
29 June								
30 June	3	NEPAC GEOSAT#2	NRL	240	250	15.5-19.5	0.5/0.8	O
	104	NEPAC Boundary#1	VXN-8	330	330	22.5-25.5	1.1/2.1	I
1 July								
2 July								
3 July	4	NEPAC Special Probes#2	NRL	200	190	5.5	1.1/1.9	O
4 July	105	VAST Line W#1	VXN-8	225	230	2.8	1.6/2.8	I
5 July	202	Downslope#1 **	VP-9	200	200	3.0	4.5/7.9	I
6 July	106	VAST Line W#2	VXN-8	230	230	3.0	0.5/0.9	I;Estimate
	203	NEPAC Grid A2 **	VP-9	330	360	27.0	2.0/3.5	I
7 July	107	NEPAC Grid C#2	VXN-8	330	320	20.5	1.4/2.5	I;Est.
	304	NEPAC Grid D2#1 *	VP-46	N/A	220	10.5	N/A	
	5	NEPAC Grid B#2	NRL	310	300	20.5	1.6/1.1	O
8 July	205	Downslope(SUS)#2 **	VP-9	220	200	1.5	2.0/3.5	N/A;Est.
9 July	6	VAST Line W#3	NRL	225	220	2.0	7.3/13.5	I
10 July	7	VAST Line F#1	NRL	220	200	2.5	0.2/0.4	O
	206	Downslope#3 **	VP-9	200	190	2.0	0.2/0.3	O
	307	NEPAC Grid E *	VP-48	200	N/A	20.0	N/A	
11 July	308	NEPAC GEOSAT#3 *	VP-46	220	N/A	10.0	5.4/10.0	I
12 July	108	VAST Line F(SUS)#2	VXN-8	225	225	2.0	1.4/2.6	I
	209	NEPAC Boundary#2 **	VP-48	230	220	10.-16.	N/A	
13 July	109	VAST Line B (SUS)	VXN-8	220	230	2.-3.	0.5/0.9	I
14 July								
15 July								
16 July								
17 July	8	NEPAC Special Probes#3	NRL	215	200	5.-7.5	0.4/0.7	O
	210	NEPAC Grid A1#2 **	VP-48/MAU	240	260	5.0	N/A	
18 July	9	NEPAC Grid C#3	NRL	290	280	19.5	0.2/0.4	O
19 July	211	NEPAC Grid B#3 **	VP-48	300	290	24.5	0.5/0.9	O;Est.
	312	NEPAC Grid D2#2 *	VP-48	N/A	N/A	N/A	N/A	

* => VP ACFT

** => VP ACFT with Isis system on board

Notes: Air speed and ground speed values are approximate averages. Altitudes are also approximate averages, except where ranges are indicated; these numbers show the minimum and maximum altitudes listed in the navigation logs. Navigation errors are one half the navigation error upon landing. "N/A" indicates the information was not available. "I" or "O" indicate that Inertial system or Omega system was used for navigation. "Estimate" or "Est." indicate that the error was estimated by a P-3 crew member; other navigation error information was not available.

Personnel

The civilian personnel participating in part or all of the experiment were:

Dr. Janice Boyd	NOARL	Chief Scientist
Richard Myrick	NOARL	
Stephen Sova	NOARL	
Shirley Baker	Planning Systems, Inc.	Ground Station Manager
Robert Broome	Planning Systems, Inc.	
Peter Flynn	Planning Systems, Inc.	
Michael Wilcox	Planning Systems, Inc.	

Data Collection and Processing

All AXBTs (US Navy designation AN/SSQ-36) were manufactured by Sippican Ocean Systems, Marion, MA, under two contract numbers. The overall failure rate was 33 out of 847, or 3.9%. A summary of the contracts, lots, number dropped, and number of failures is given in Table 2.

Table 2. Summary of AXBT contract numbers, lots, number deployed, number failed, and failure rates. A failure rate of 5 - 10% is normal. Shallow (nominally 305 m) AXBTs had a NALC (Navy Ammunitions Logistics Code) of 8W59 and deep (nominally 750 m), 8W52.

<u>Contract N00163-87-C-001</u>		<u>Contract N00163-85-C-001</u>	
Shallow	Deep	Shallow	Deep
Lot numbers: 03,14,17,27,29	27	11,12,16,17,20,21, 22,24,26,27,30	21,24,27
# Dropped: 277	424	135	11
# Failures: 10	8	14	1
Failure rate: 3.6%	1.9%	10.4%	9.1%

Acquisition

Three different systems were used in data collection. The NOARL Physical Oceanography Branch (Code 331) Isis system was used on all NRL aircraft flights and most VP-squadron flights (see Fig. 4). Fig. 5 outlines the capabilities of the Isis system, which allows full processing and considerable analysis of the data

to be completed in the field. The Naval Oceanographic Office's (NAVOCEANO's) ADAPS (Airborne Data Acquisition and Processing System) system was used on the VXN-8 aircraft. On the VP-squadron flights for which no Isis system was installed, the AXBT signals were recorded on the 14-track mission data tapes and the tapes were later played back in the ASWOC (ASW Operations Center) into an Isis unit. A problem with the mission data tapes made the replayed data for the 10 July NEPAC Grid E flight so noisy as to be unusable.

Data was transmitted from the AXBTs as a frequency modulated signal on one of three standard carrier frequencies (channel 12 or 170.5 MHz, channel 14 or 172.0 MHz, and channel 16 or 173.5 MHz). Typically all three channels were transmitting at the same time. The signals were picked up by standard Navy sonobuoy receivers, and either sent to the on-board 14 track tape recorder (in the case of Fleet aircraft without the Isis system on board), or else they were amplified, and sent to either the Isis or the ADAPS data interface unit where they were again amplified and filtered, digitized and sent along a 16 bit parallel GPIO interface bus to the acquisition computer, i.e. Hewlett-Packard 9000 model 320 (ADAPS) or 330 (Isis). With the Isis and ADAPS systems, the incoming signal was also sent to a VCR-based backup recording system for later replay, if necessary. No degradation of data quality is noticed when data is replayed.

With both the Isis and ADAPS systems, the HP 9000 acquisition computer subsampled each input data stream at 10 Hz (about every 15 cm in depth) and displayed the data in real time on the CRT display. Upon termination of an AXBT the data was stored on 3.5" microdiskettes. The data on the microdiskettes was then read into a PC-AT compatible microcomputer where it was processed and plotted. As the NAVOCEANO ADAPS interface unit is an earlier version of the Isis unit, complete compatibility existed between both acquisition systems and the Isis processing and analysis modules. Usually processing was completed on the return leg of the flights.

Navigation

The on-board inertial and Omega navigation systems were used on each aircraft. The navigation system was initialized as part of pre-flight procedures and the system position drift was usually recorded at the conclusion of the flight. If system drift is reasonably linear with time, the mean position error can be taken as about one-half of the error at the flight's conclusion. The mean position errors are listed in Table 1. Drop position accuracies are generally taken to be 1.5 times the navigation accuracy. To estimate drop position errors for the flights in Table 1, multiply the given position error by 1.5. The wide variations in errors from flight to flight are typical.

On board the NRL and VXN-8 aircraft the drop positions were automatically recorded by the data acquisition system as a probe was launched. On Fleet aircraft the AXBT positions were automatically logged by the onboard CP 901 computer system. Positions were later transcribed by hand from the mission printout and merged with the data.

Initial Data Processing

The data from the 3.5" microdiskettes was read into 80386 PC computers for processing. A 21 point (2.1 second) median filter was applied to remove most of the one to several point data spikes and other "glitches" that occur in the data for various reasons and to filter out much of the high frequency noise. The raw data was then converted to engineering units using the Navy standard conversion equations. For temperature this is

$$T = -40.0 + 0.02778 F,$$

where F is frequency in hertz and T is temperature in $^{\circ}\text{C}$. The Navy standard requires the temperature accuracy to be about $\pm 0.55^{\circ}\text{C}$ within the range from -2° to 35°C , but the probes marketed by Sippican are known to be accurate to about $\pm 0.2^{\circ}\text{C}$ (e.g., Boyd, 1987).

The Navy standard elapsed-fall-time to depth conversion equation is

$$z = 1.52 t,$$

where z is depth in meters and t is elapsed time after probe release in seconds. The standard requires the depth to be accurate to $\pm 5\%$ down to 305 m, and studies done on earlier versions of the deep and shallow AXBTs showed the depth error was bounded by this value throughout the appropriate depth ranges of the probes (Boyd, 1987).

After conversion to engineering units, if necessary, navigation information was merged with the data, the data were decimated to a 1-meter resolution, and a final 9-point median filter was applied to complete the smoothing process. The processed data were then visually scanned, primarily to find occasional data spikes at the very beginning or end of the profile which were not removed by the filtering process. These and a few other problems were removed using the Isis system interactive data editor, and the data were archived in the standard Isis archive format in 2-meter resolution and major temperature inflection point forms.

Depth Equation Corrections

About six months after the experiment, another set of data became available which allowed considerable improvements to be made to the shallow and deep AXBT fall rate equations. A series of shipboard CTD (conductivity-temperature-depth) stations were taken in the study area as part of the VAST experiment. As these observations included direct measurement of pressure, accurate depth versus temperature profiles could be constructed for those stations (accurate to ± 1 m in depth for the prevailing conditions and processing techniques). A significant number of deep AXBTs were dropped near the stations, so the following statistical procedure was developed for calculating an improved depth equation for deep AXBTs. This improved equation was then used in the comparison of adjacent shallow and deep AXBTs, and an improved shallow AXBT fall rate equation was determined.

Deep AXBTs dropped within 30 km and 12 hours of a CTD cast were used. The depths of 15 isotherms were determined for both the deep AXBTs and the CTDs, and linear regressions of AXBT depth versus CTD depth were computed for the resulting 202 data points (see Fig. 6). Based on earlier work, a quadratic equation for deep AXBT depth was expected, but in this study the quadratic term coefficient was never found to be significantly different from zero, probably due to the inherent variability of measurements separated this far in both space and time. However, a significant modified linear term coefficient was found, giving a new equation of

$$z_{\text{DAXBT}} = 1.6094 t$$

where z is depth in meters and t is elapsed time in seconds. The correlation coefficient was significantly different from zero at a 95% confidence level. The resulting corrected depths compared much more favorably with the CTD depths (Fig. 7).

During the GEOSAT lines on 28 and 30 June and 11 July 1989, deep and shallow AXBTs were dropped sequentially at an 11 nmi (22 km) separation. Depths of 13 isotherms from the shallow AXBTs were compared with the corrected depths from the adjacent deep AXBTs (Fig. 8). Linear regressions of shallow AXBT depth versus corrected deep AXBT depth were computed. Again the quadratic term was never

significantly different from zero. The resulting corrected shallow AXBT fall rate equation was

$$Z_{\text{SAXBT}} = 1.4969 t$$

where z is depth in meters and t is elapsed fall time in seconds. The correlation coefficient was significantly different from zero at a 95% confidence level. The resulting depth correction, while subtle (Fig. 9), is important, particularly for maintaining consistency in the depths of features when deep and shallow AXBTs are dropped alternately.

Final Data Processing

The depths of all profiles were corrected according to the above equations. The temperature profiles were then merged with climatological temperatures using a procedure which reduces the deviation between actual temperature and climatological temperature exponentially with depth until the climatological temperature is reached. The scale depth for the merge was chosen as 500 m, and the climatology was the Navy standard GDEM (Generalized Digital Environmental Model) climatology for the summer season. GDEM has values at every half degree of latitude and longitude. The climatological profile was computed as the weighted mean of the nearest four GDEM values, weighted by the fractional N-S and E-W distances. Profiles were extended from surface to ocean bottom, with the bottom depth being taken as that from the Navy standard DBDB5 bathymetry, which comes on a five minute grid. Values were interpolated the same way as with climatology, the weighted mean of the four nearest values, weighted by the fractional N-S and E-W distances.

A salinity profile was then computed for each temperature profile using climatological or CTD T-S-z relationships. If no CTD cast was within 60 km (approximately one horizontal correlation scale), only the T-S-z relationship from the interpolated GDEM climatological profile was used. If a CTD was within 60 km, the mean profile was calculated with the addition of the CTD profile, weighted 10 times as much as a climatological profile. Surface to bottom sound speeds were then computed using the UNESCO-87 algorithm (Fofonoff and Millard, 1983).

Some of the descriptive results from the experiment are described in the next section.

Results

Oceanographic Background

The region of interest for the NEPAC project is primarily the subarctic frontal zone of the Northeast Pacific. In 1989, however, in order to cooperate with the VAST project, the part of the region to be modeled was extended southward into the transition region to the northern limits of the subtropical frontal zone (Fig. 10). The region is a complex one from the physical oceanographic standpoint, with the subarctic region lying north of about 42°N, the subtropical region lying south of about 32°N, and a transition region with multiple fronts and mixed subarctic and subtropical waters lying in between.

The subarctic region is characterized by low temperatures and low salinities (<33.8 psu) in the surface domain, ranging from the upper 30 m in summer to 100 m in winter. Below the surface region is a well defined permanent halocline between 100 and 150 m in which salinity increases from about 33.0 psu to 33.8 psu. Temperature inversions are often found in the halocline, and the southern limit of the subarctic region is that beyond which persistent temperature inversions do not occur. During summer a distinct temperature minimum is located between the bottom of the shallow seasonal thermocline and the underlying temperature

Inversion.

The southern limit of the subarctic region is the subarctic front, which is defined by the abrupt change in the salinity structure. The 33.8 ppt isohaline rises from near the base of the subarctic halocline to the surface in the subarctic front. The front extends from the western North Pacific east to North America where it turns southward off California and Baja California and forms what has been called the California Front (Saur, 1980). West of 150°W it generally lies between latitudes 40° - 43°N, and then bends southward east of 150°W. The front consists of not one but several meandering temperature, salinity, and density fronts and their associated eddies, all of which are most pronounced in the upper several hundred meters. Roden and Robinson (1988) review and summarize the properties of the subarctic frontal zone.

The subtropical region lies south of about 32°N, consisting of what Sverdrup (1942) called the North Pacific Central Waters. It is characterized at the surface by salinities greater than 34.8 psu and has a halocline and associated thermocline between about 100 - 250 m in which salinity decreases with depth.

The northern limit of the North Pacific Central Waters is the subtropical front. This front has not been studied as well as the subarctic front, but it appears that the average position of the subtropical front may be defined by the position of the 34.8 or 34.9 psu isohaline at or near the surface (Lynn, 1986). It lies between about 31° - 33°N. Somewhat north of this, around 33°N, is what Lynn (1986) called the northern subtropical front. It appears to originate in the Kuroshio Extension and is continuous or semi-continuous across the North Pacific, and has a temperature range of 14° - 17° (all temperatures are in Celsius) and salinity range of 34.4 - 34.6 psu.

Between the two frontal zones lies the subarctic-subtropical transition zone. It contains waters with both subtropical and subarctic characteristics, mixed in various proportions depending primarily upon the distance from the source regions. Transient temperature inversions between 100 - 200 m are not uncommon in the northern part where the subarctic water is more common.

The figures presented in Appendices A - P will be discussed in light of this oceanographic background. The scales of the figures were chosen to coincide with the figures of the other NOARL Technical Notes which will be coming out in this series.

Horizontal Planes

Horizontal temperature contours at the surface, 25 m, 50 m, 75 m, 100 m, 150 m, 200 m, 250 m, 300 m, 400 m, 500 m, 600 m, and 700 m are presented in Appendices A (Grid 1, 25-28 June 1989), B (Grid 2, 6-7 July 1989) and E (Grid 3, 17-19 July 1989). Appendices C and D contain the same depth levels for the Grid 2 inferred salinity and for sound speed. Preceding each collection of figures is a plot of all drop locations.

The contours at 50 m provide a good example of the features that may be observed in the data. The subarctic front is well defined, with the characteristic presence of several meandering frontal zones and their associated eddies quite apparent. The main portion of the front lies between about 36° - 38° N, with a meander penetrating south between 144° - 148°W. The presence of several eddies is suggested in the meander region, but the sampling was too coarse to properly resolve them. A second but less intense frontal zone lies to the north, with a suggestion (see the Grid 2 temperature and sound speed contours in particular) that the subarctic front bifurcated west of about 143° W into northern and more intense southern filaments. This determination of the region of the subarctic frontal zone is also borne out by the limits of the 8° and 10° isotherms at 150 m (Roden and Robinson, 1988). The southern limit of the subarctic salinity front may be defined by the surfacing of the 33.8 psu isohaline (Roden and Robinson, 1988), and on the inferred surface salinity plot for Grid 2, this lies in the southern portion of the frontal zone as defined by the 8° and 10° isotherms. There is some evidence from the three grids that over the three weeks of the

experiment, the meander pushed further south and pinched off into an eddy (see, for example, the evolution at 50 m of the 15° isotherm in the meander over the three grid resolutions).

The second front which is visible in the data, between 34° - 36°N, may be a northward meander of the northern subtropical front. Its position agrees quite closely with Lynn's (1987) observations except that the temperature range of the frontal region is about 18° - 20° rather than the 14° - 17° quoted above.

Vertical Transects

Temperature contours along the vertical transects flown during each of the three grids are plotted from the surface to 300 m in Appendices F, H, and M. In addition, temperature extended to the bottom, inferred salinity and calculated sound speed are plotted from the surface to 5500 m for the second grid in Appendices I, J, and K. Preceding each collection of figures is a plot of all drop positions, annotated with the transect numbers which appear in the figure labels.

Flights around the boundary of the region in which the tactical scale modeling was emphasized were conducted between Grids 1 and 2 and Grids 2 and 3. Temperature contours from 0 - 300 m are plotted for all four sides of each boundary flight in Appendices G and L.

GEOSAT Tracks

Temperature contours from surface - 300 m and surface - 5500 m from each of the three GEOSAT underflights are presented in Appendices N, O, and P, along with the inferred salinity and calculated sound speed from the surface to 5500 m. Drop positions are plotted on the charts preceding each collection of transects.

In all six GEOSAT lines, centered around 40 m is a strong seasonal thermocline to the north of about 37°N. The thermocline region seems to bifurcate south of 37°, with a less intense thermocline continuing at 40 m and a rapid descent of another portion of the thermocline down to greater than 100 m. Signatures of the subarctic and northern subtropical (?) fronts may be observed around 37°N and 34°N on most of the transects.

References

- Boyd, J.D. (1987). Improved Depth and Temperature Conversion Equations for Sippican AXBTs. *J. Atm. Oc. Tech.*, 4, p. 545-551.
- Boyd, J.D. (1989). *Aircraft Measurements in the Northeast Pacific in Support of the Downslope Conversion Experiment*. Naval Ocean Research and Development Activity, Stennis Space Center, MS, NORDA Technical Note 470.
- Boyd, J.D., and R.W. Linzell (1990). *Environmental Data Inventory, VAST-I, July 1989*. Naval Oceanographic and Atmospheric Research Laboratory, Stennis Space Center, MS, NOARL Technical Note 13.
- Fofonoff, N.P., and R.C. Millard (1983). *Algorithms for the Computation of Fundamental Properties of Seawater*. UNESCO Tech. Pap. in Mar. Sci., no. 44, 53 pp.
- Lynn, R.J. (1986). The Subarctic and Northern Subtropical Fronts in the eastern North Pacific Ocean in Spring. *J. Phys. Oceanogr.*, 16, p. 209-222.

Pickett, R.L. (1989). *U. S. Navy Tests of Sonobuoy-sized Environmental Data Buoys*. Naval Ocean Research and Development Activity, Stennis Space Center, MS, NORDA Technical Note 420.

Roden G.I. and A.R. Robinson (1988). *Subarctic Frontal Zone in the North-Eastern Pacific: Mesoscale Structure and Synoptic Description*. Harvard University, Cambridge, MA, Harvard Open Ocean Model Report # 31.

Roden, G.I. and A. R. Robinson (1989). *Subarctic-Subtropical Transition Zone in the North-East Pacific: Mesoscale Structure and Synoptic Description*. Harvard University, Cambridge, MA, Harvard Open Ocean Model Report # 35 (DRAFT).

Saur, J.F.T. (1980). Surface salinity and temperature on the San Francisco-Honolulu route, June 1966-December 1970 and January 1972-December 1975. *J. Phys. Oceanogr.*, 10, p. 1669-1680.

Sverdrup, H.U., M.W. Johnson and R.H. Fleming (1942). *The Oceans*. Prentice Hall, 1087 pp.

NEPAC, 25 June - 19 July 1989

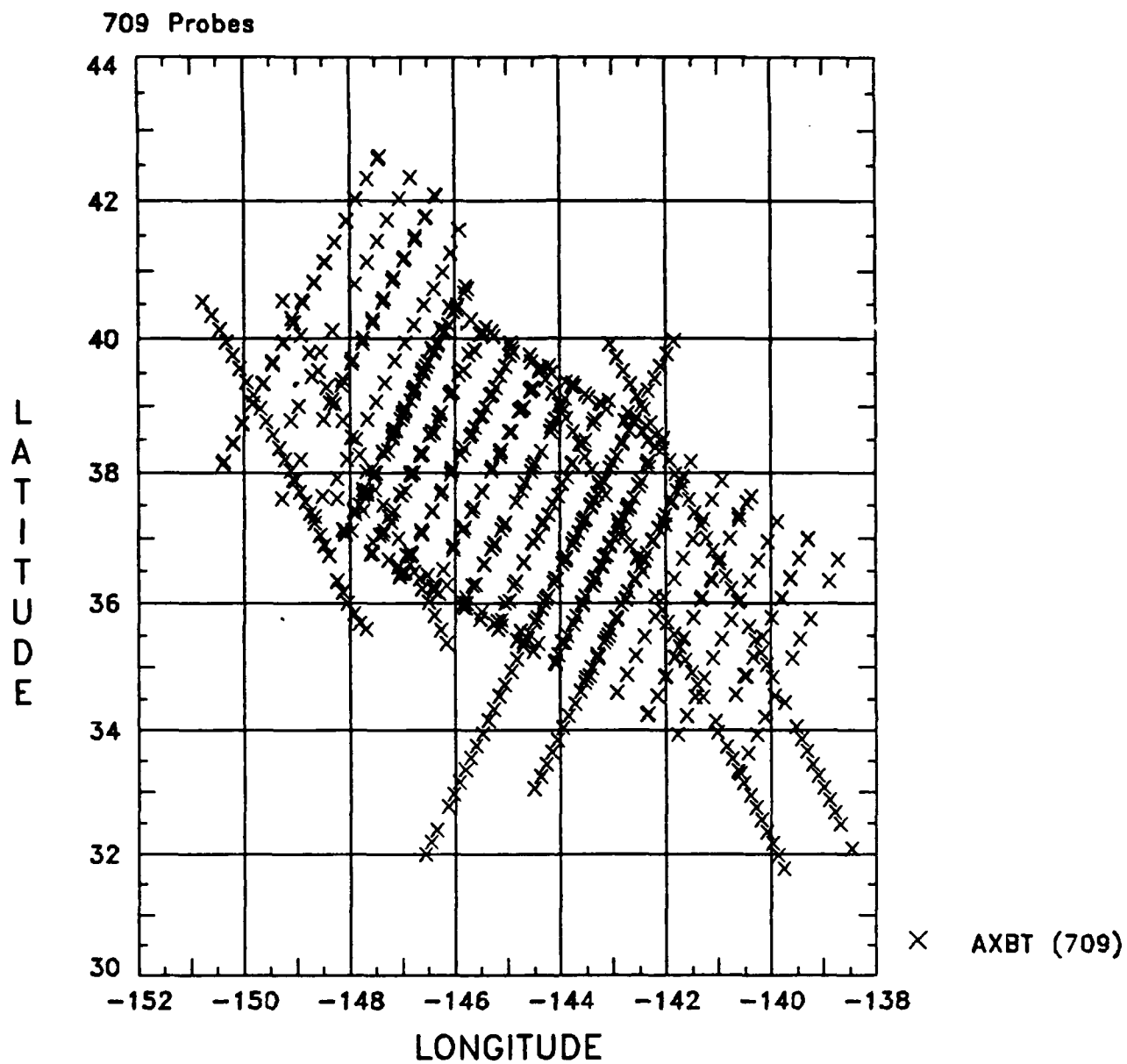


Figure 1. Composite of all NEPAC drop positions between 25 June - 19 July 1989.

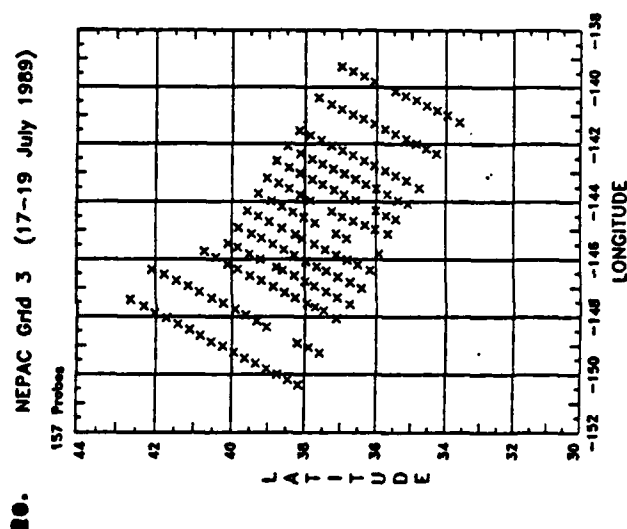
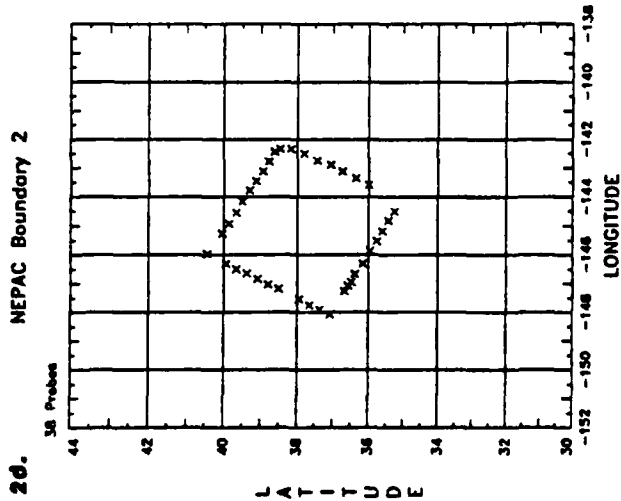
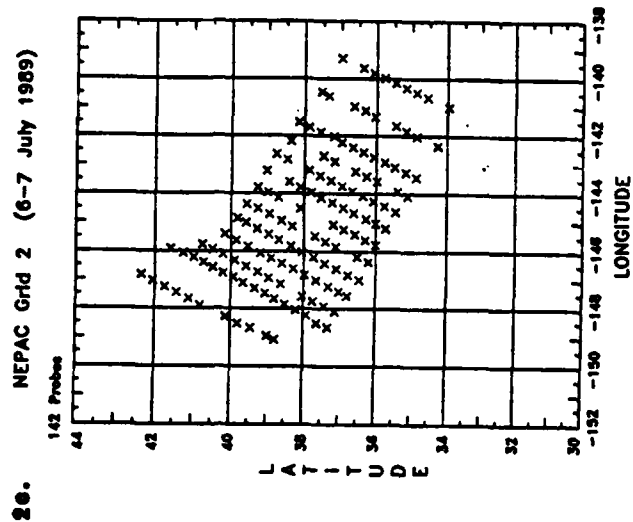
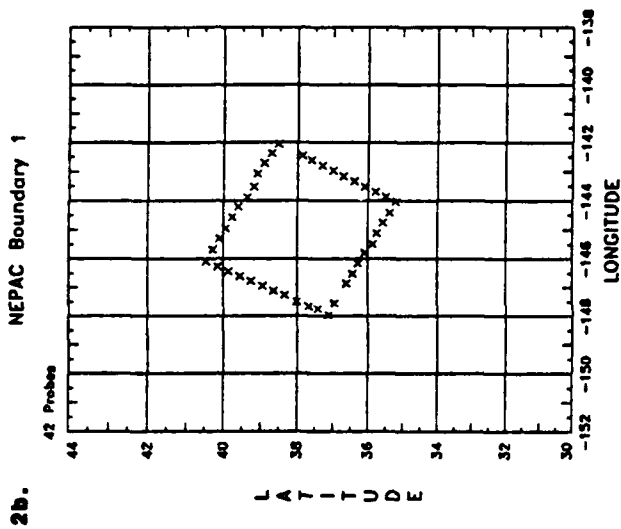
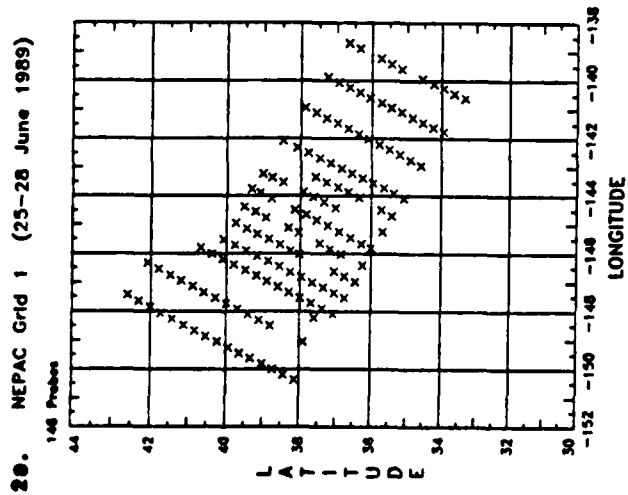


Figure 2. The three individual NEPAC grids (a, c, e) and the two boundary flights (b, d).

NEPAC GEOSAT 1, 2 & 3

189 Probes

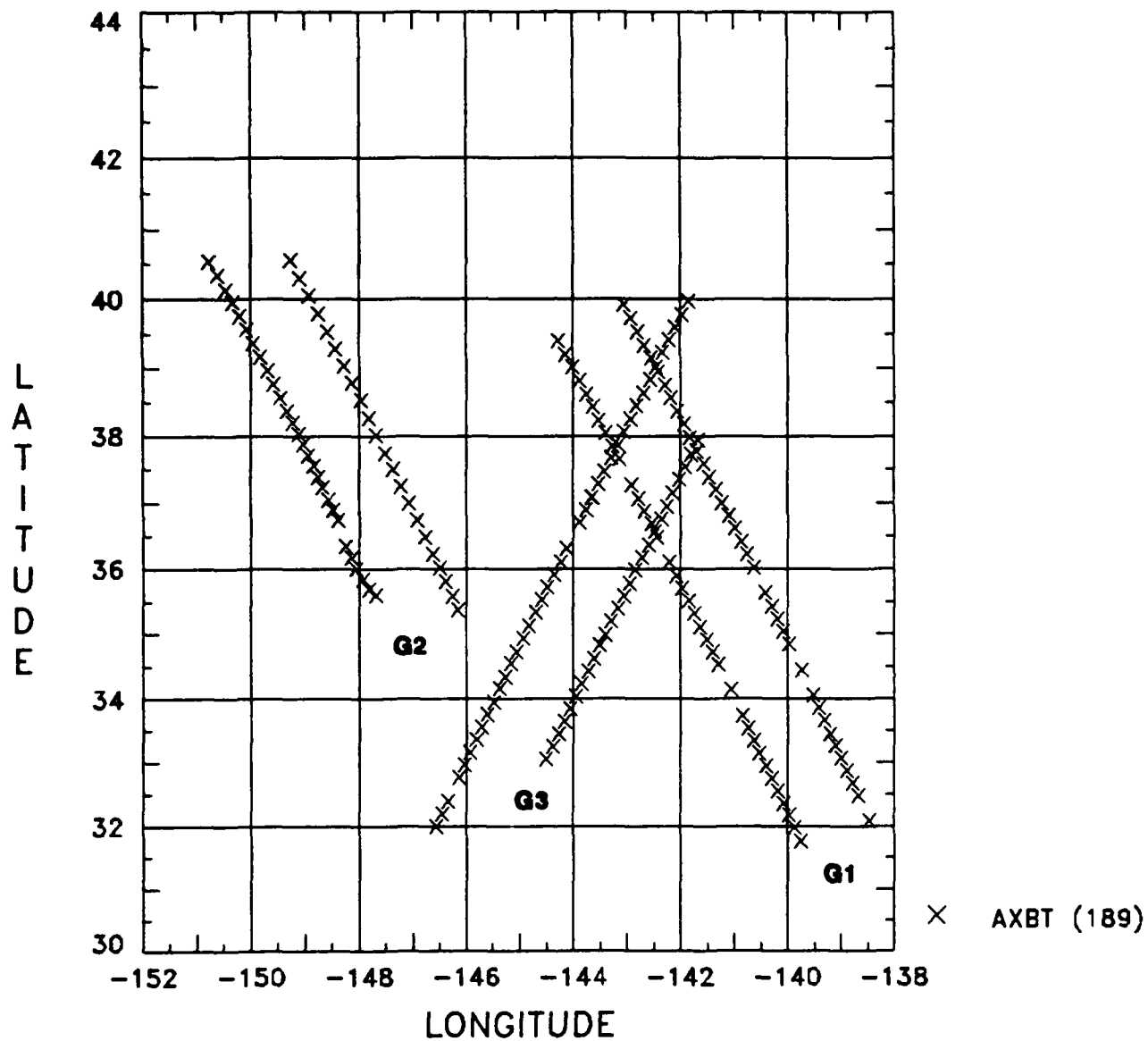


Figure 3. The three sets of NEPAC GEOSAT tracks.

ISIS ACQUISITION, PROCESSING, AND ANALYSIS SYSTEM

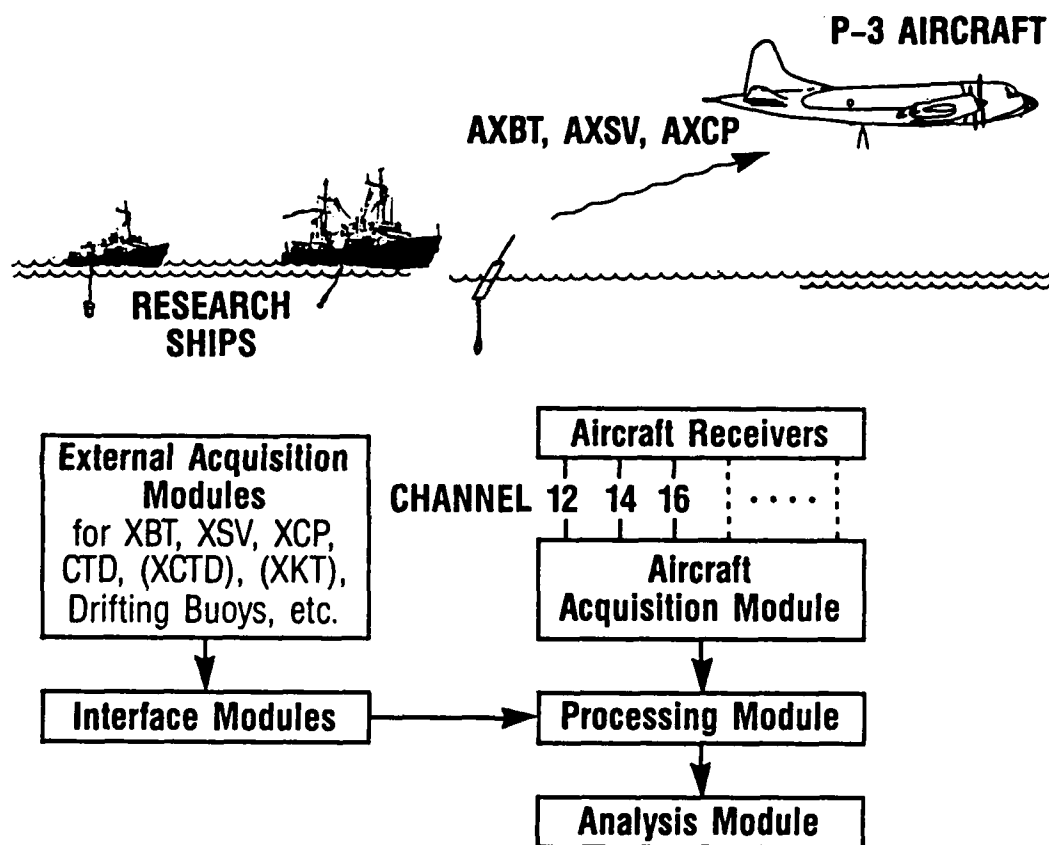


Figure 4. Outline of the Isis acquisition, processing, and analysis system.

ISIS ANALYSIS MODULE

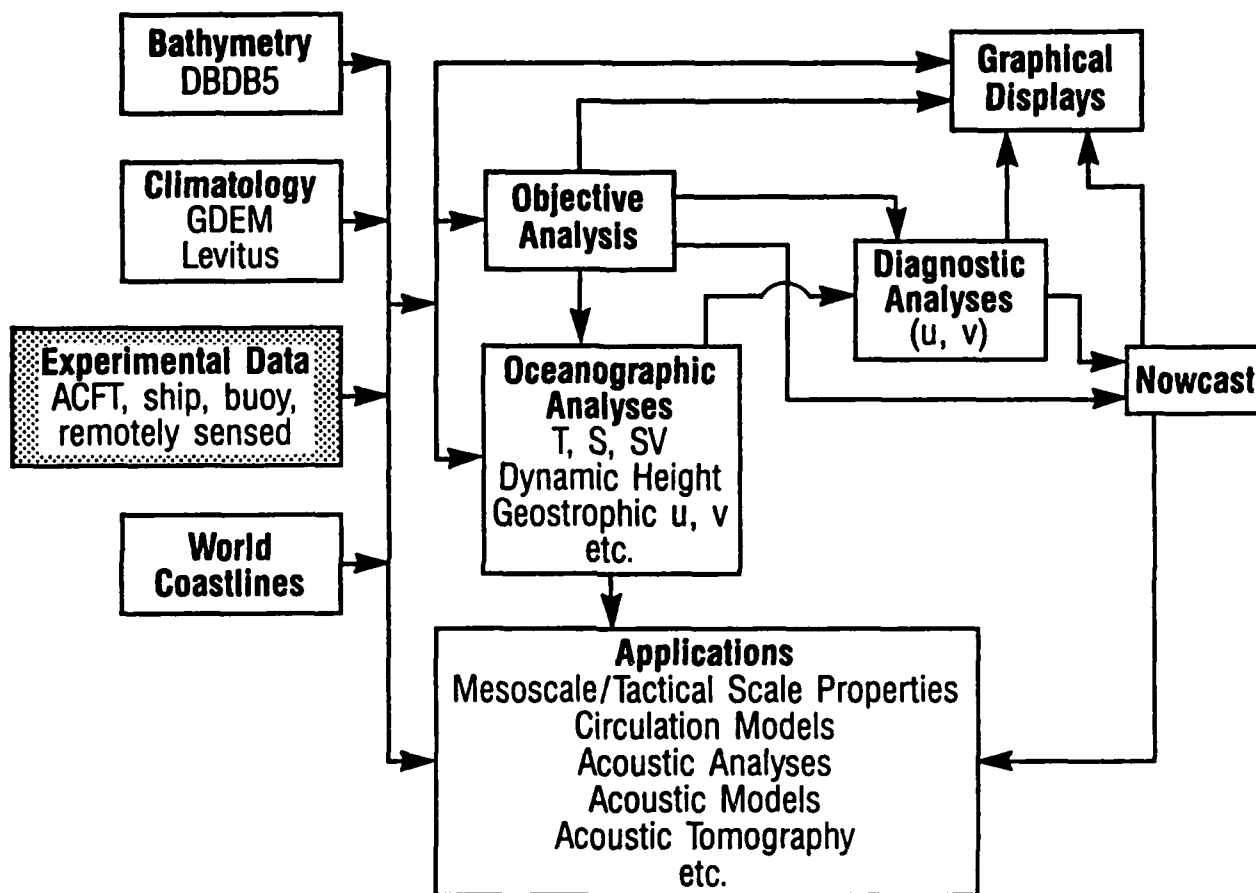


Figure 5. Isis system capabilities.

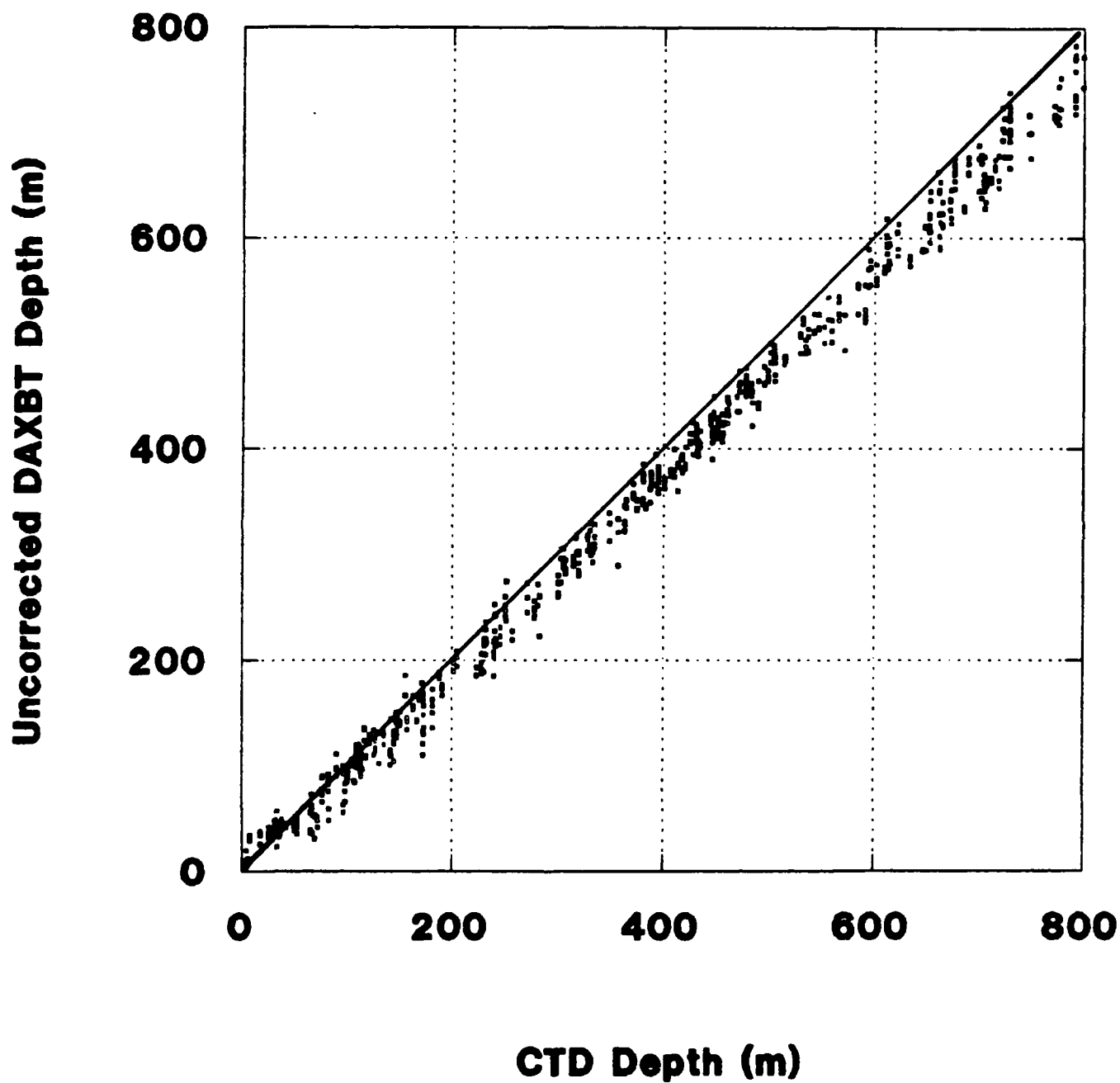


Figure 6. Uncorrected deep AXBT (DAXBT) isotherm depths versus CTD isotherm depths.

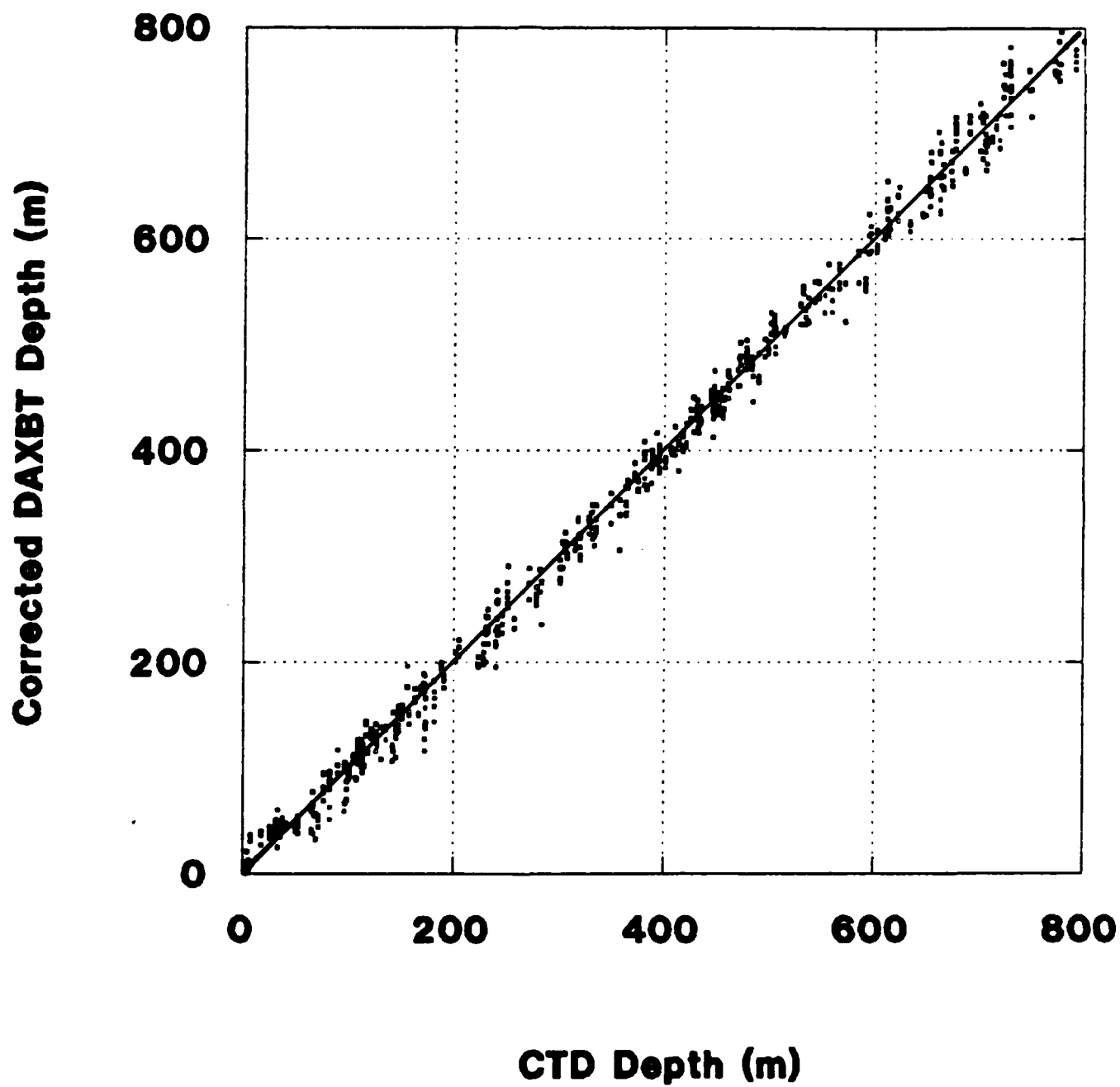


Figure 7. Corrected deep AXBT (DAXBT) isotherm depths versus CTD isotherm depths.

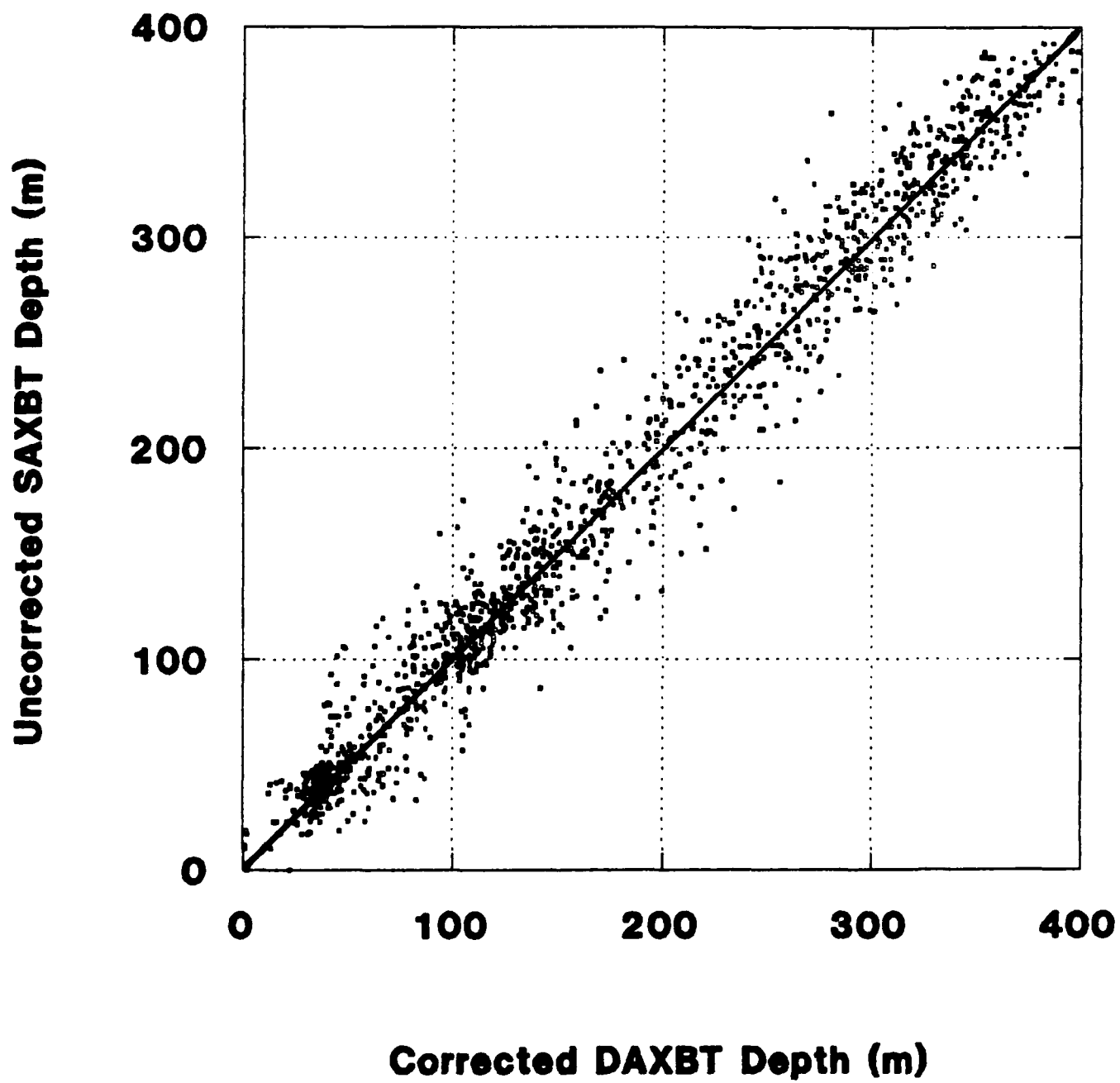


Figure 8. Uncorrected shallow AXBT (SAXBT) isotherm depths versus corrected deep AXBT (DAXBT) isotherm depths.

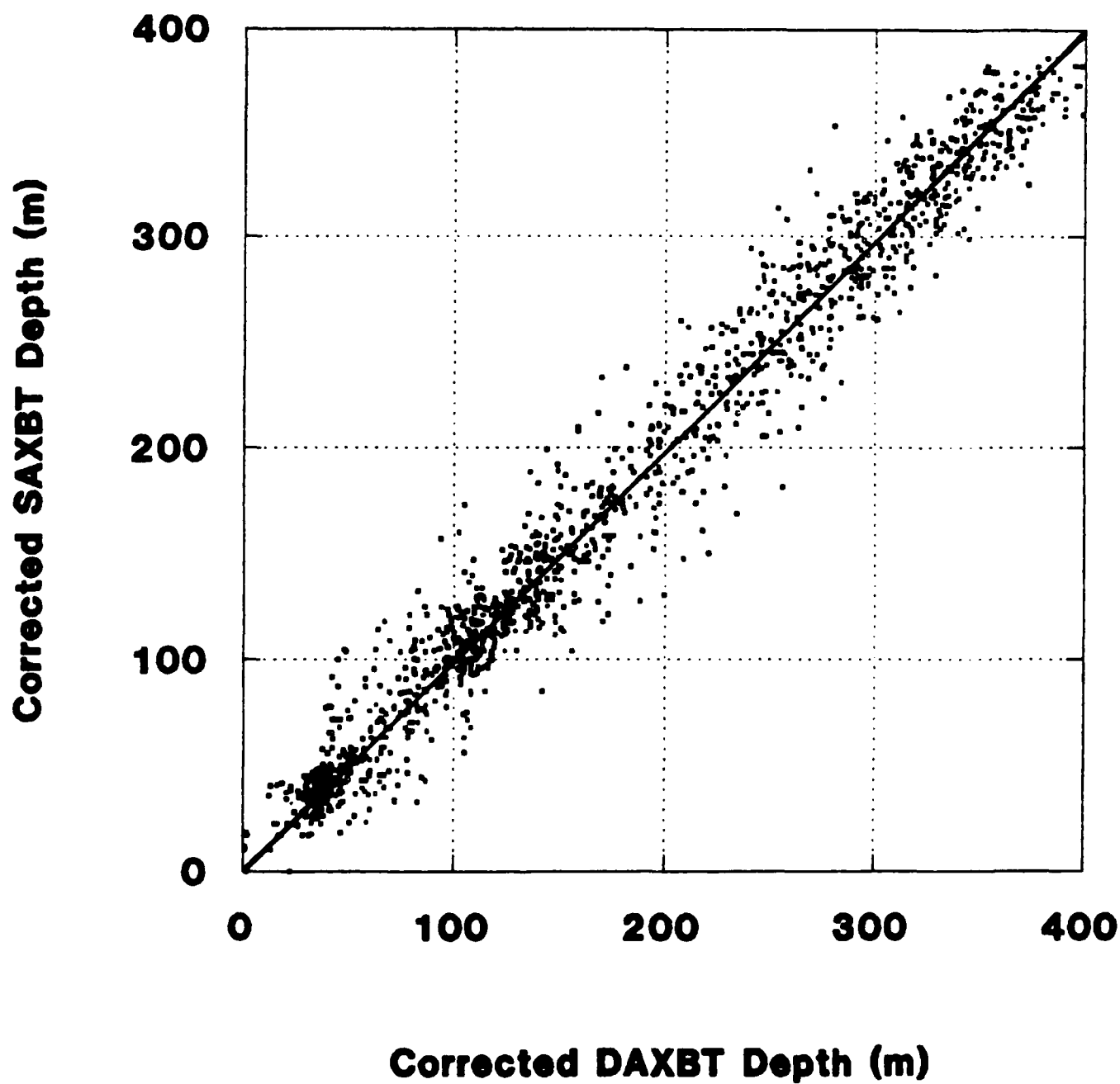


Figure 9. Corrected shallow AXBT (SAXBT) isotherm depths versus corrected deep AXBT (DAXBT) isotherm depths.

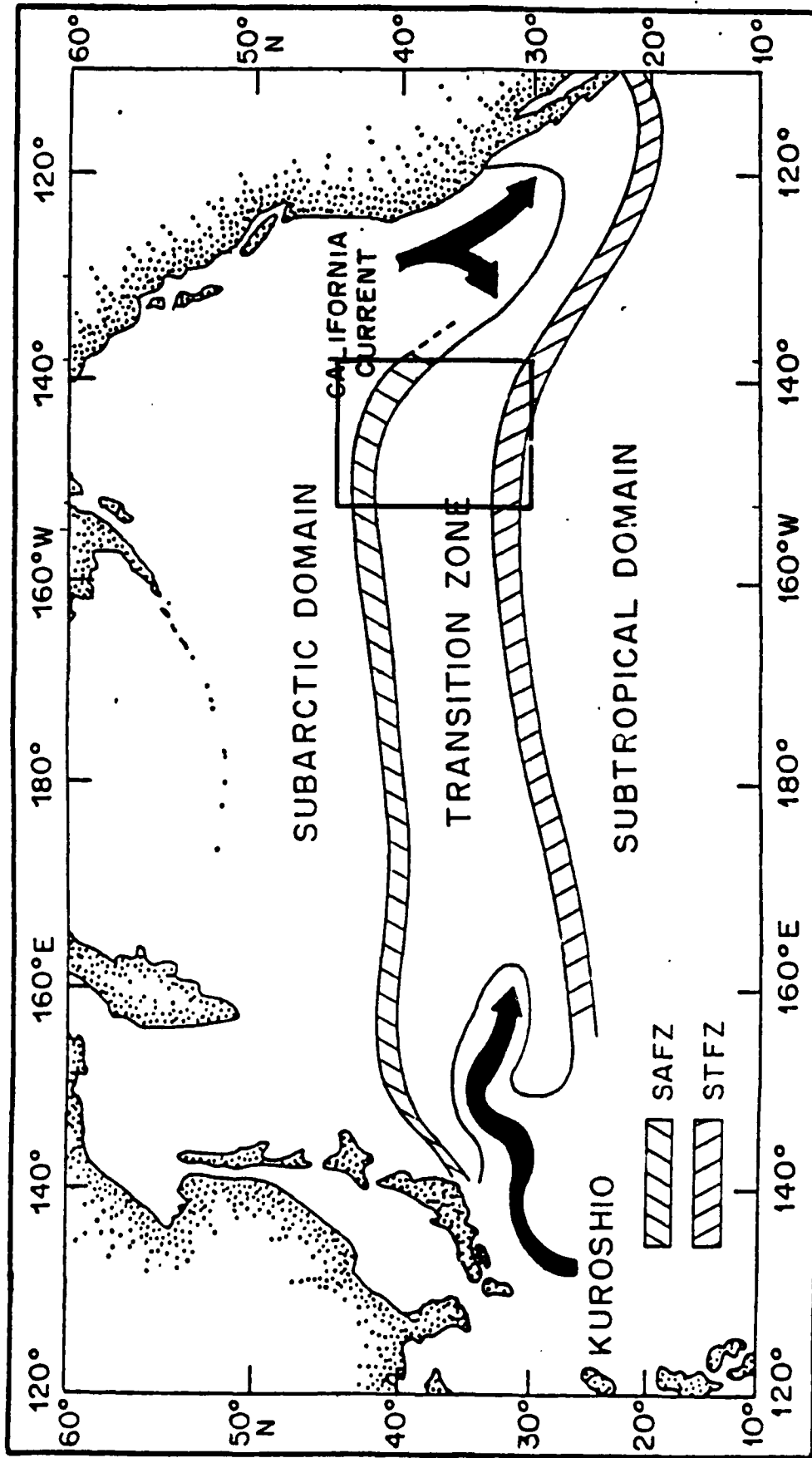


Figure 10. Schematic view of the principal oceanic regions in the mid-latitude North Pacific. Arrows indicate prevailing current directions. SAFZ is subarctic salinity frontal zone; STFZ is the subtropical temperature frontal zone. The NEPAC area during June - July 1989 is shown by the box. (From Roden and Robinson, 1989).

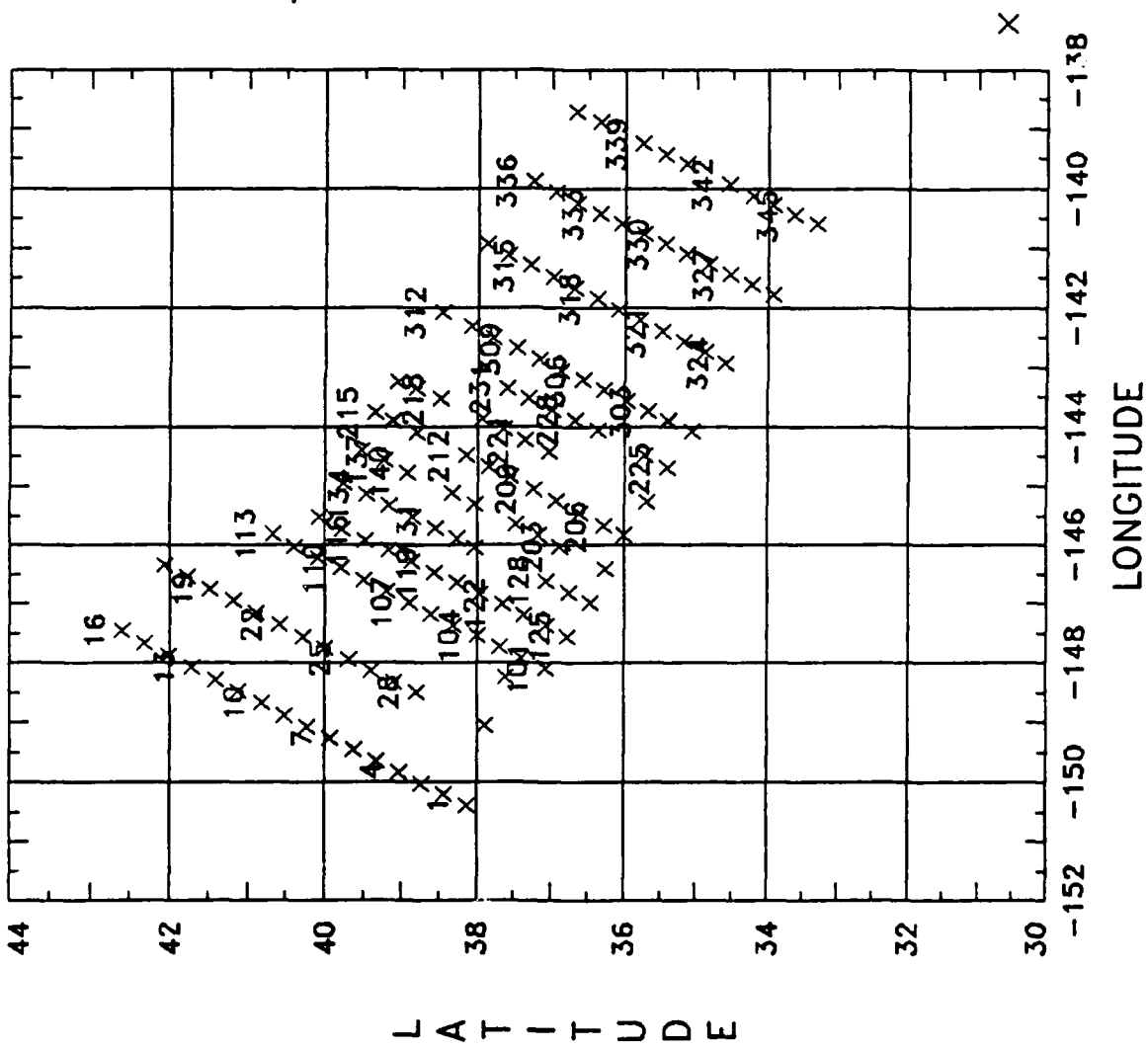
Appendix A.

NEPAC Grid 1 (25 - 28 June 1989)

Temperature Contours at Selected Depths

NEPAC Grid 1 (25-28 June 1989)

146 Probes



NOARL Code 331

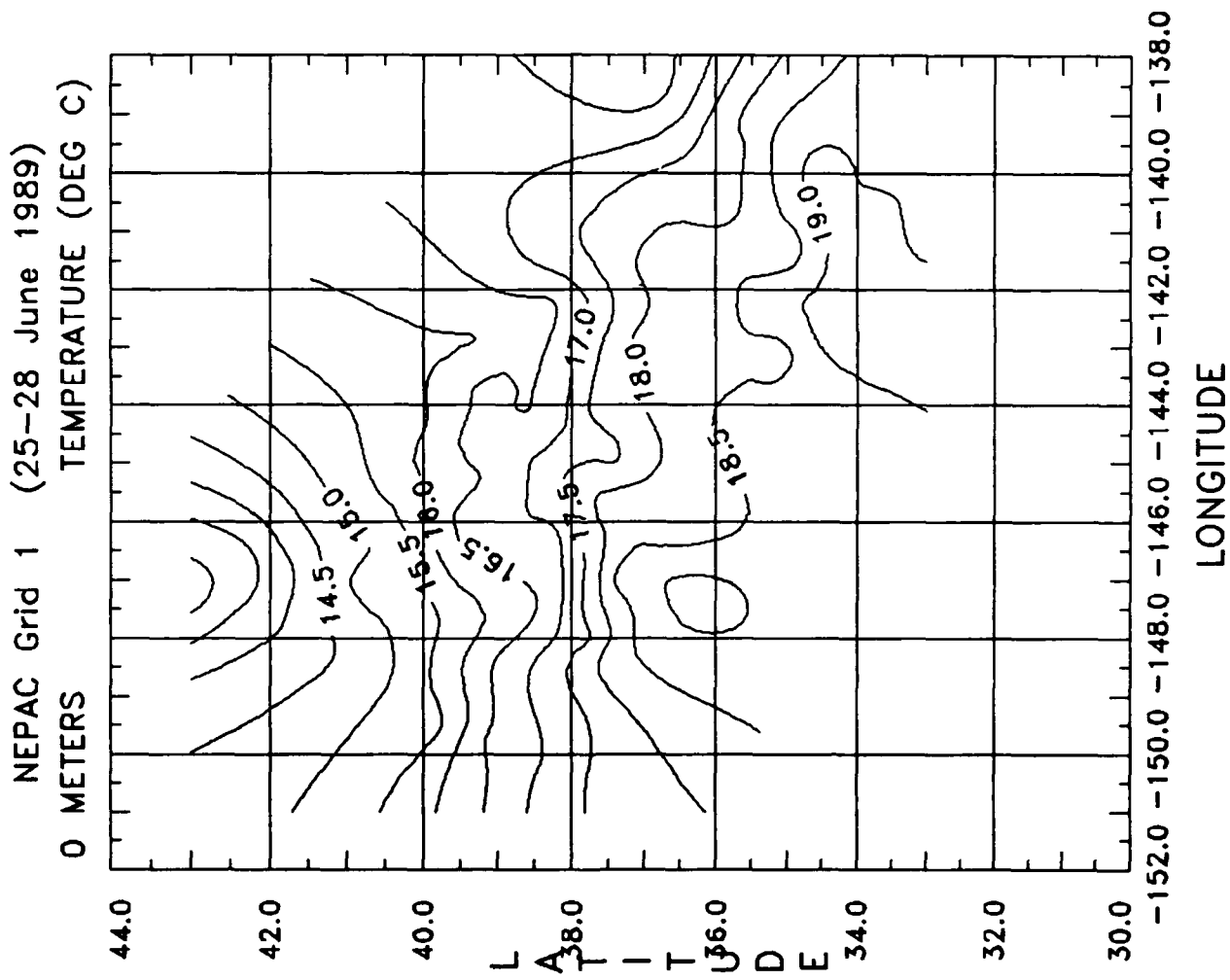
9:05:57

5/09/90

15:18:44

11/27/89

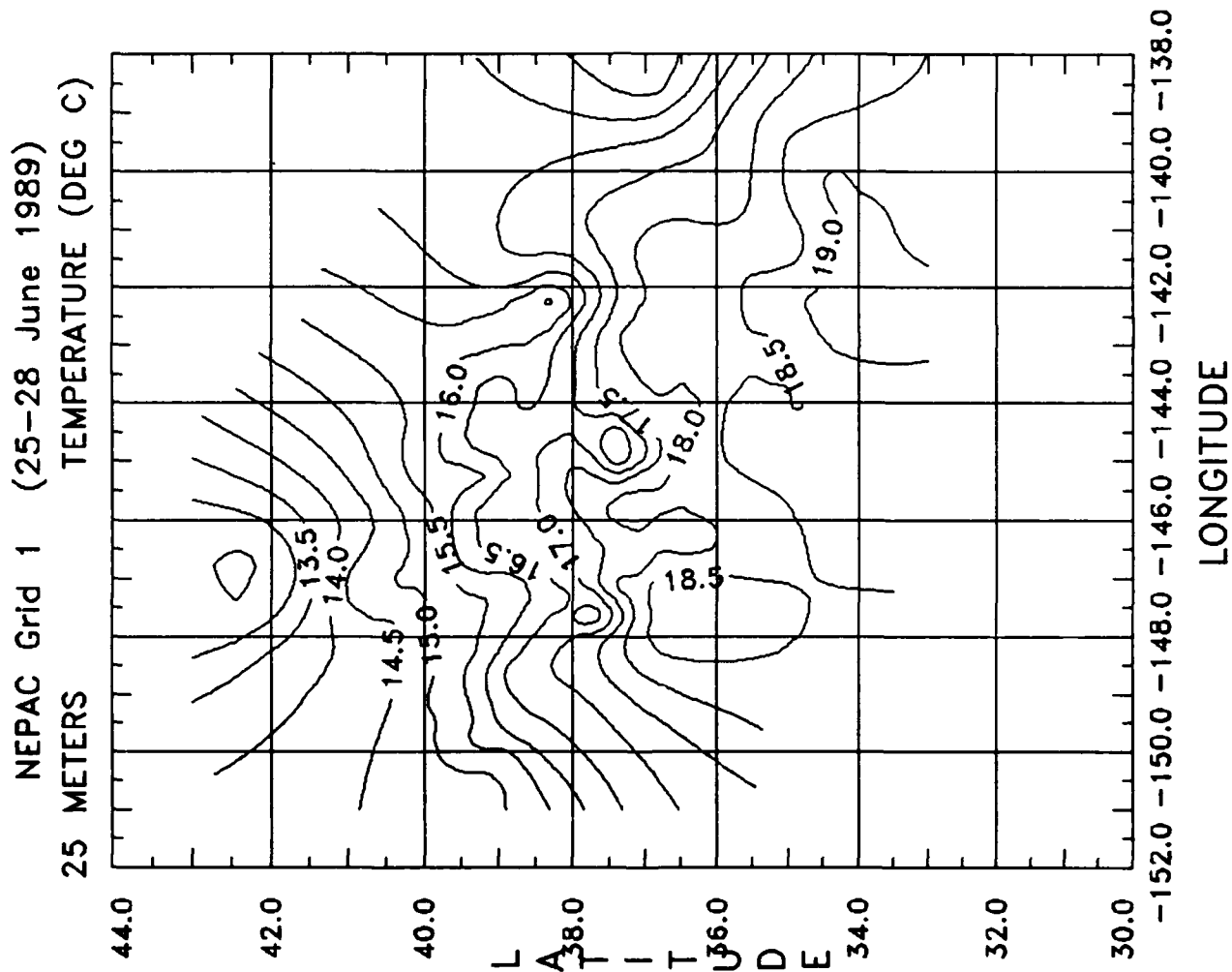
dx=.3, dy=.3



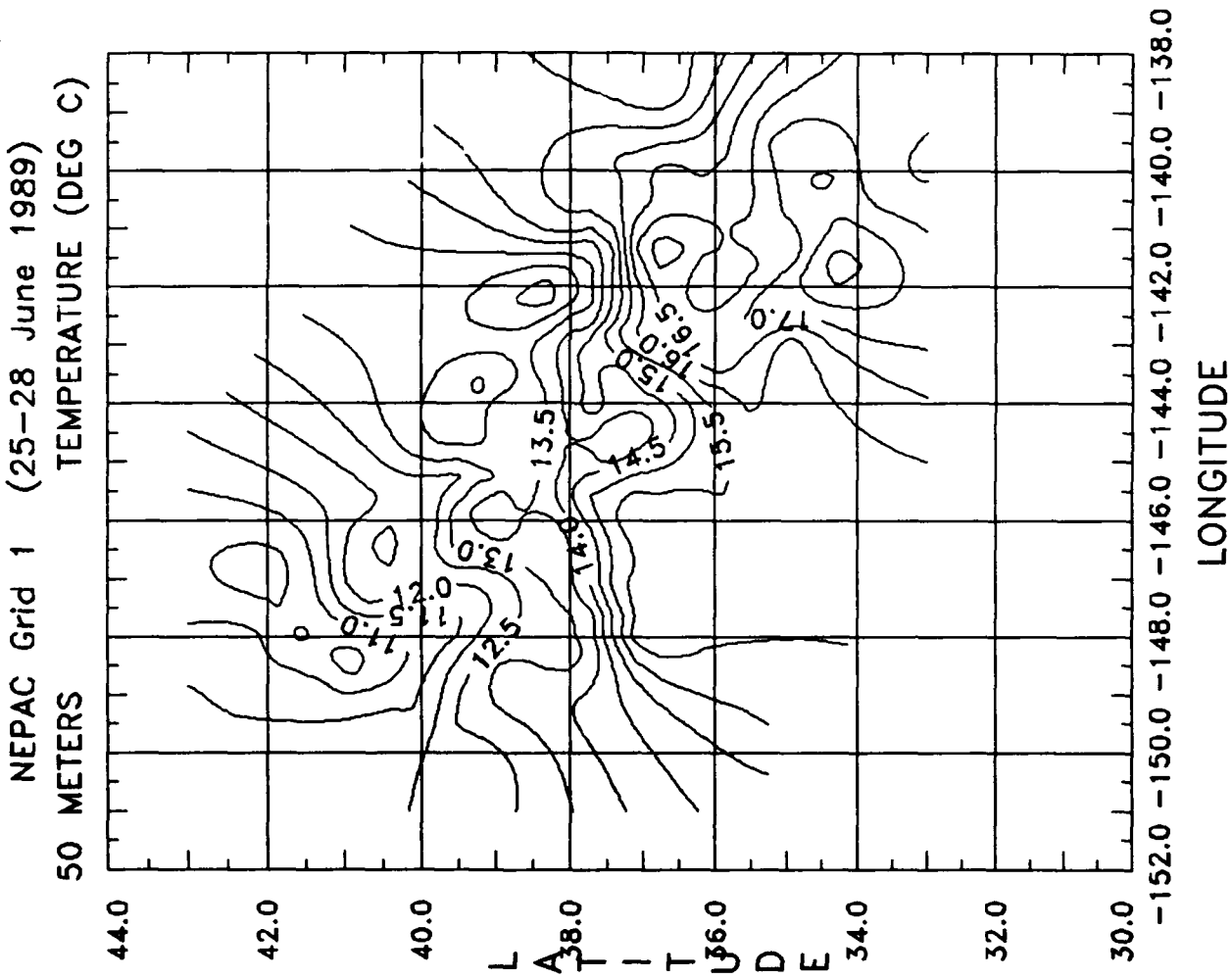
15:19:55

11/27/89

dx=.3 ,dy=.3



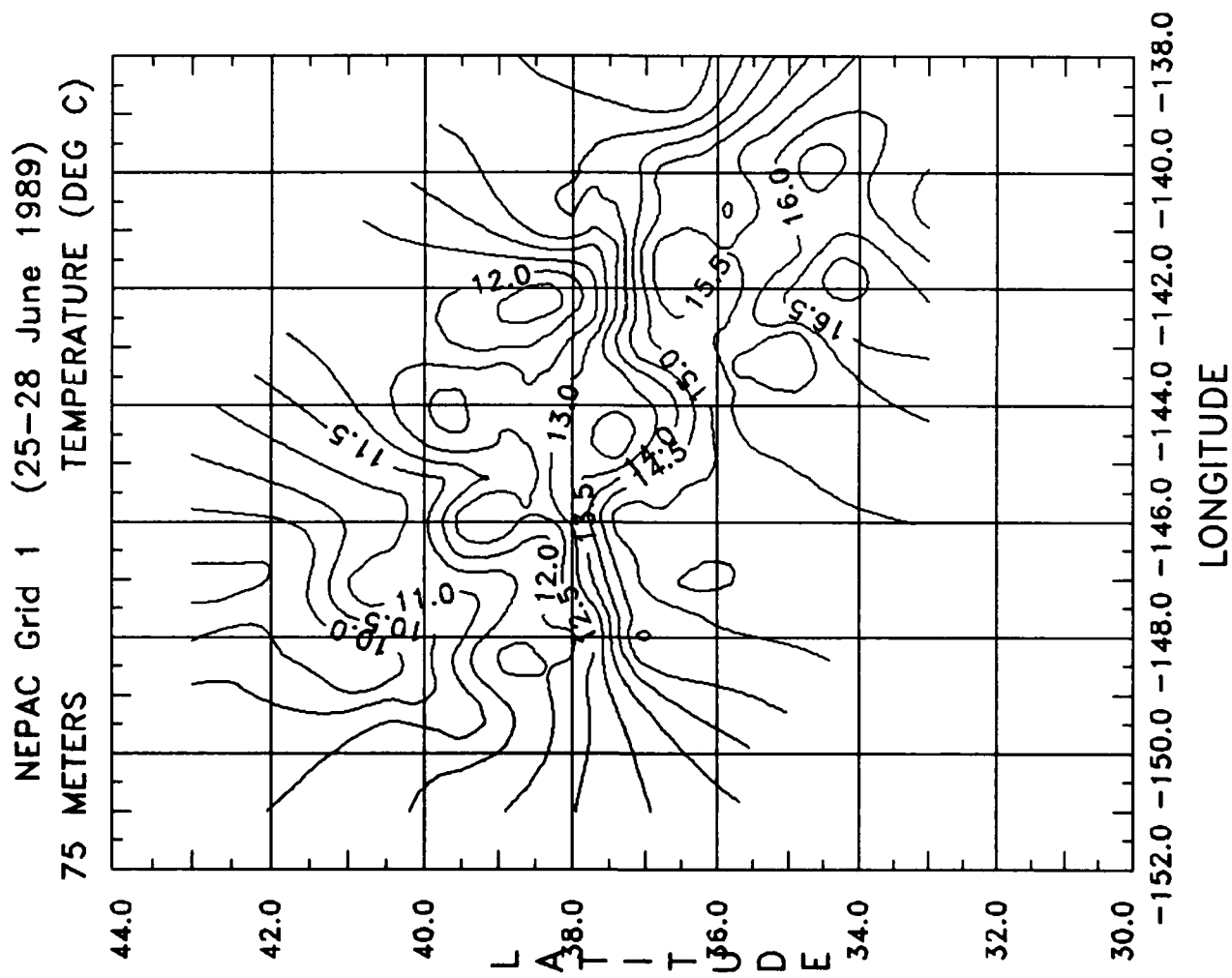
NOARL Code 331



15:22:31

11/27/89

dx=.3, dy=.3

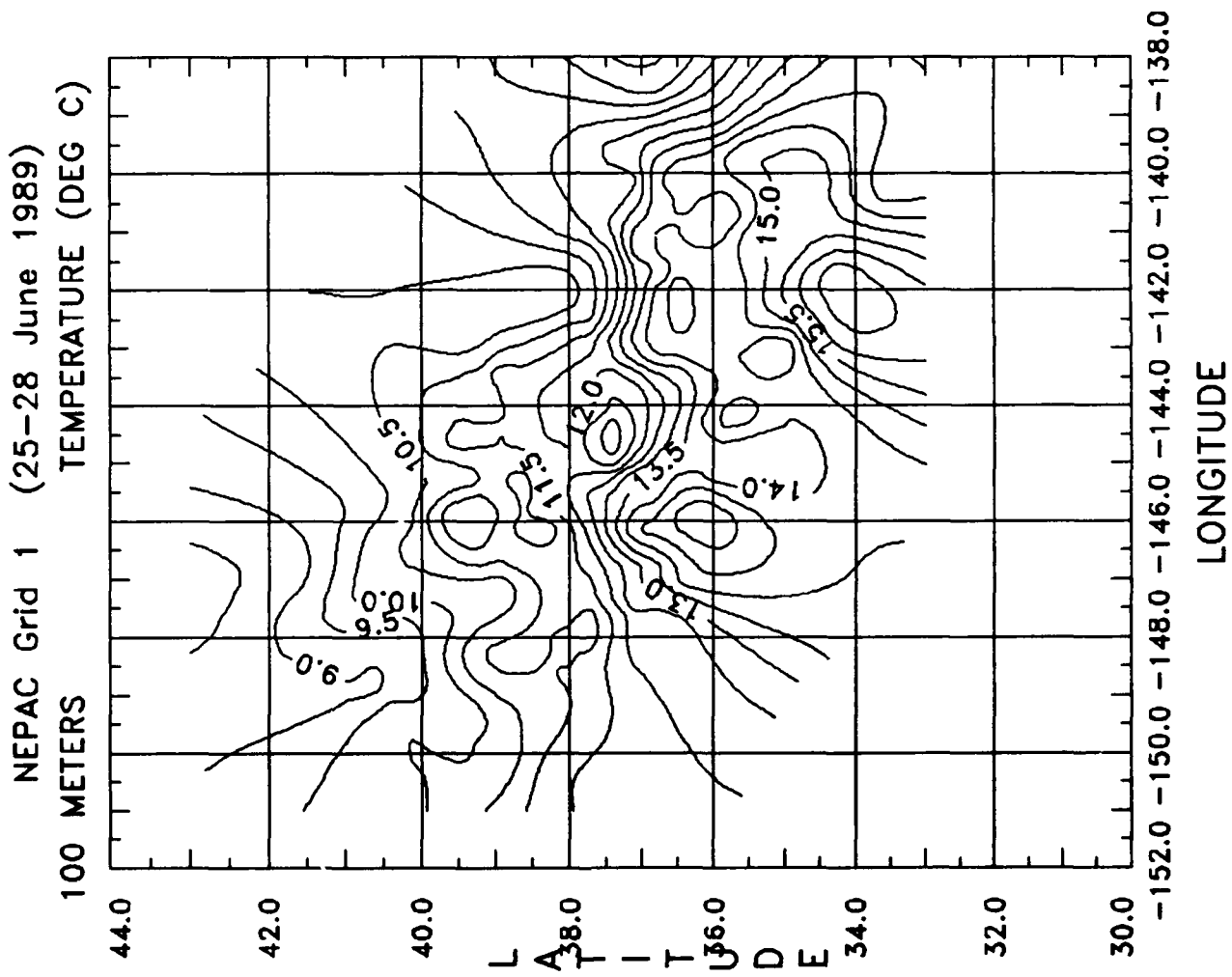


NOARL Code 331

15:24:05

11/27/89

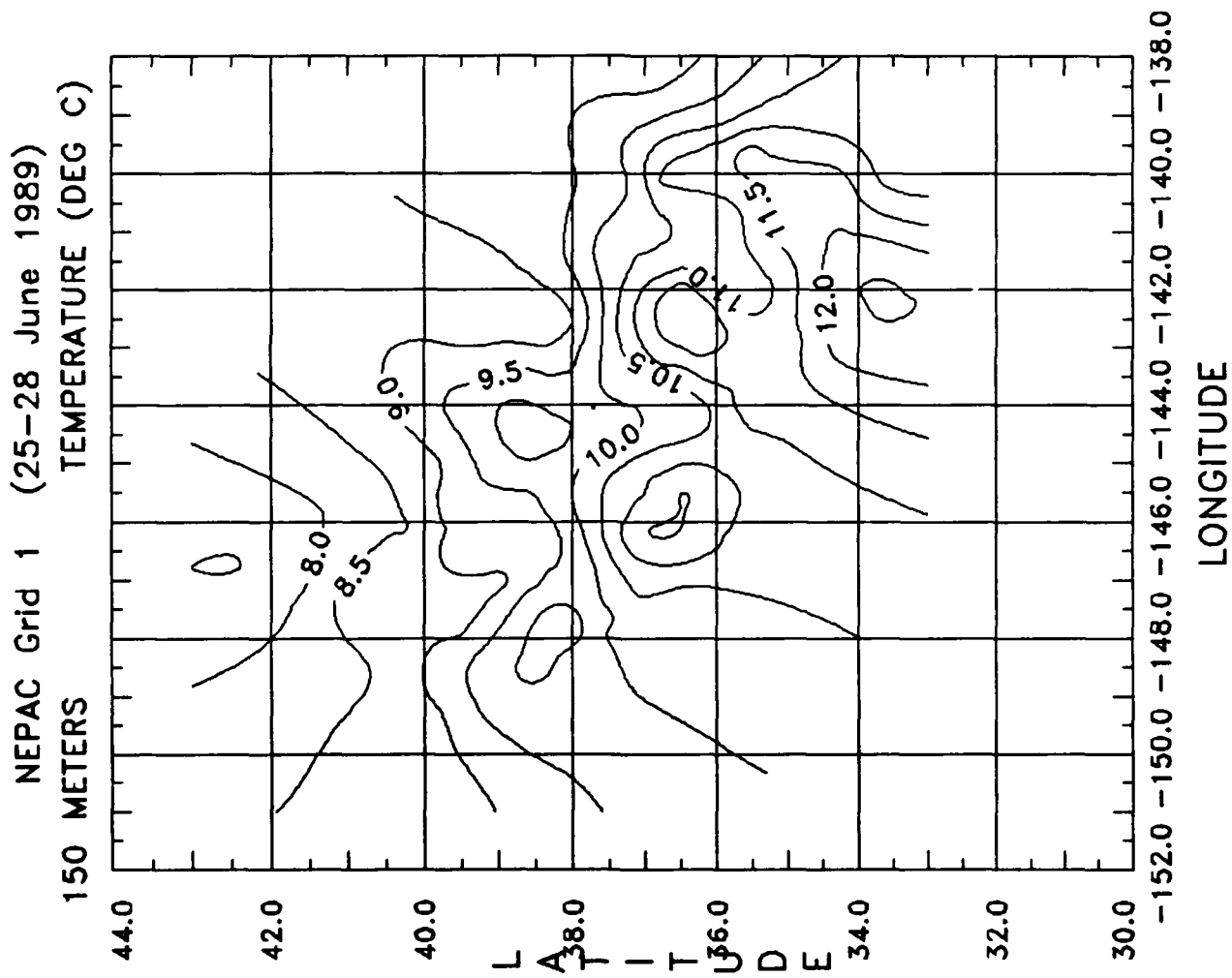
dx=.3 ,dy=.3

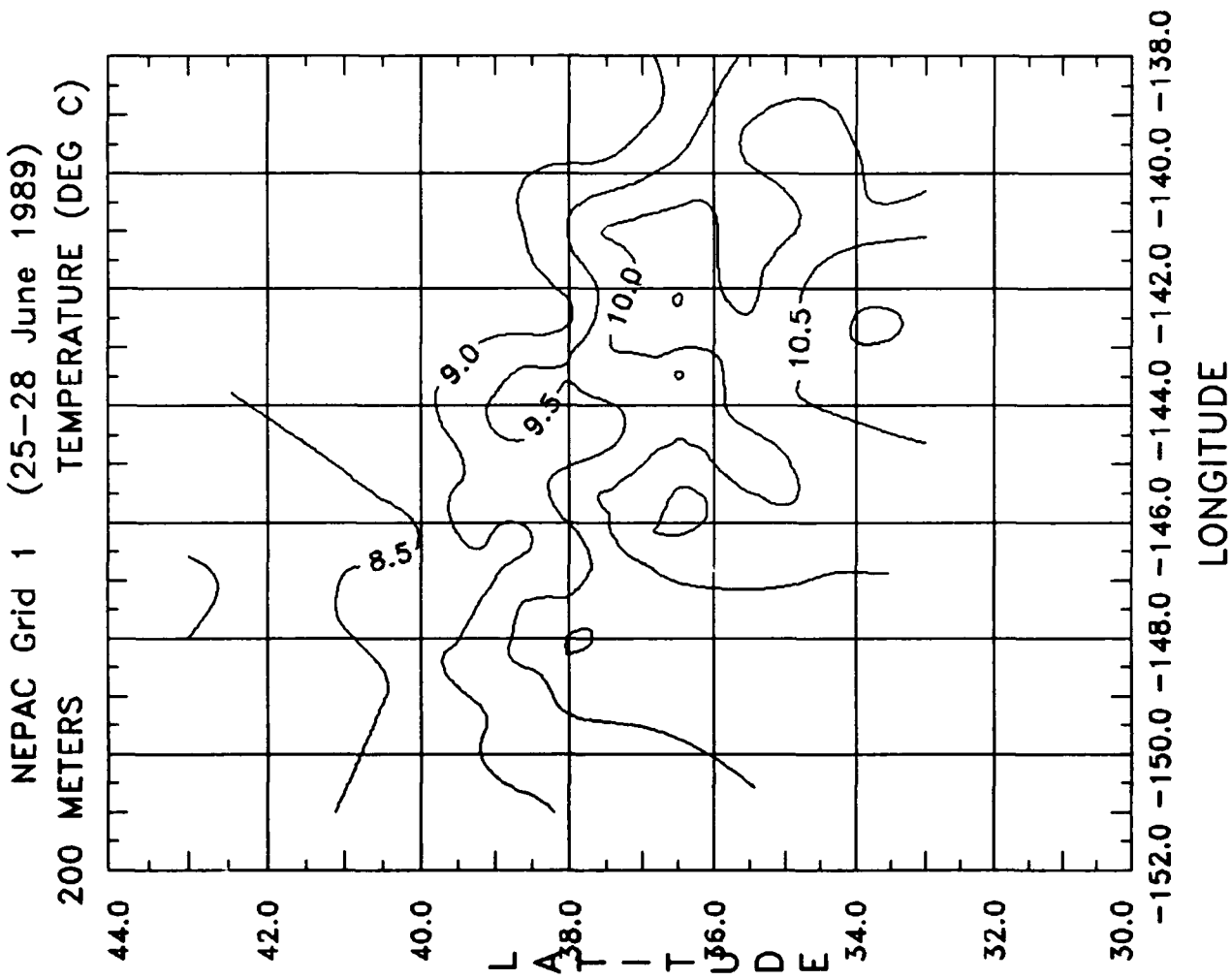


15:25:29

11/27/89

dx=.3, dy=.3





15:26:34

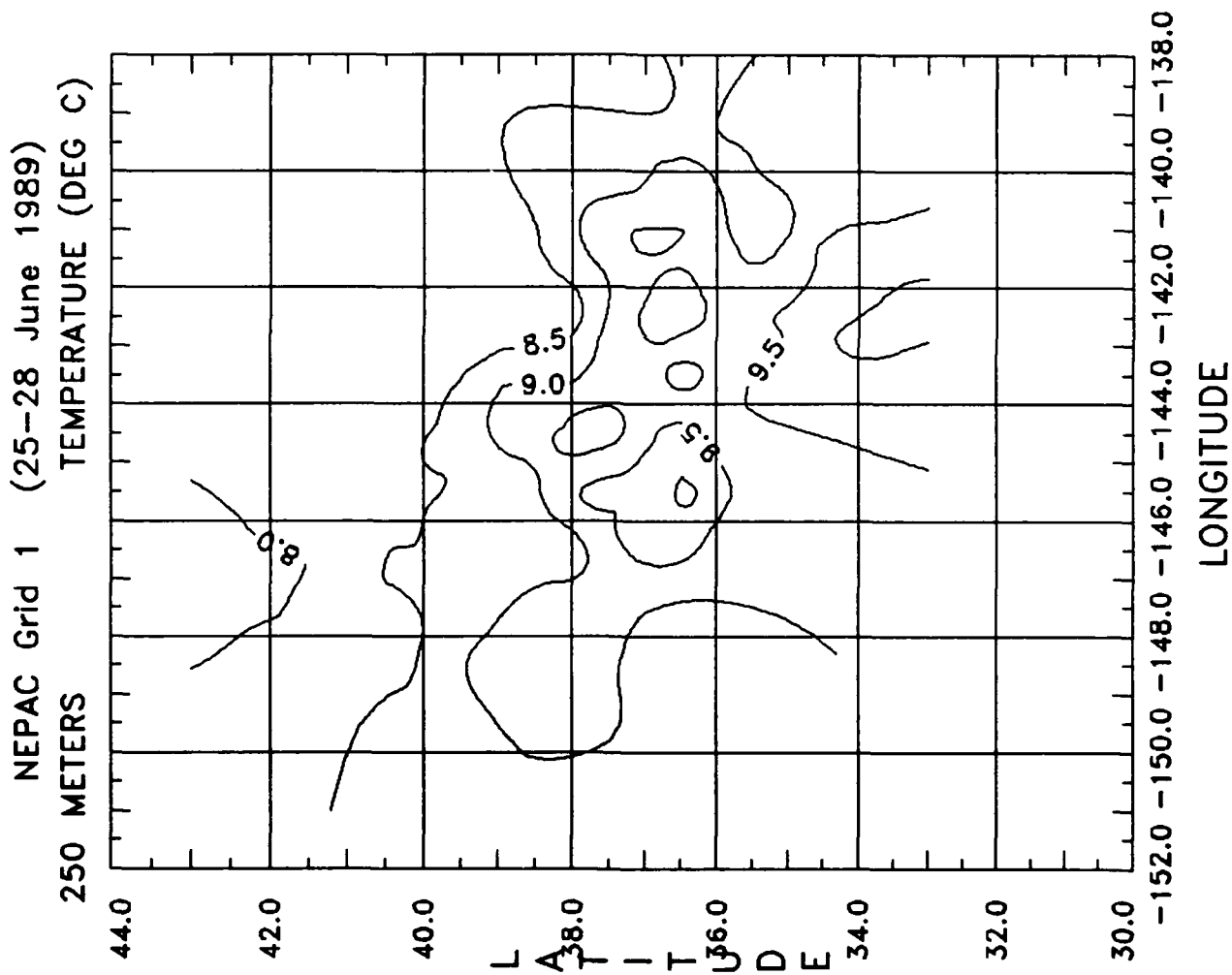
11/27/89

dx=.3 , dy=.3

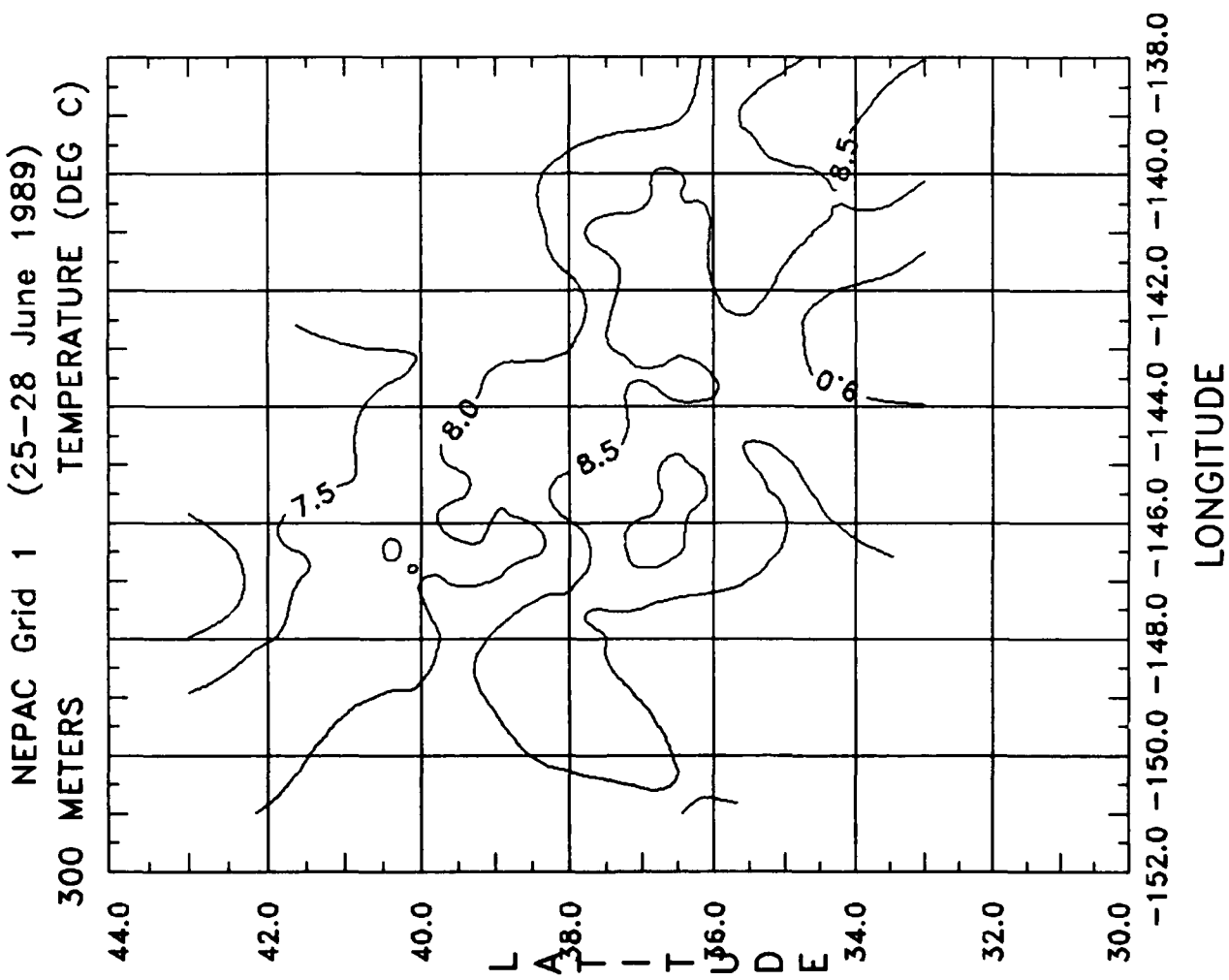
15:27:33

11/27/89

dx=.3 ,dy=.3



NOARL Code 331

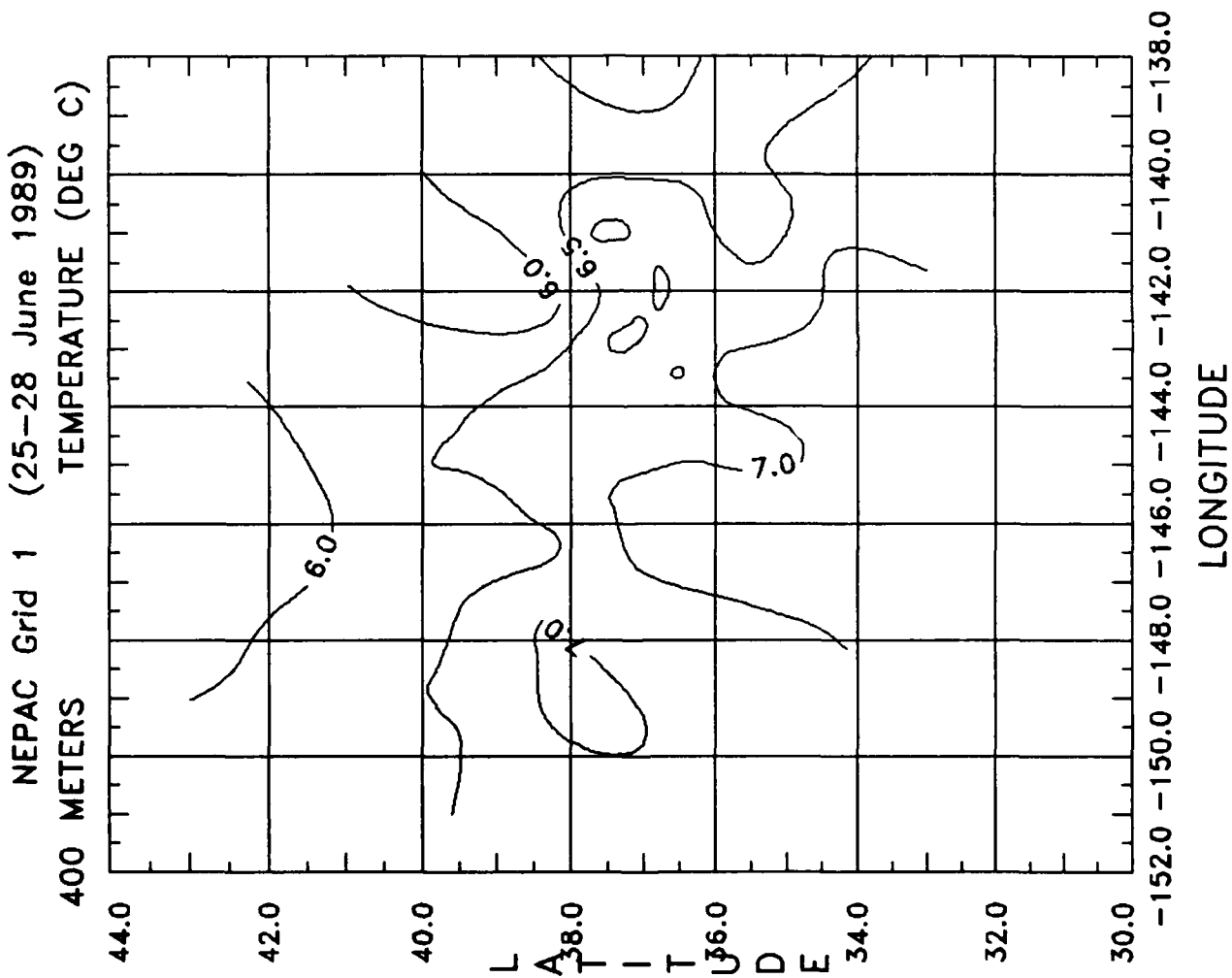


NOARL Code 331

15:28:31

11/27/89

dx=.3, dy=.3

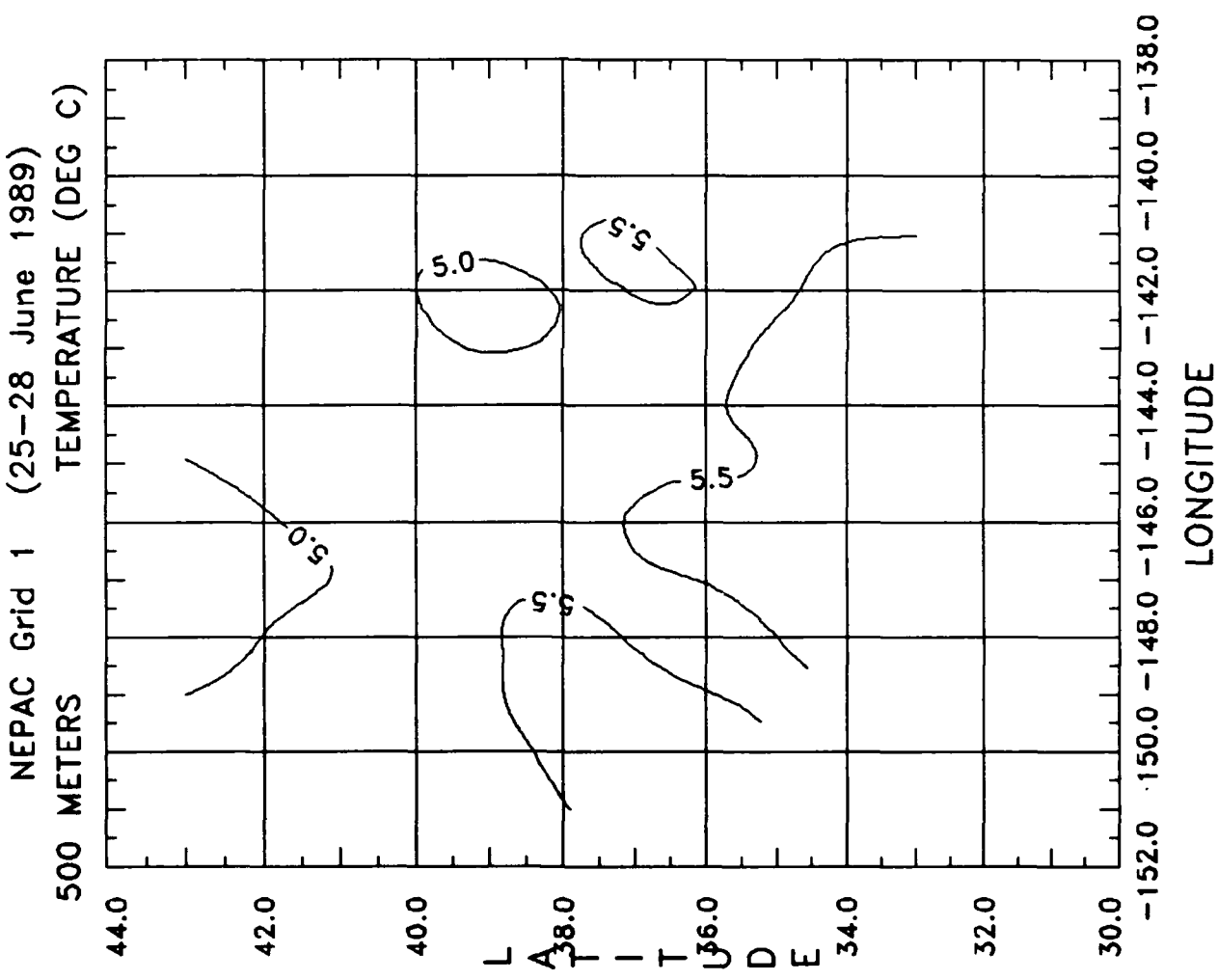


NOARL Code 331

15:29:41

11/27/89

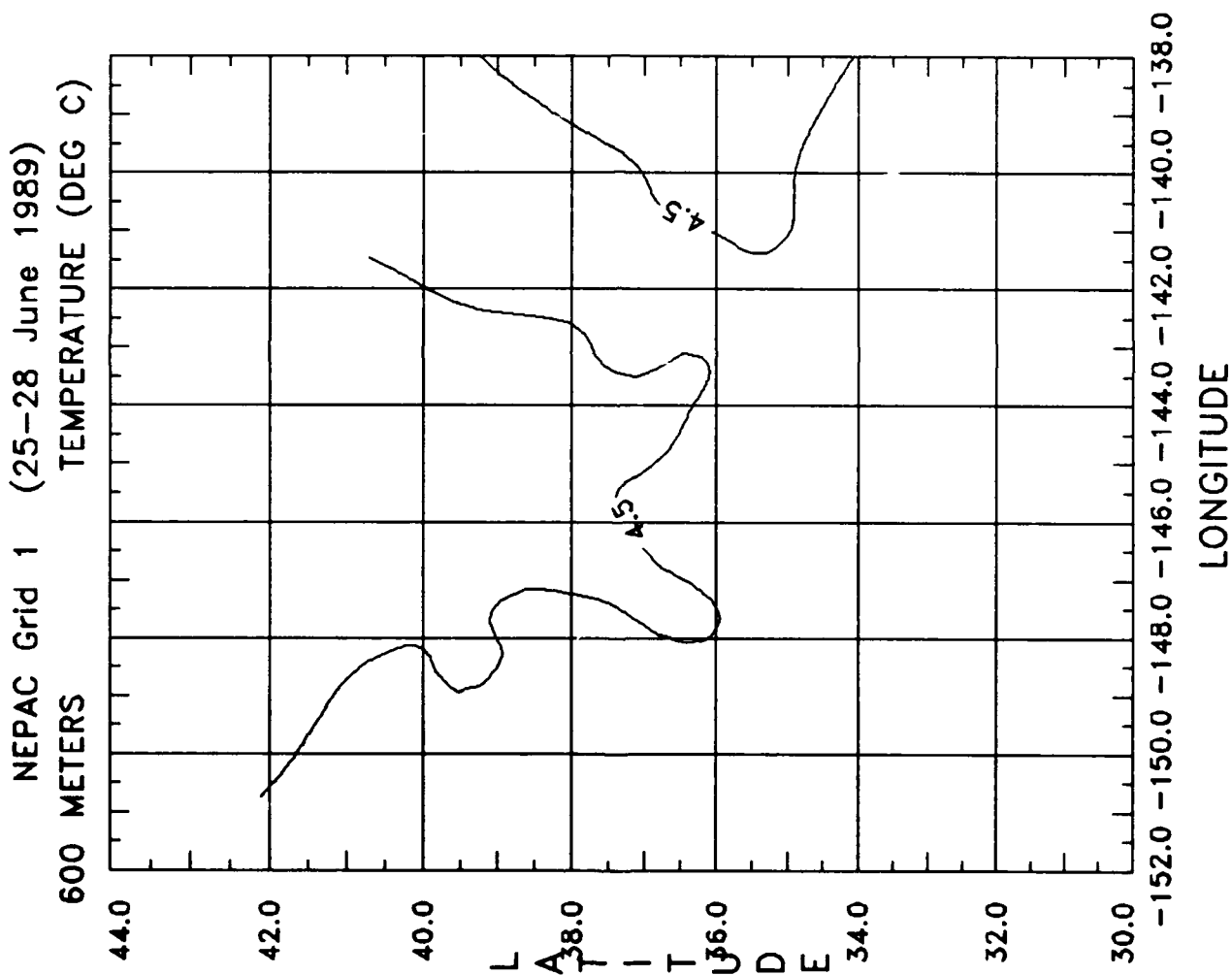
dx=.5, dy=.5



15:30:33

11/27/89

dx=.5, dy=.3

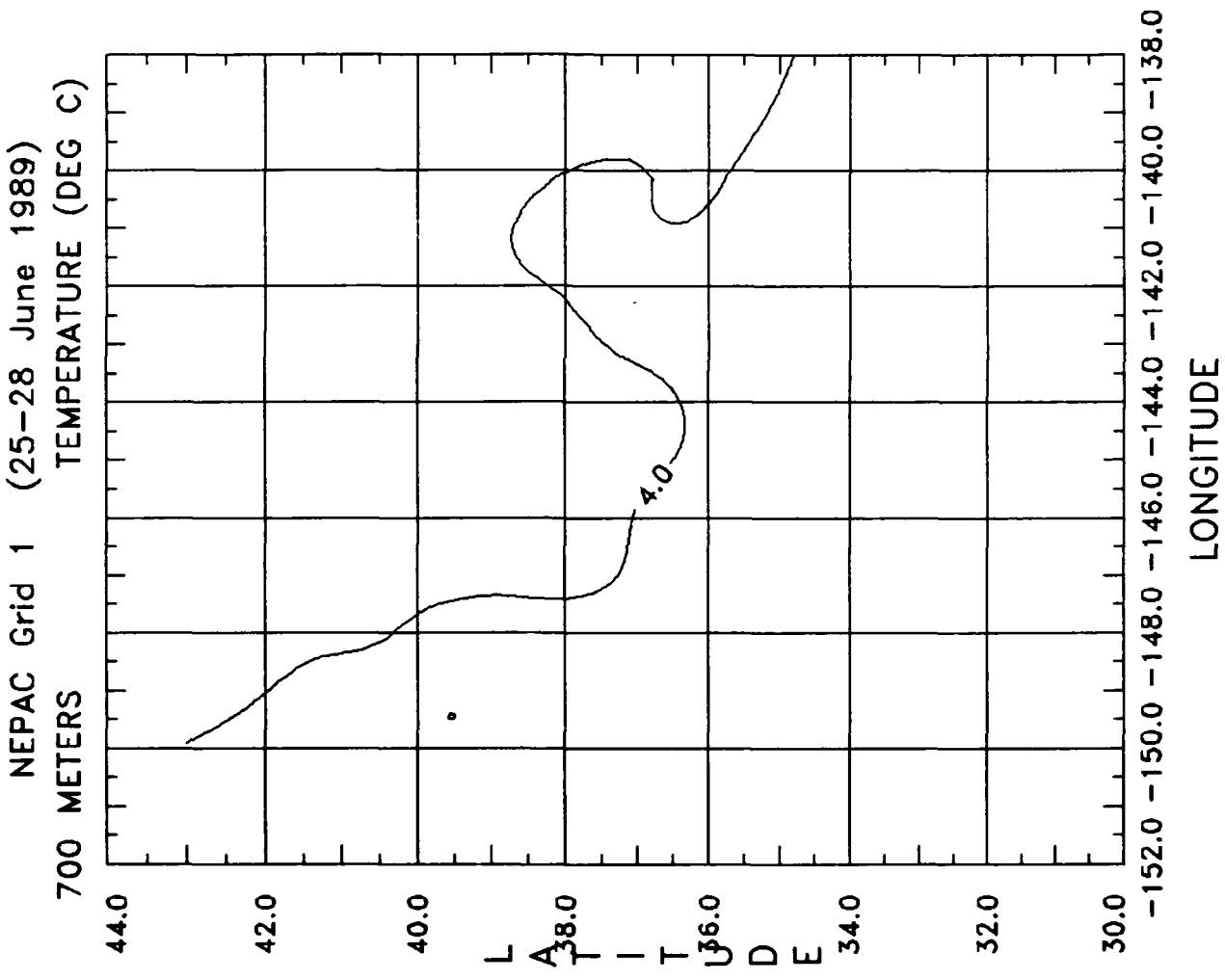


NOARL Code 331

15:31:21

11/27/89

dx=.3 ,dy=.3



15:52:08

11/27/89

dx=.3, dy=.3

Appendix B.

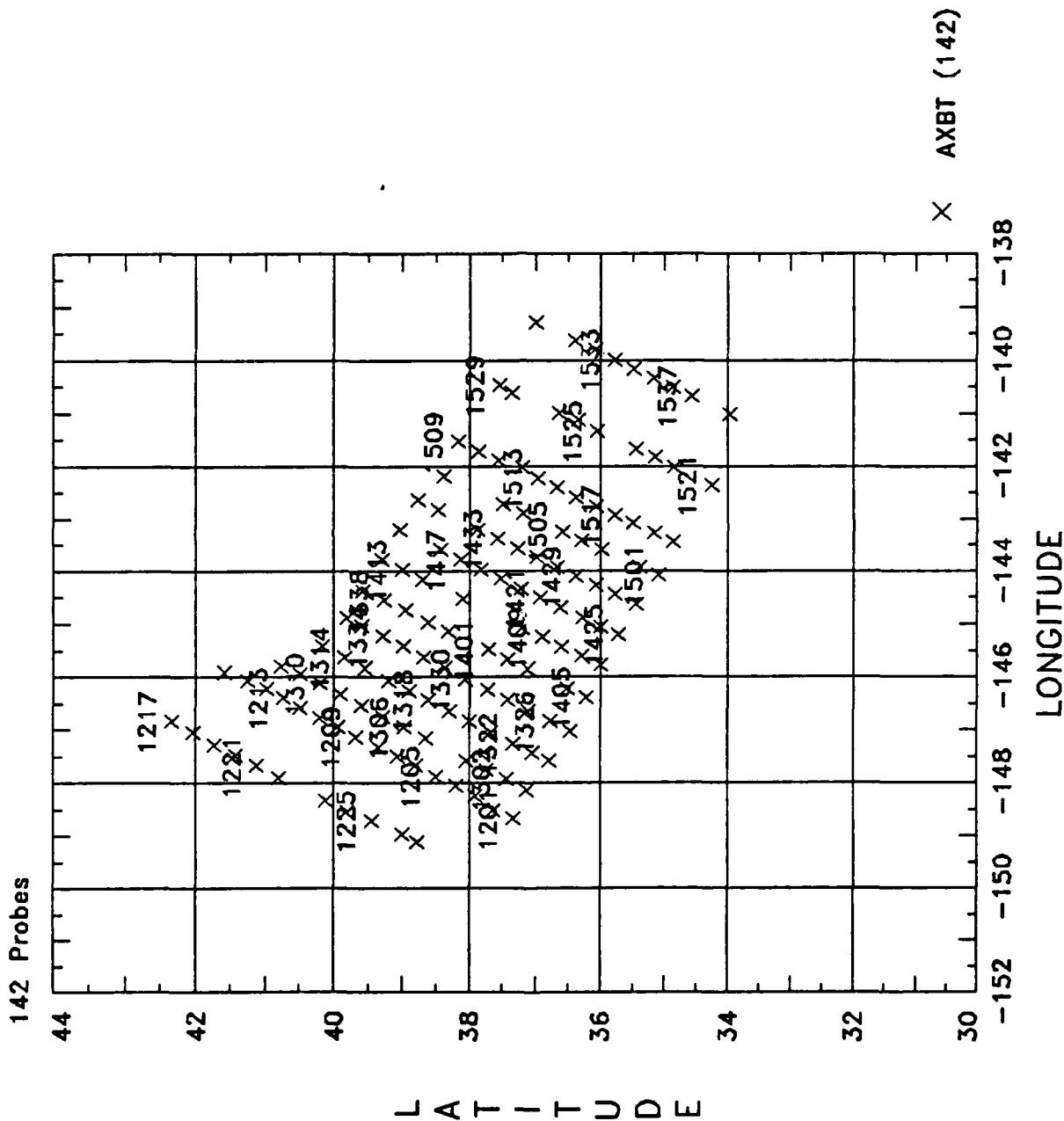
NEPAC Grid 2 (6 - 7 July 1989)

Temperature Contours at Selected Depths

8:55:51

5/09/90

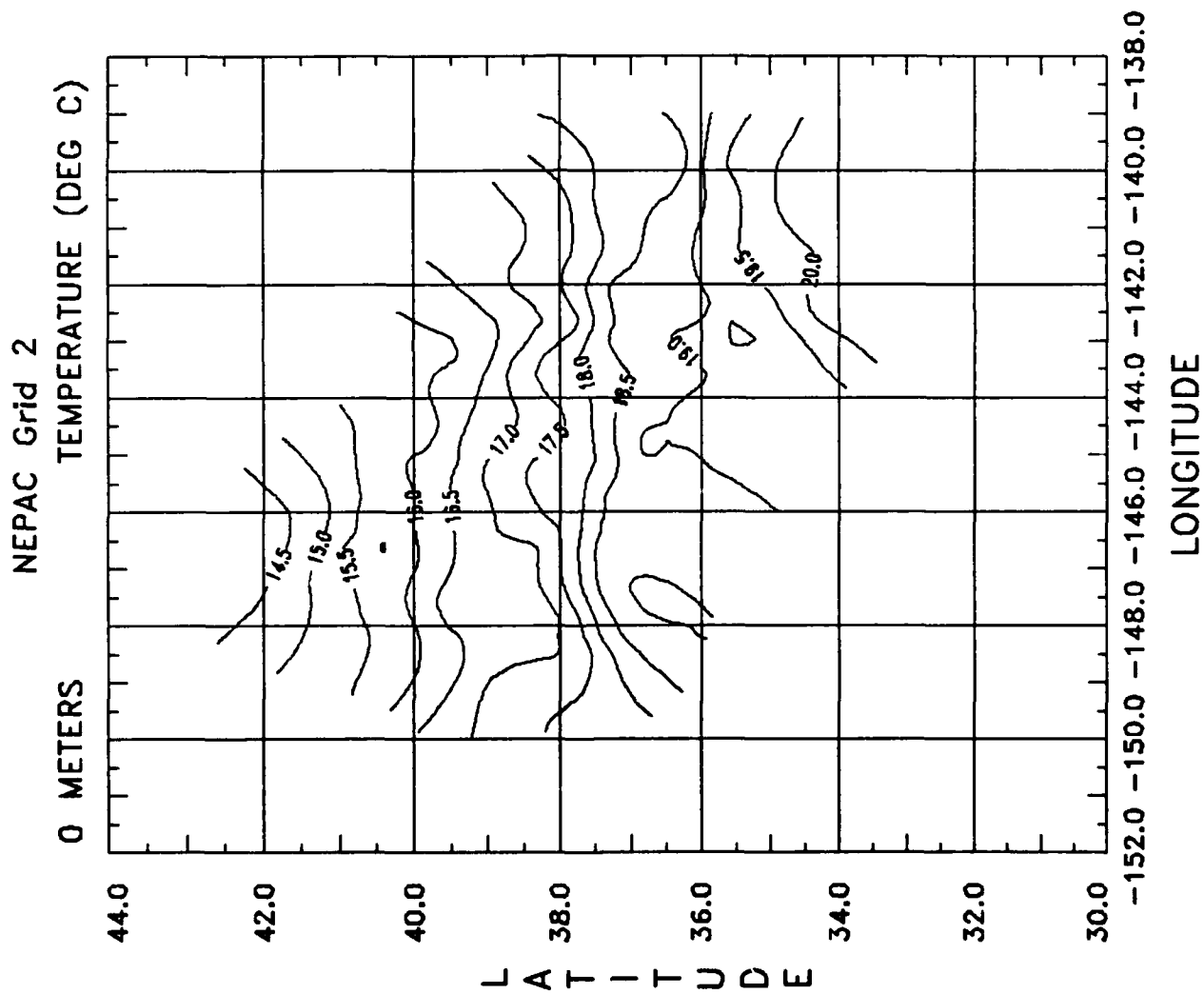
NEPAC Grid 2 (6-7 July 1989)



7:41:59

2/12/90

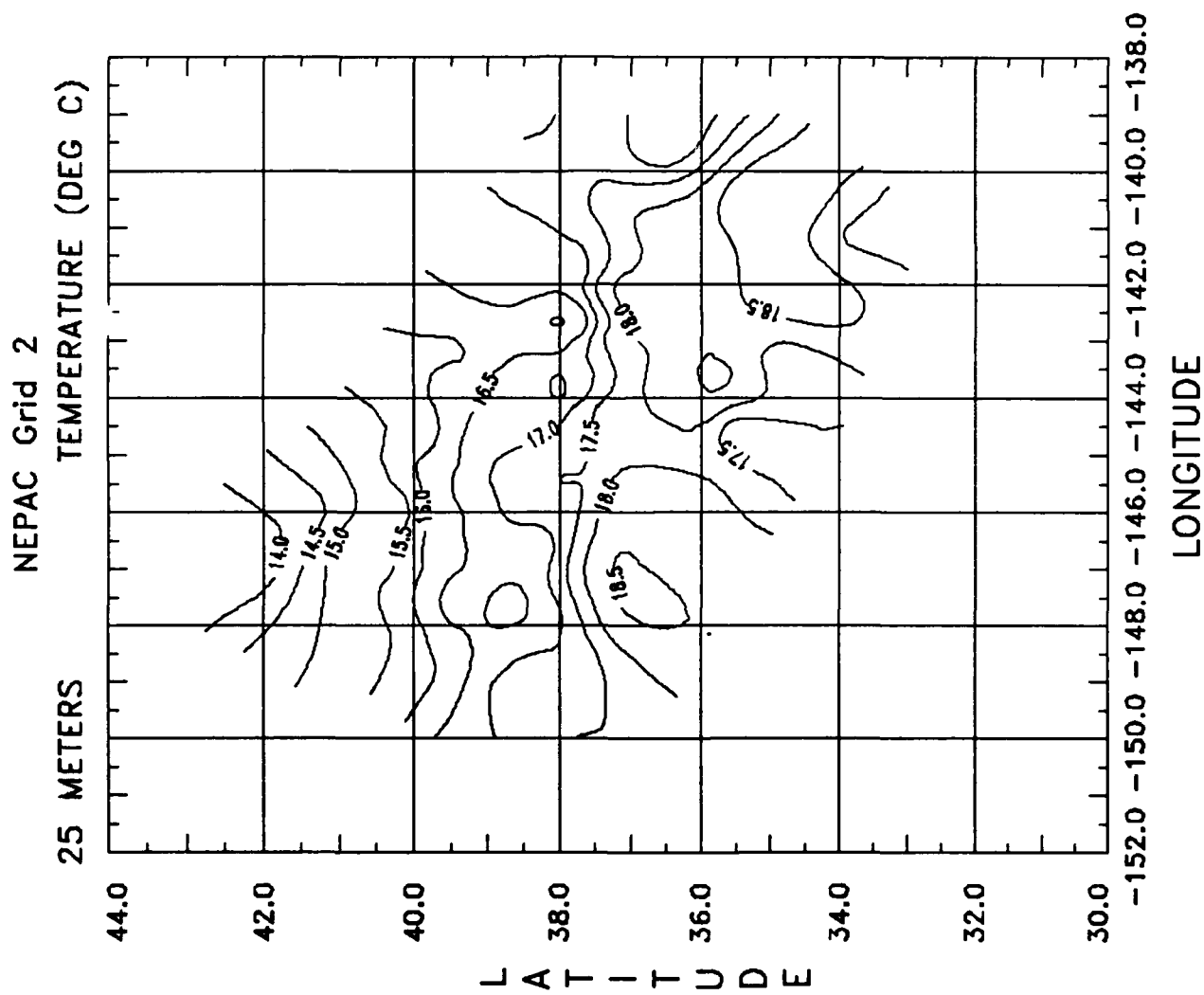
dx=.3 ,dy=.3



7:42:52

2/12/90

dx=.3, dy=.3

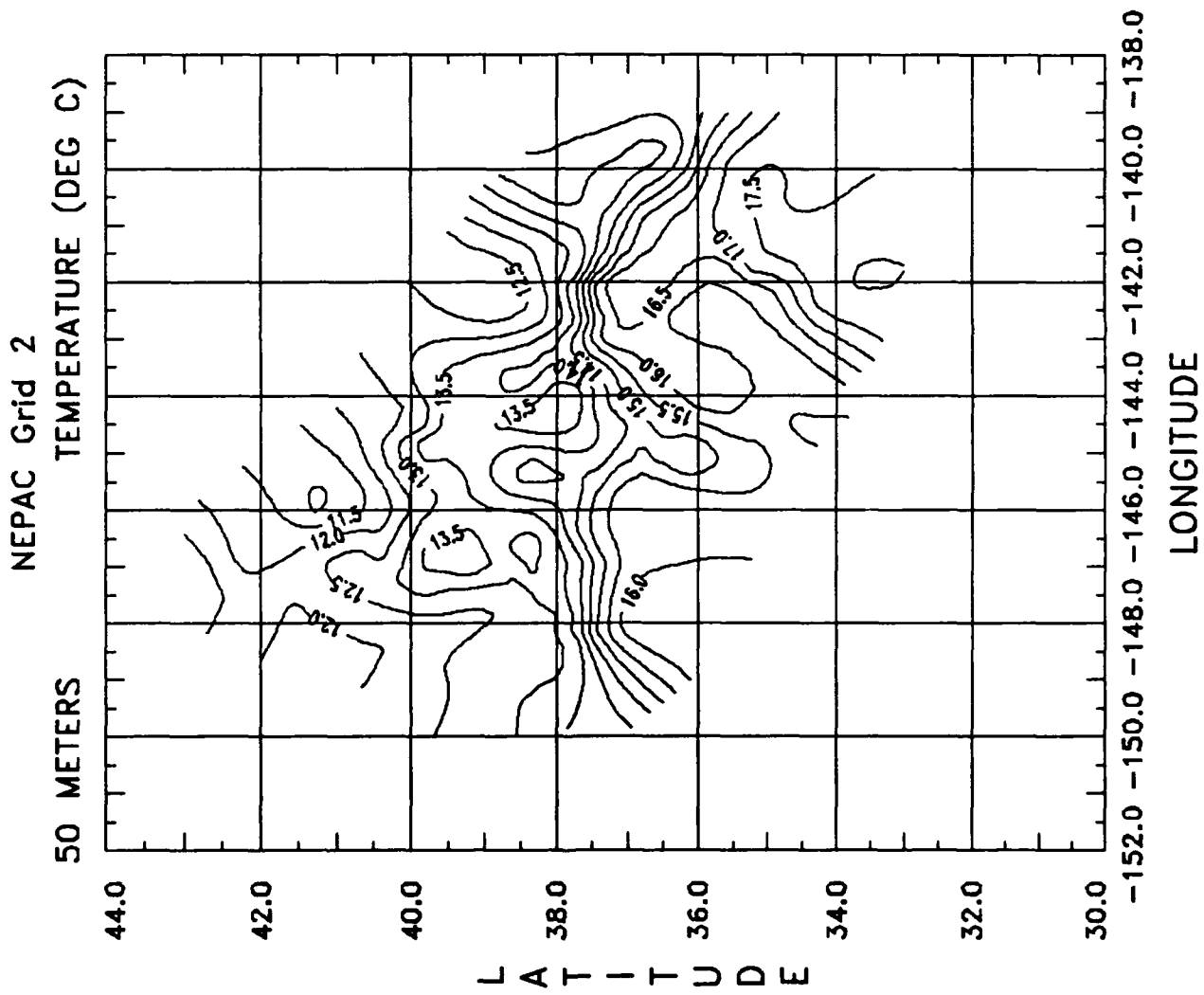


NOARL Code 331

7:43:49

2/12/90

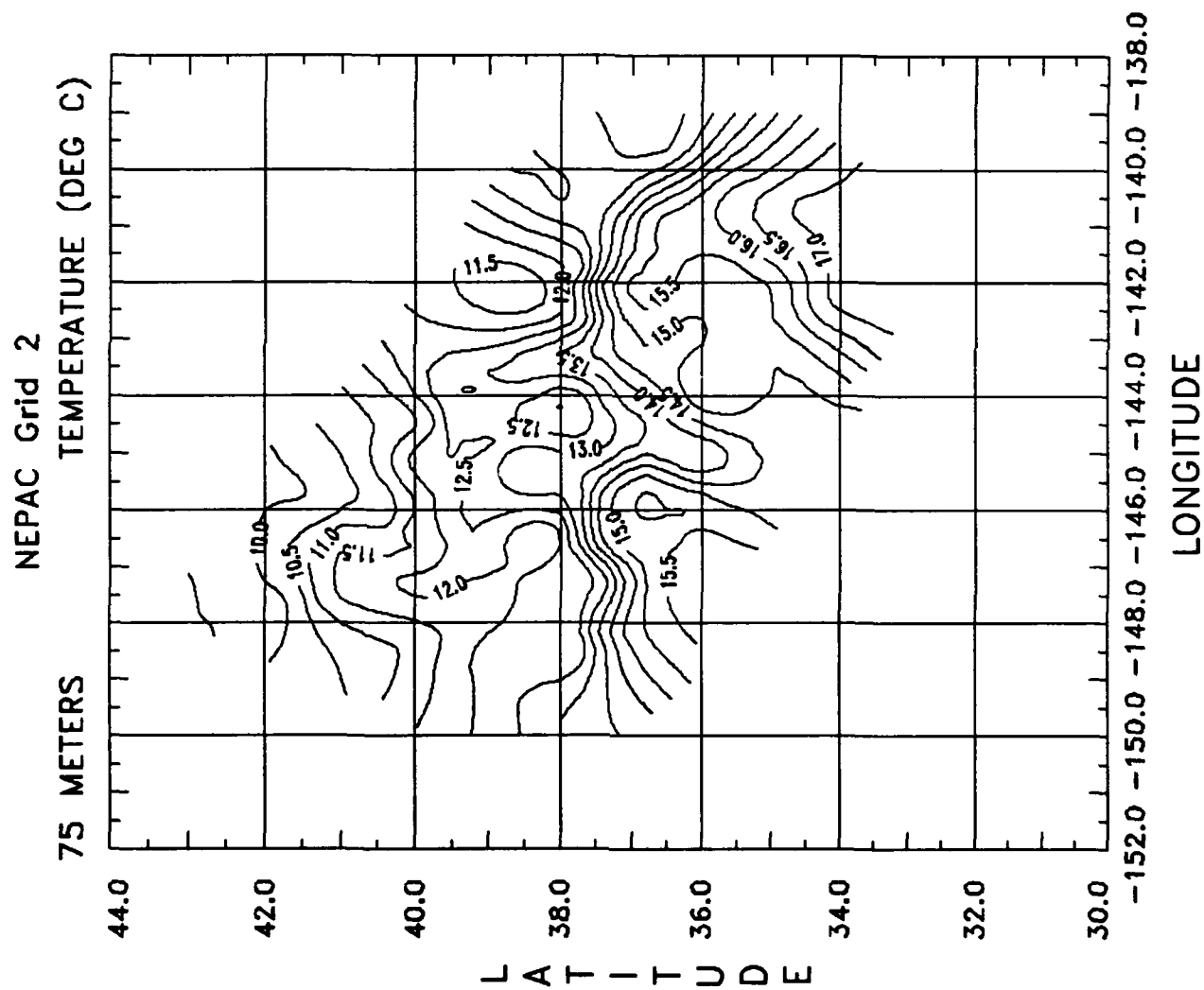
dx=.3 ,dy=.3



7:44:47

2/12/90

dx=.3 ,dy=.3

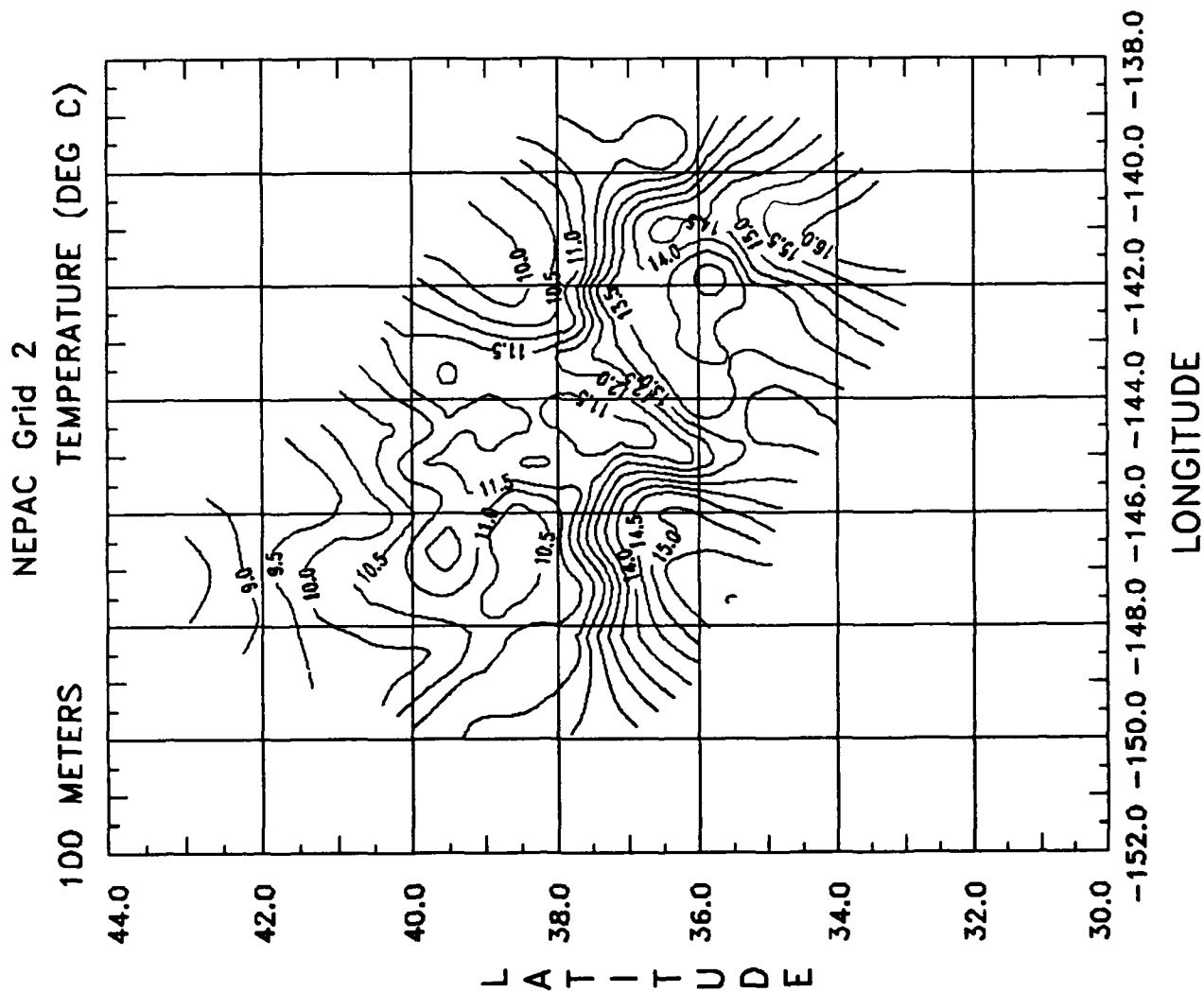


NOARL Code 331

7:45:47

2/12/90

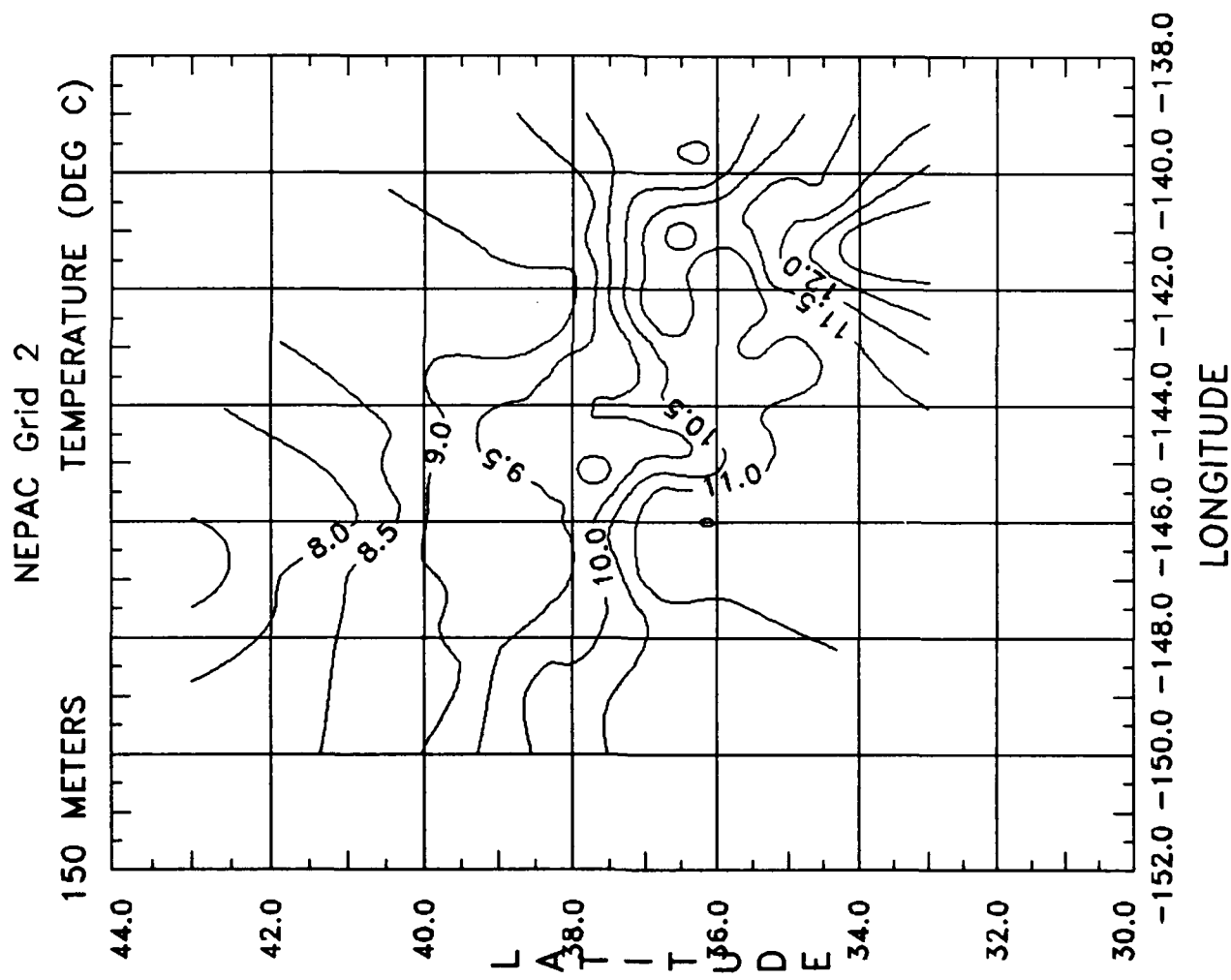
dx=.3 ,dy=.3



8:31:45

11/28/89

dx=.3 ,dy=.3

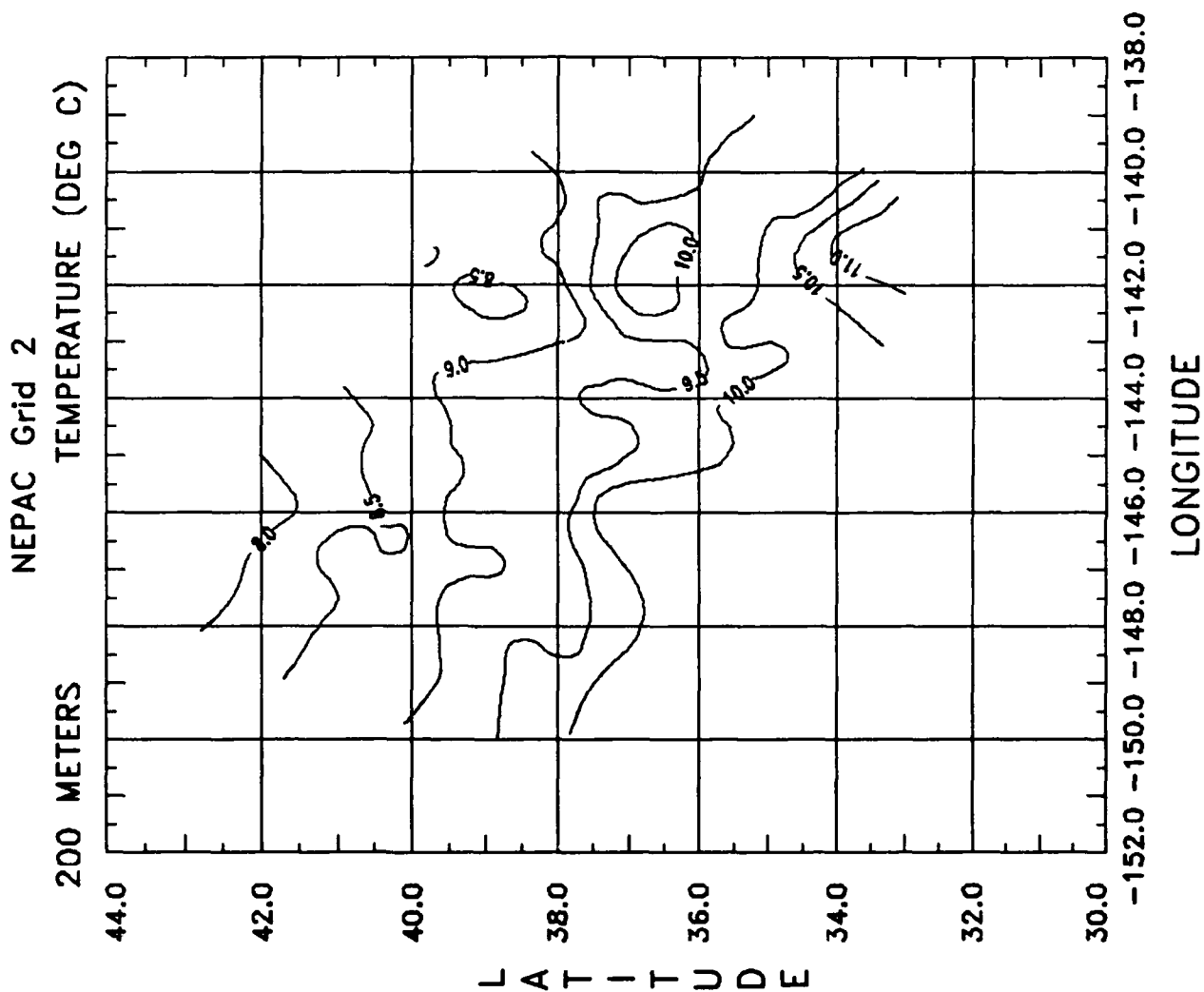


NOARL Code 331

7:47:34

2/12/90

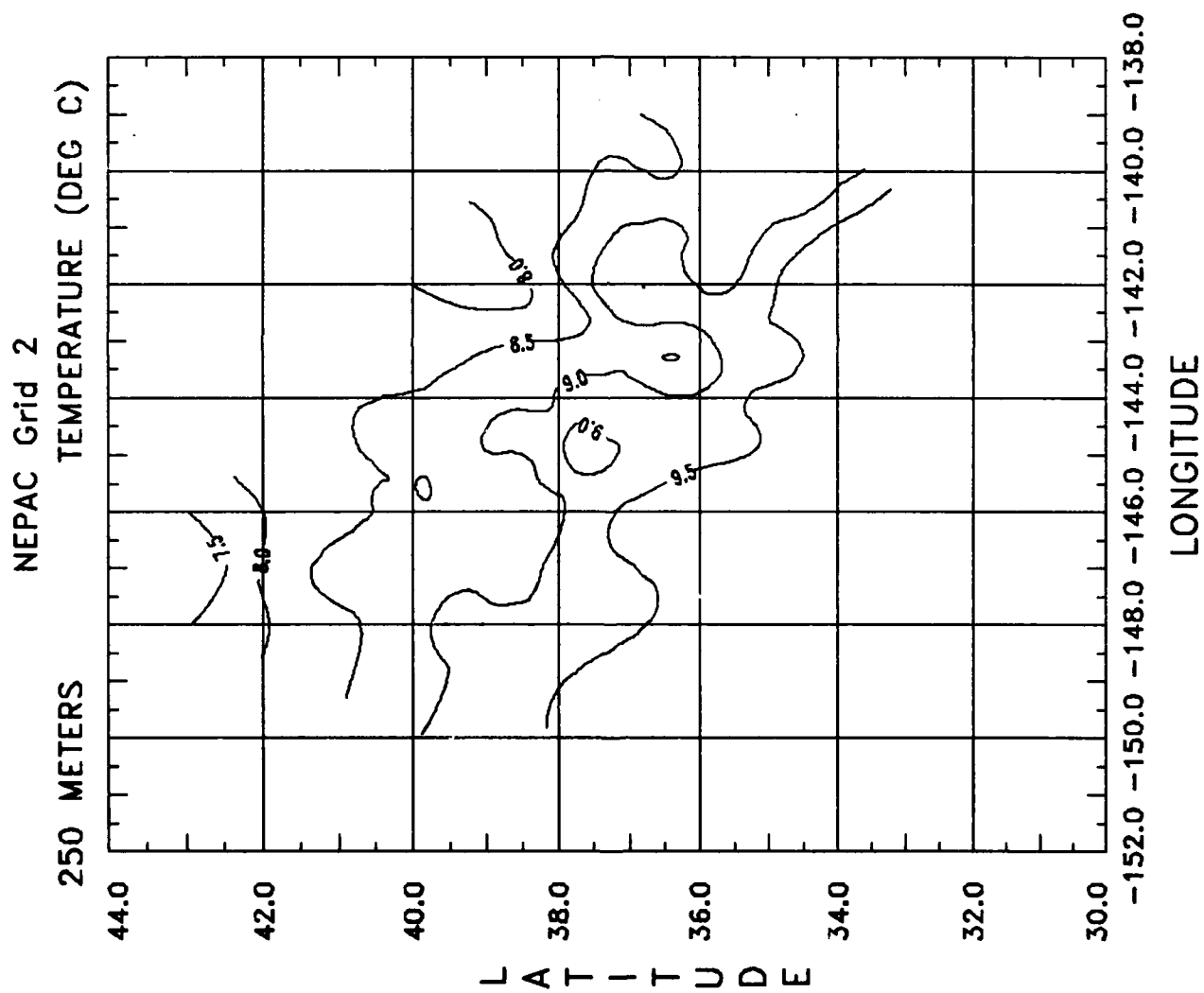
dx=.5, dy=.5



7:48:24

2/12/90

dx=.3, dy=.3

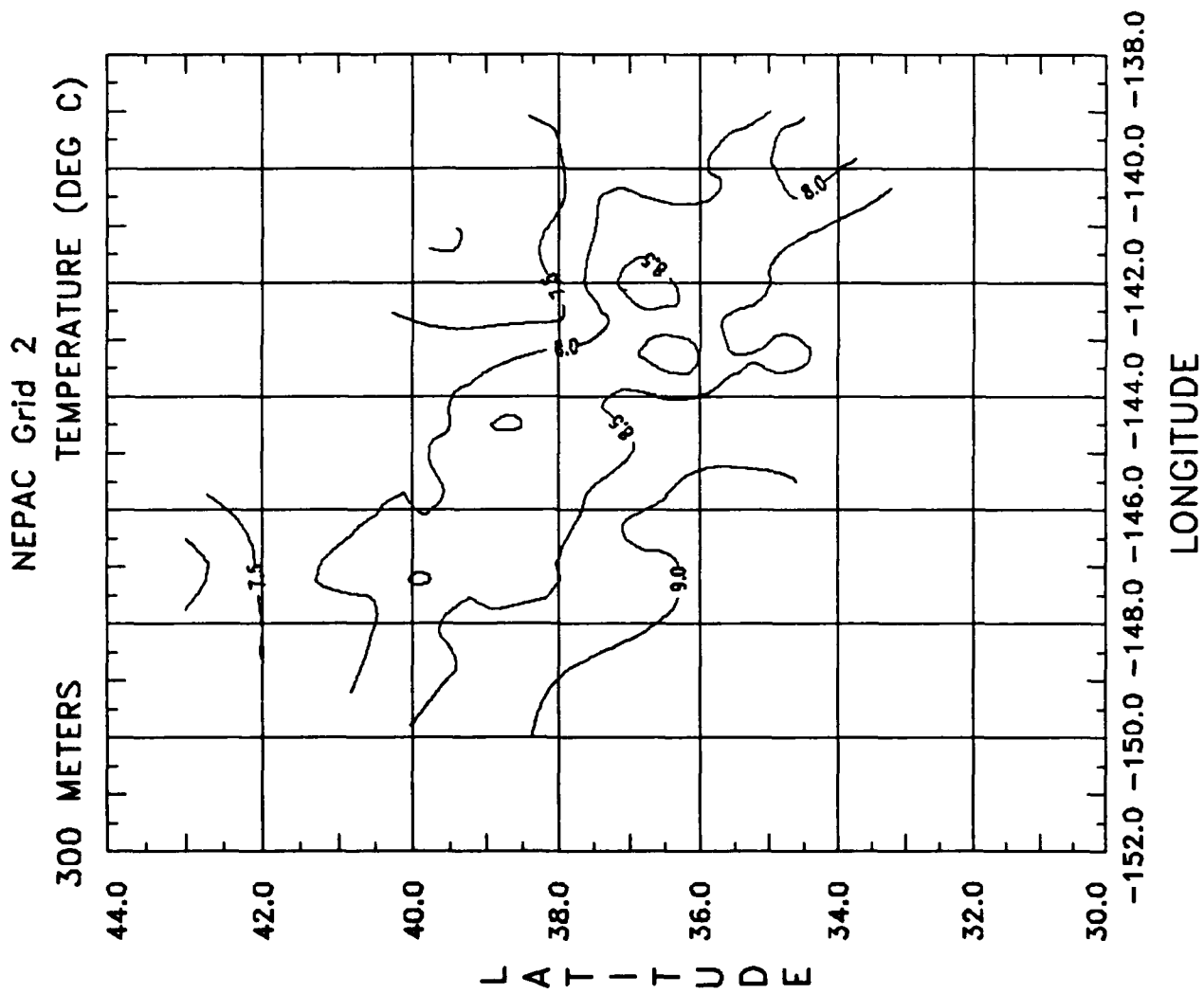


NOARL Code 331

7:49:14

2/12/90

dx=.3, dy=.3

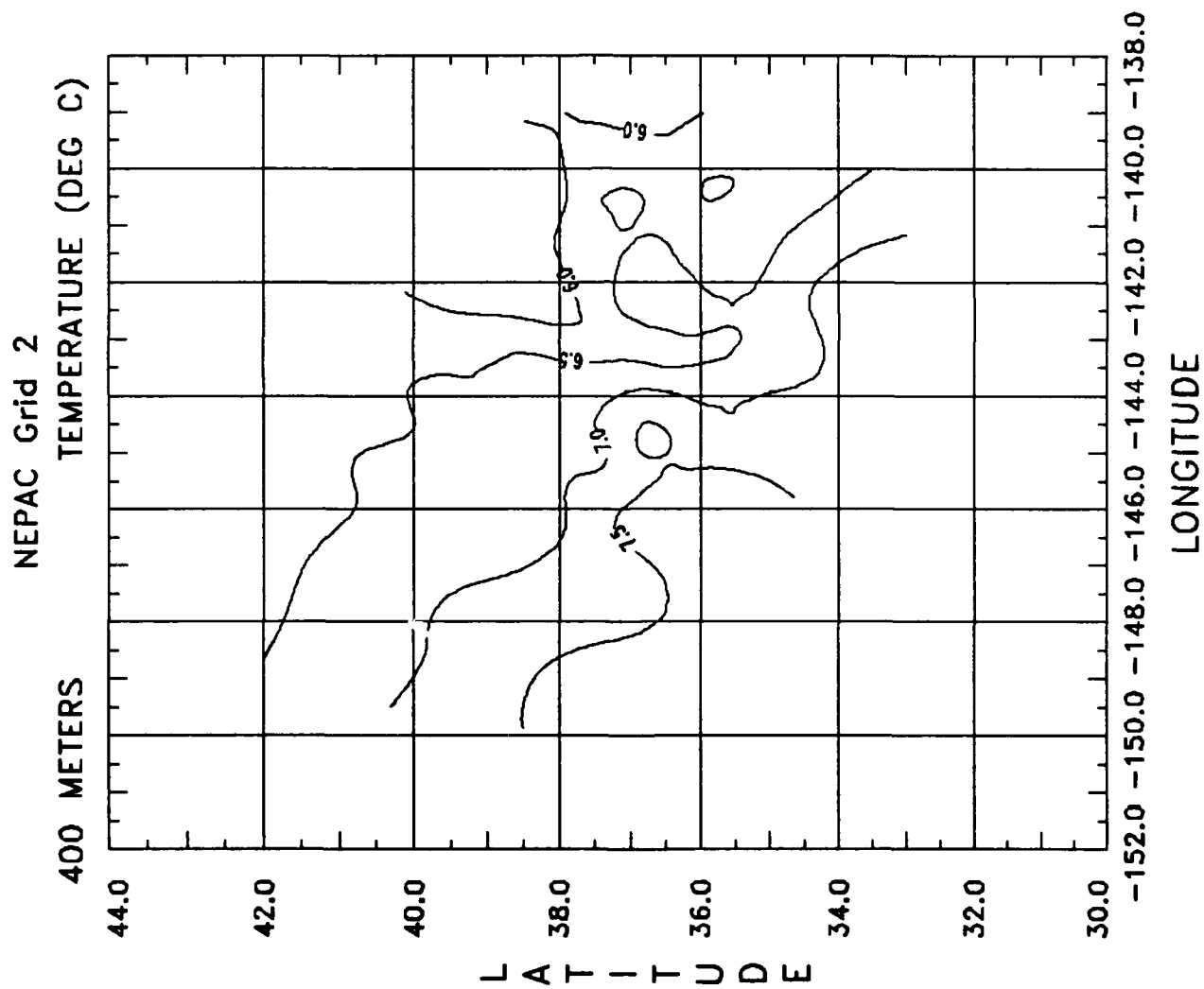


NOARL Code 331

7:50:03

2/12/90

dx=.3 , dy=.3

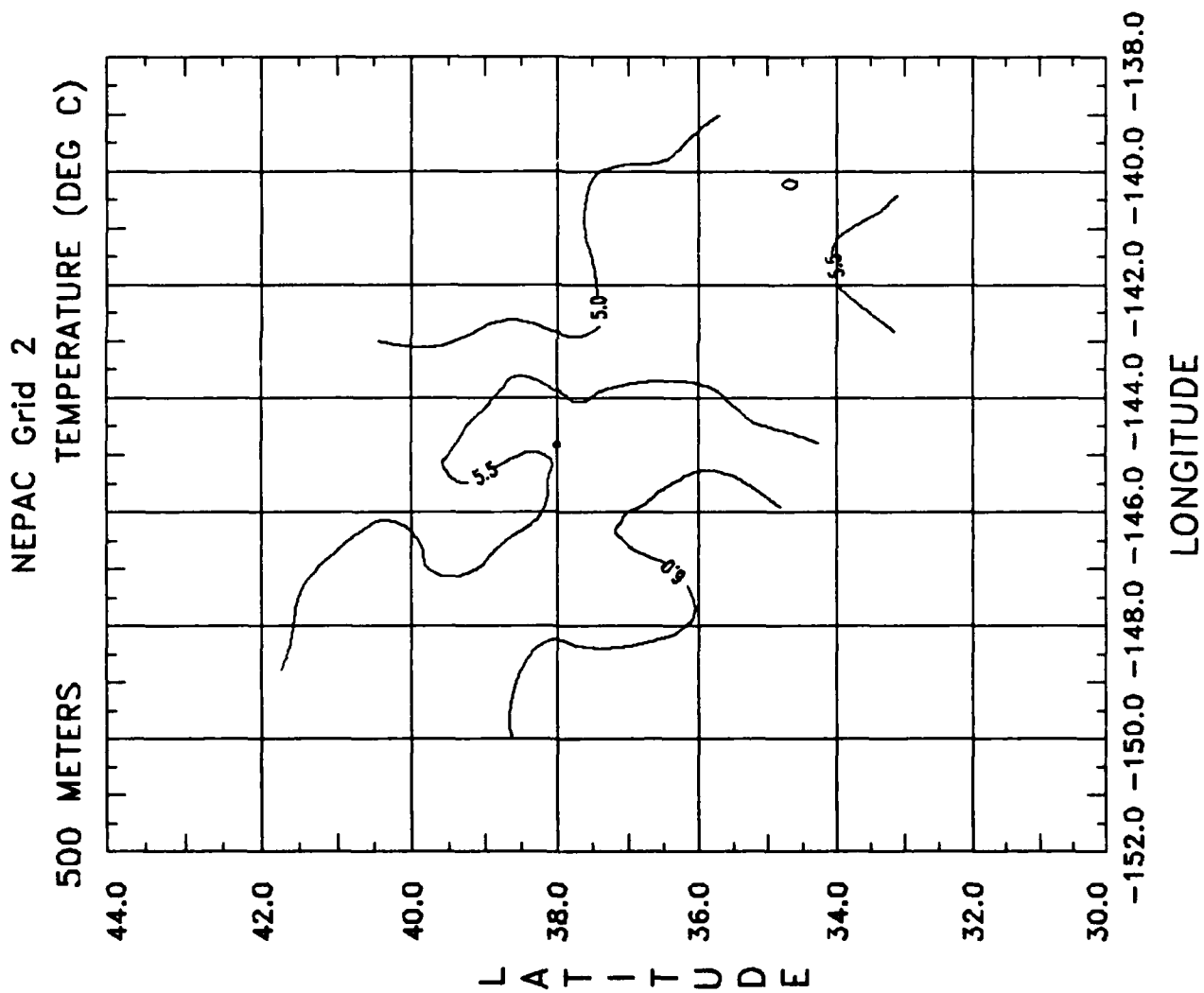


NOARL Code 331

7:50:50

2/12/90

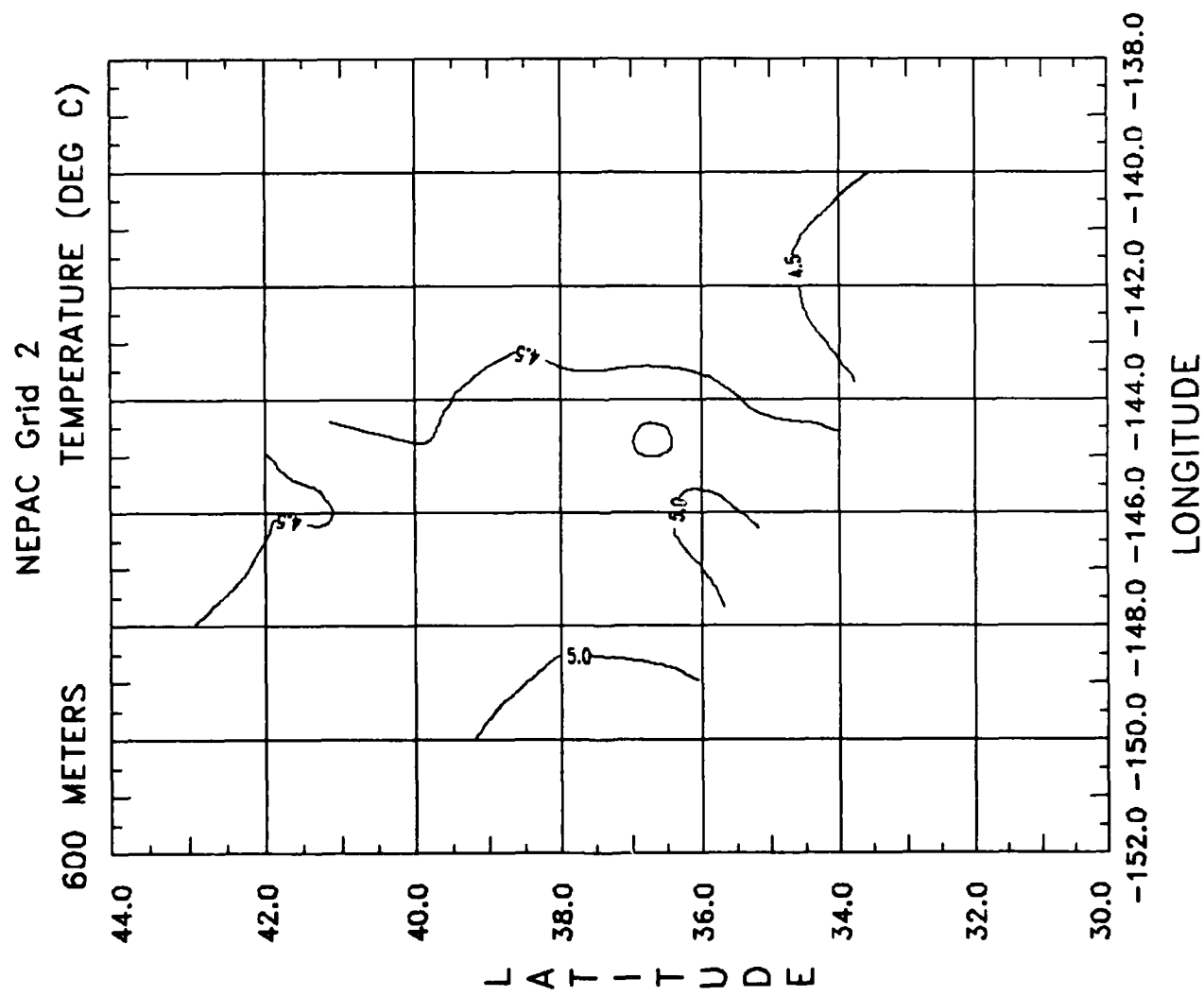
dx=.3, dy=.3



7:51:38

2/12/90

dx=.3 , dy=.3

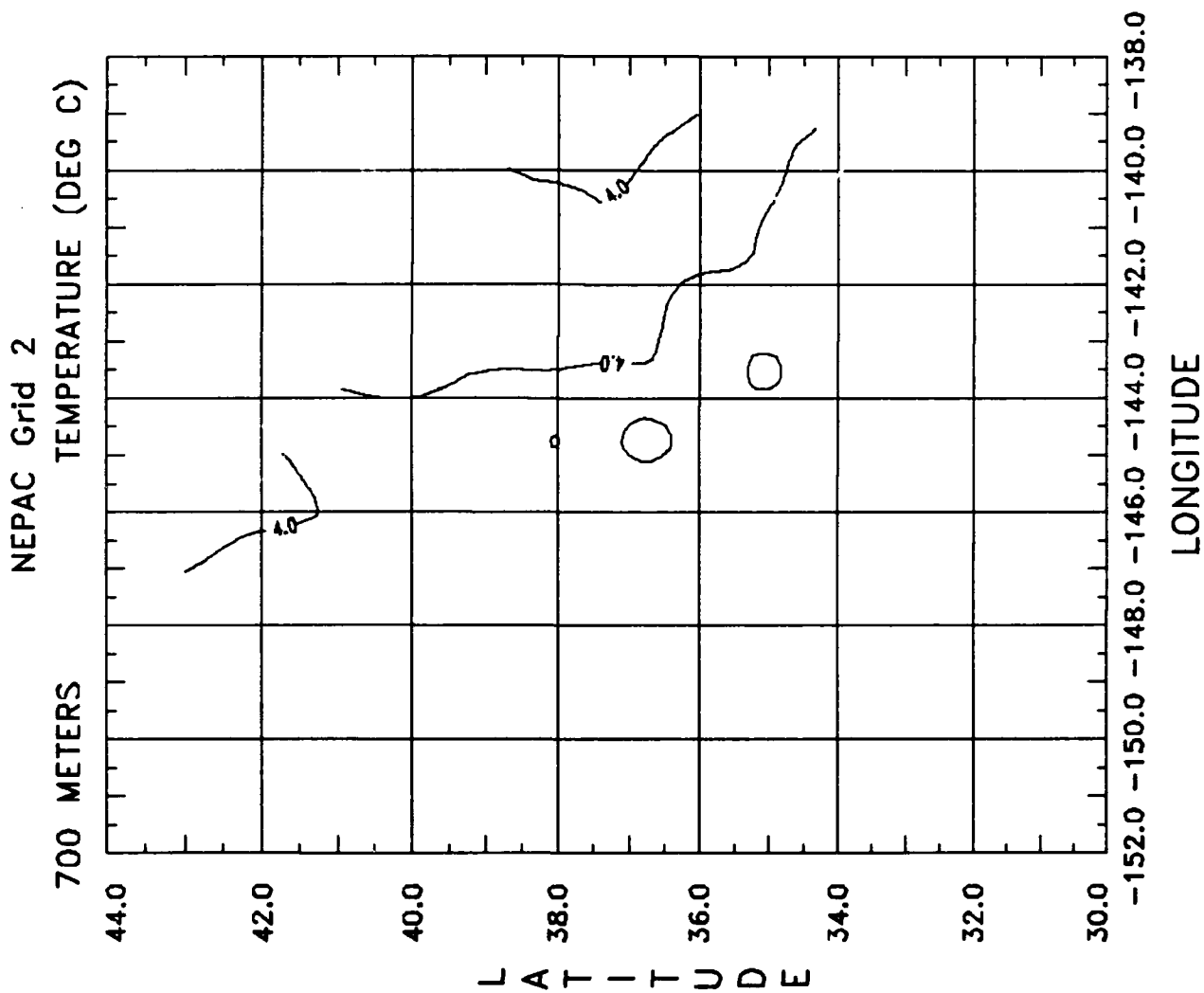


NOARL Code 331

7:52:22

2/12/90

dx=.3, dy=.3



Appendix C.

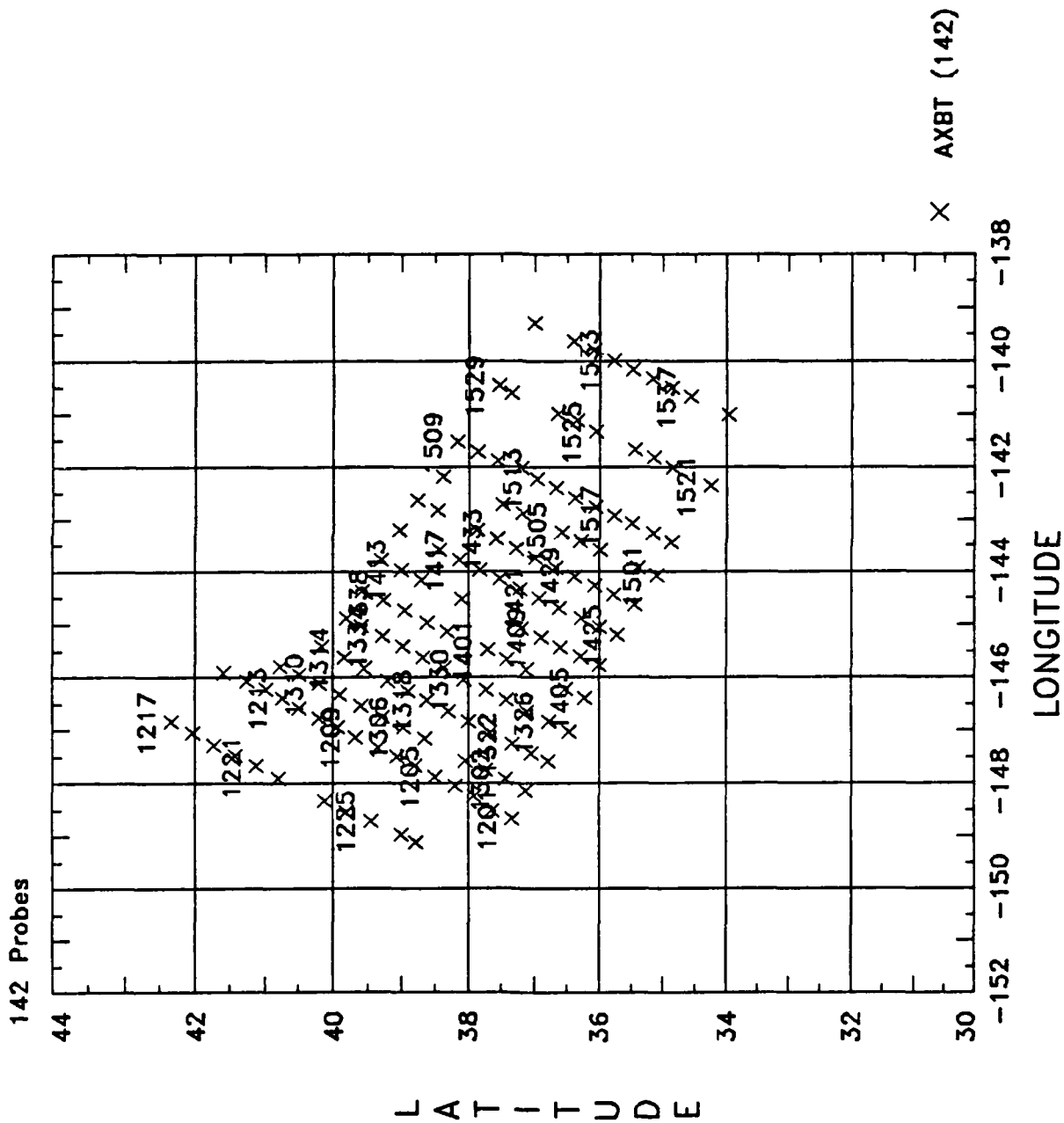
NEPAC Grid 2 (6 - 7 July 1989)

Inferred Salinity Contours at Selected Depths

8:55:51

5/09/90

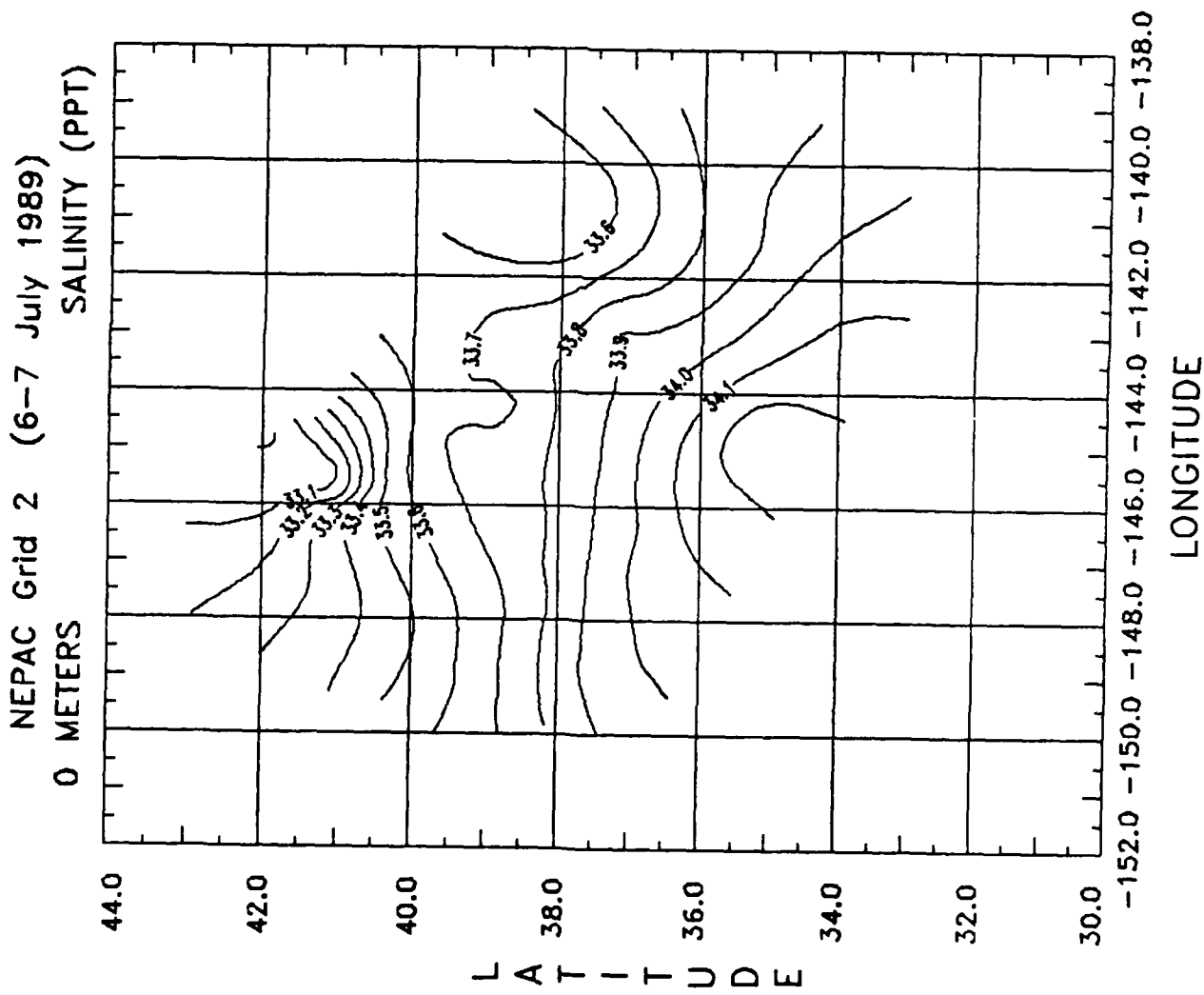
NEPAC Grid 2 (6-7 July 1989)



10:47:48

4/17/90

dx=.3 dy=.3

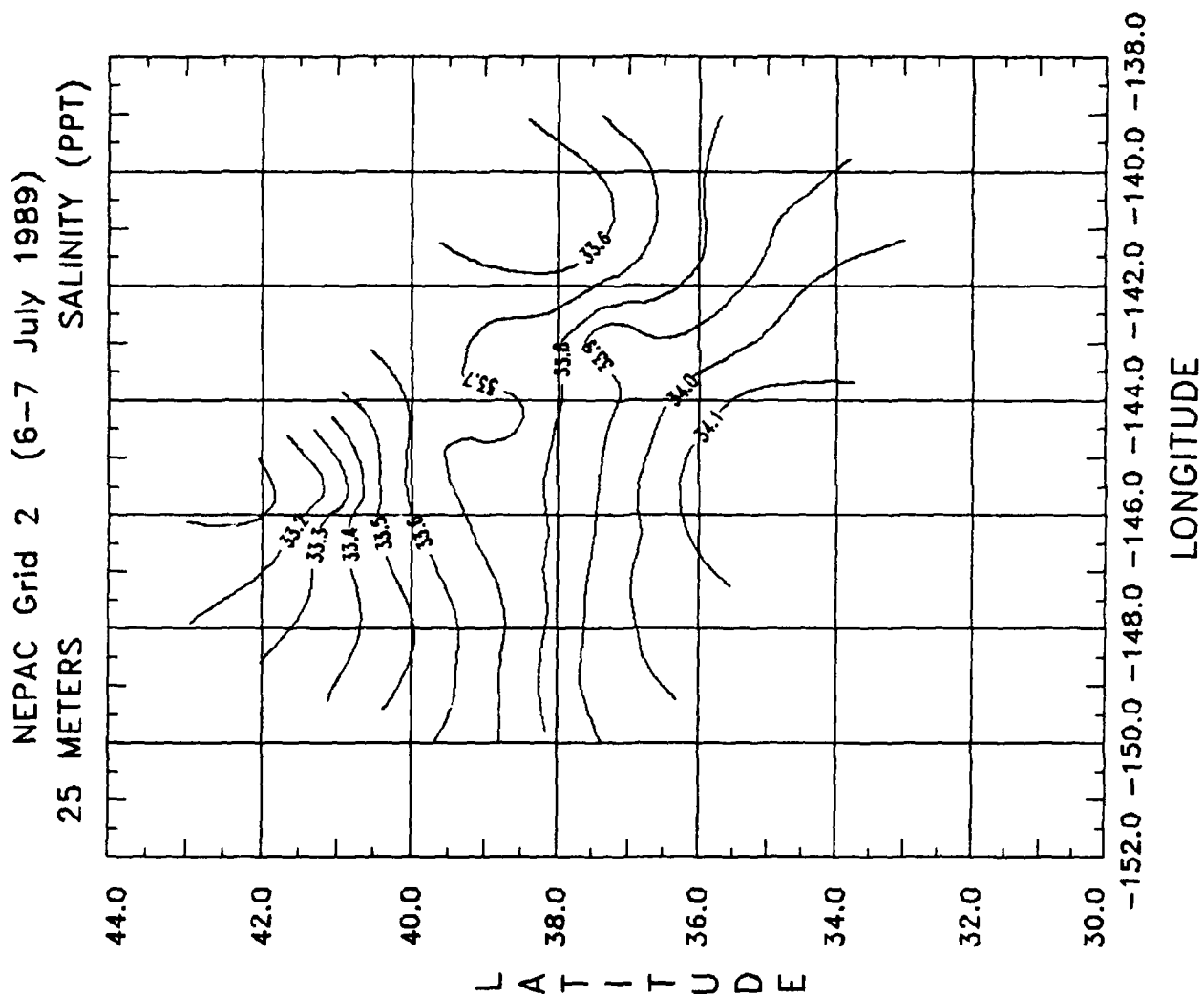


NOARL Code 331

12:28:05

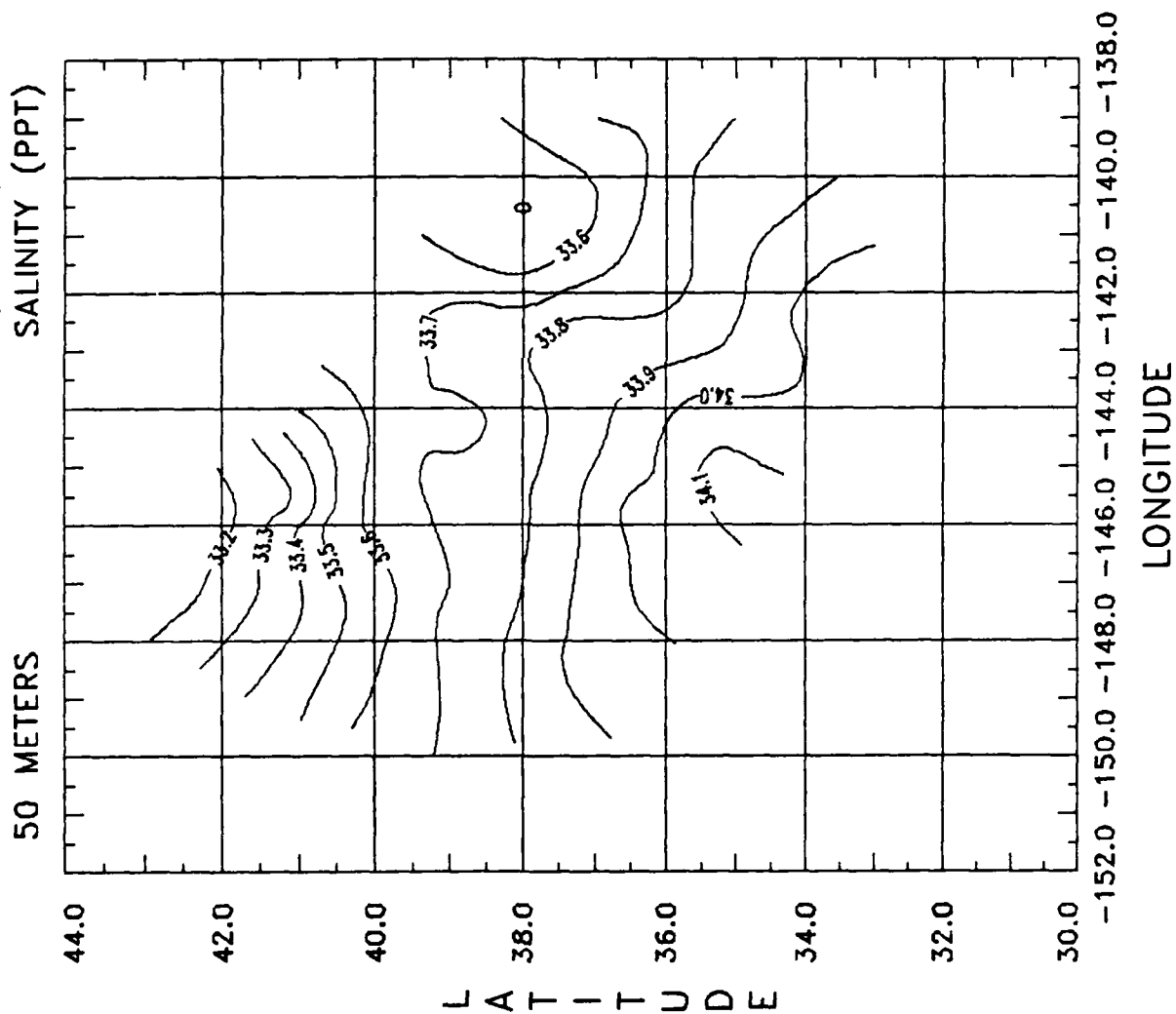
4/17/90

dx=.3 .dy=.3



NOARL Code 331

NEPAC Grid 2 (6-7 July 1989)



12:29:58

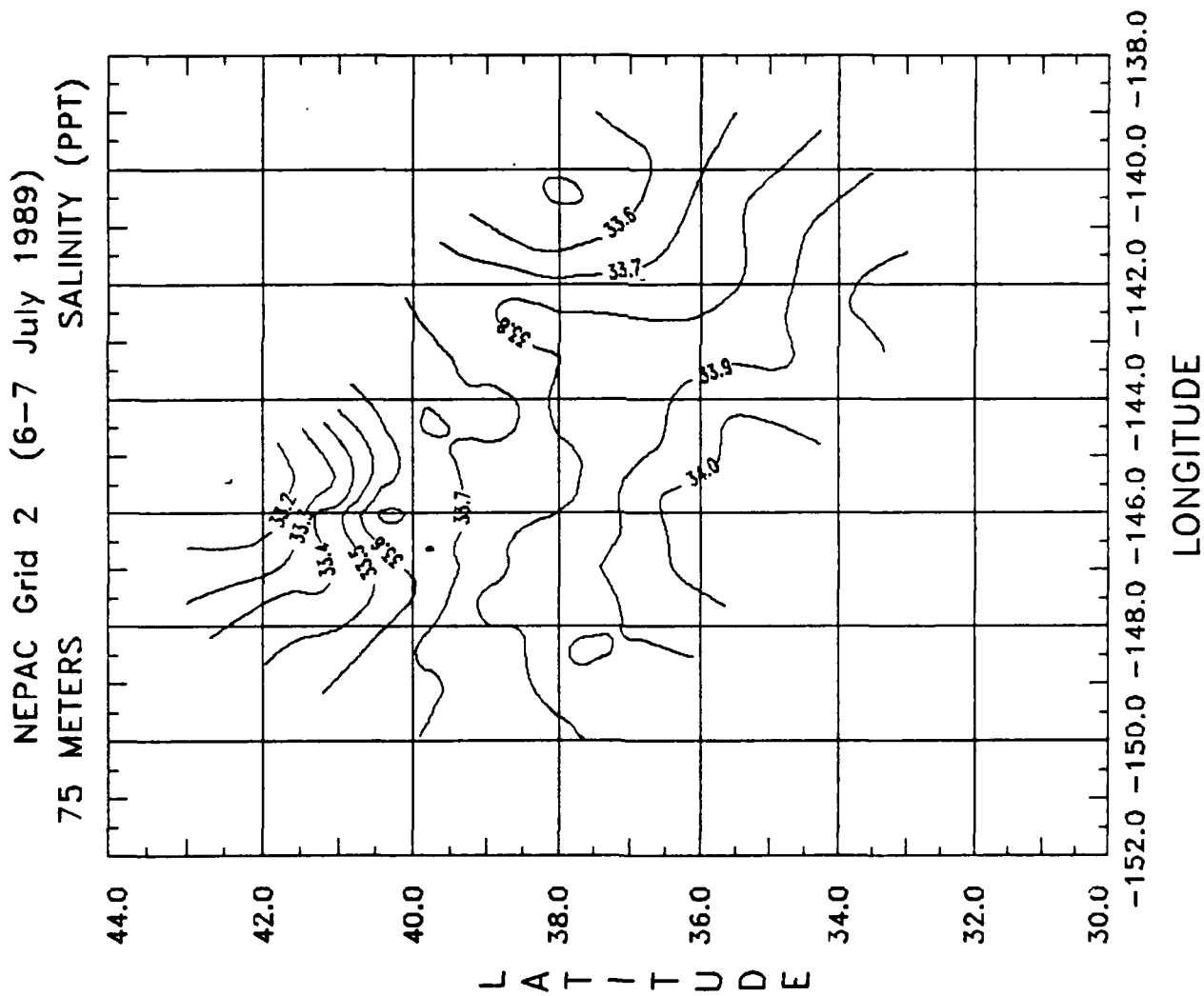
4/17/90

dx=.3, dy=.3

12:30:43

4/17/90

dx=.3, dy=.3

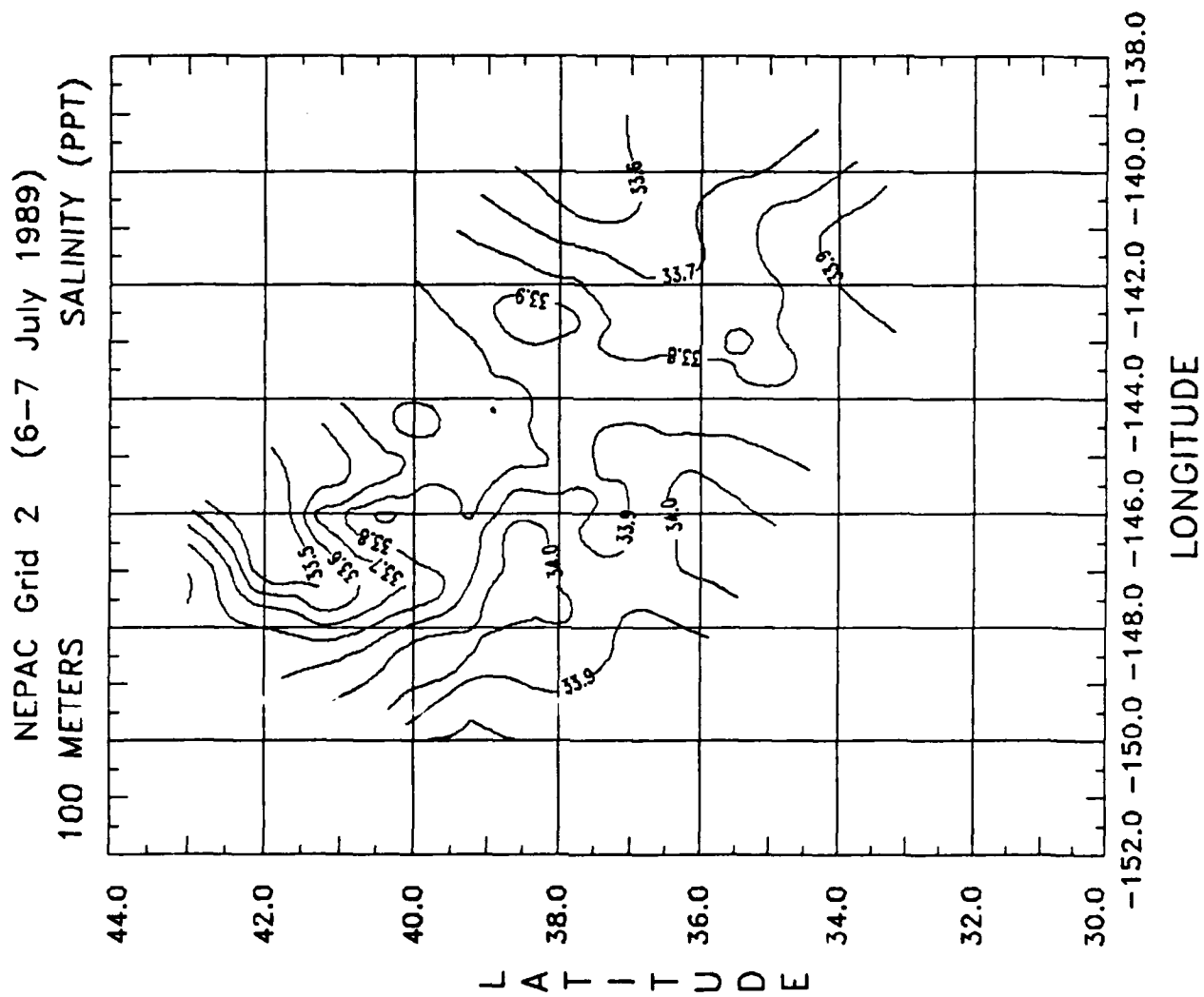


NOARL Code 331

12:31:30

4/17/90

dx=.3 dy=.3

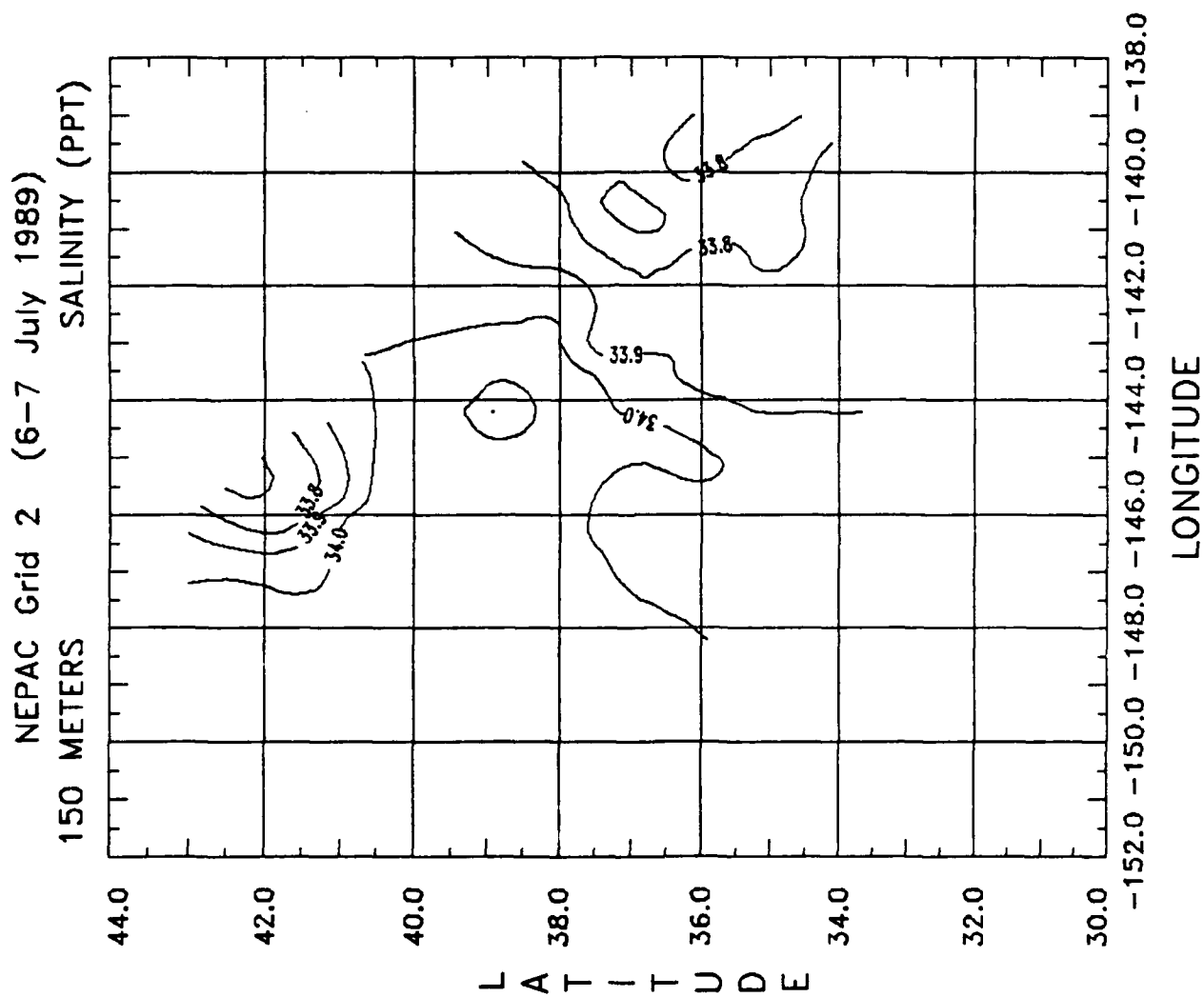


NOARL Code 331

12:32:14

4/17/90

dx=.3 dy=.3

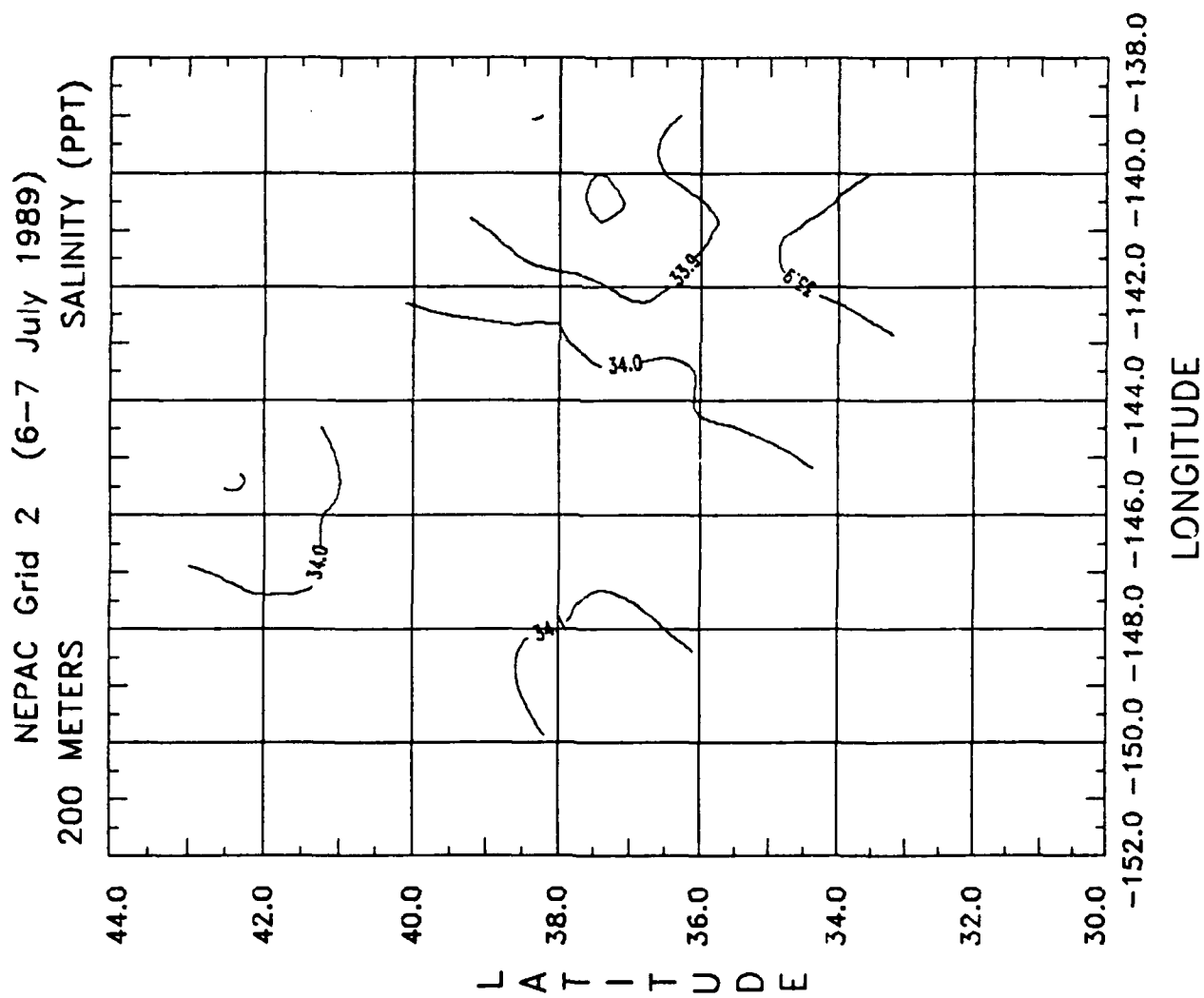


NOARL Code 331

12:32:54

4/17/90

$dx=.3$ $dy=.3$

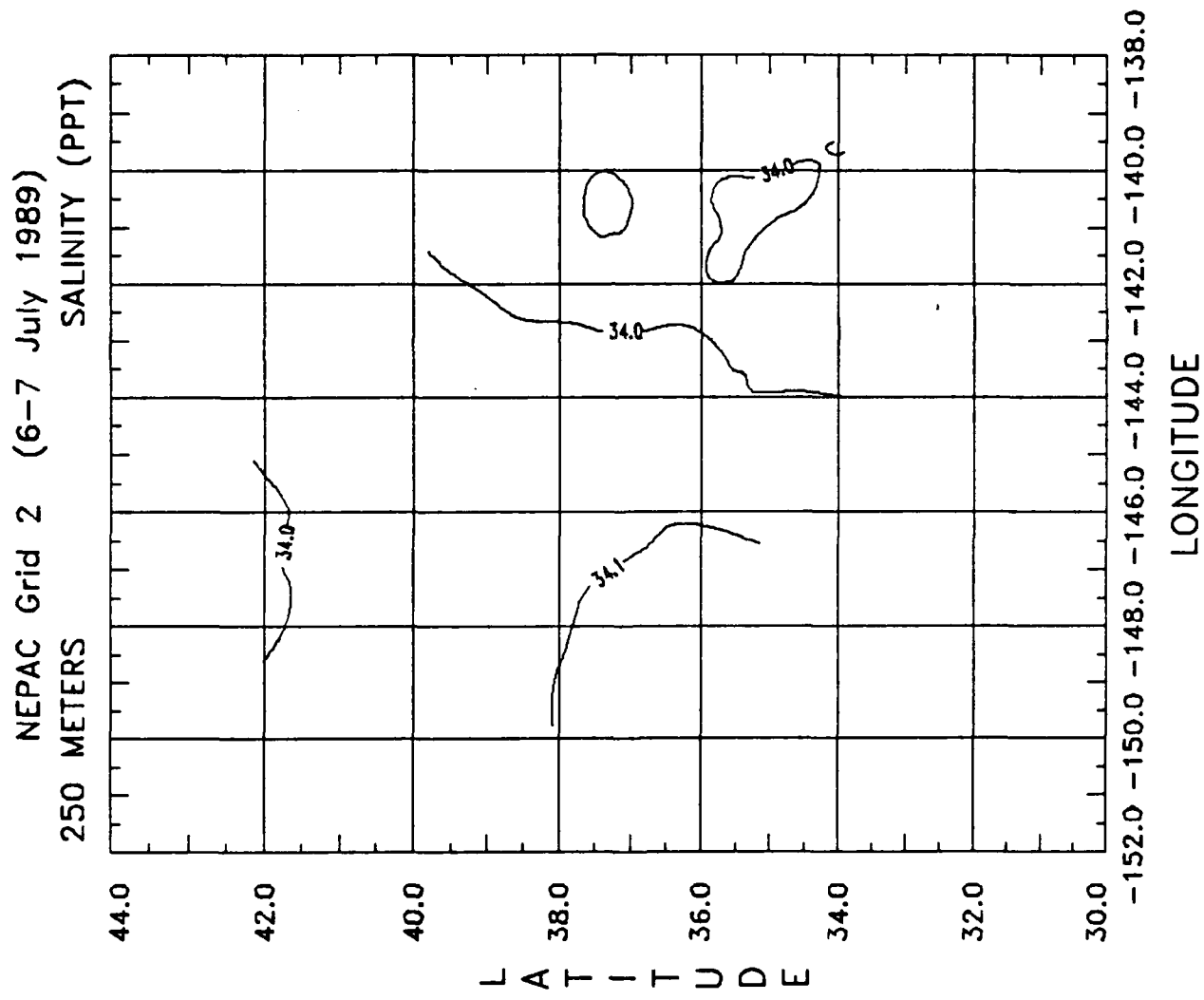


NOARL Code 331

12:33:33

4/17/90

dx=.3, dy=.3

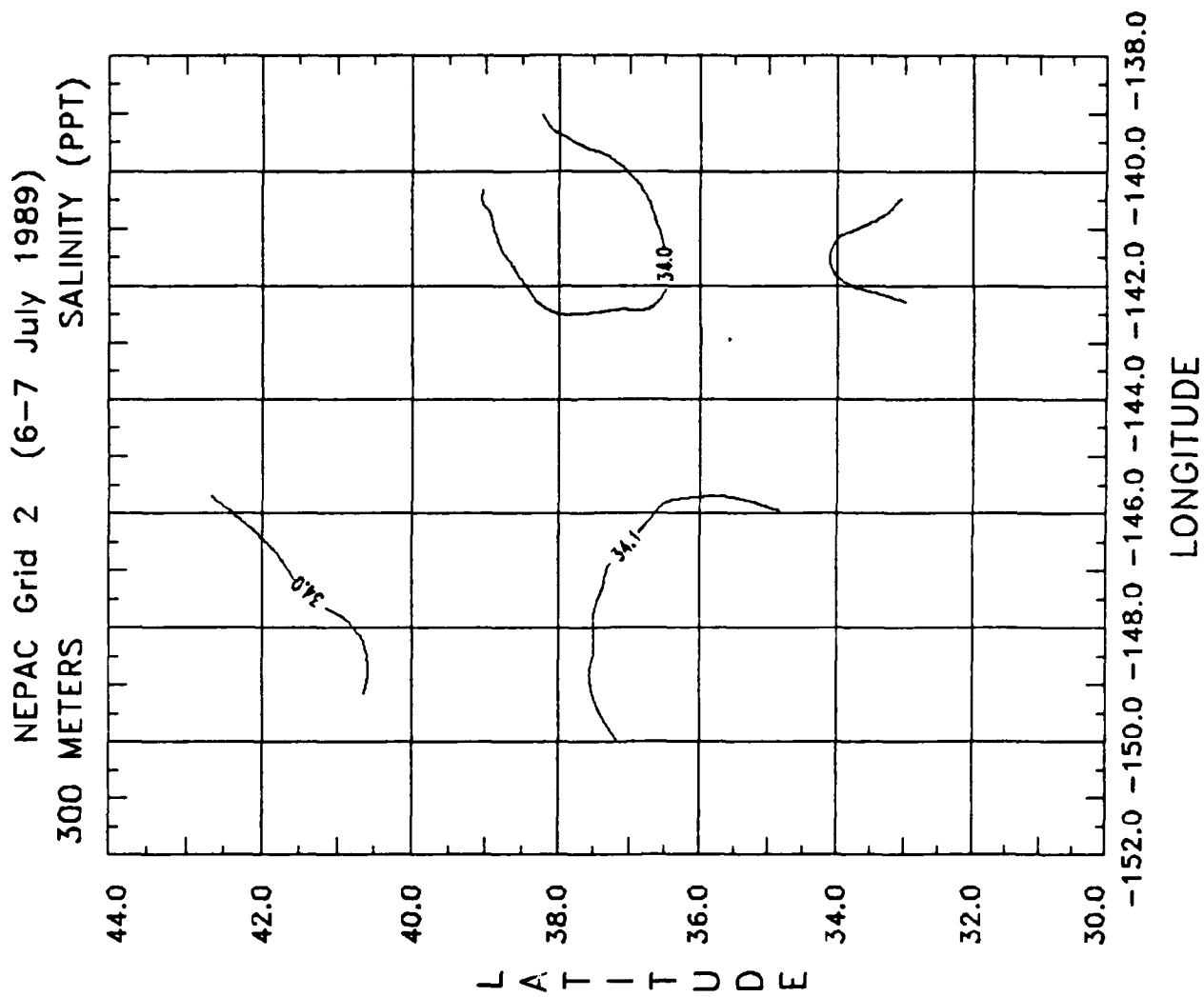


NOARL Code 331

12:34:11

4/17/90

dx=.3 .dy=.3

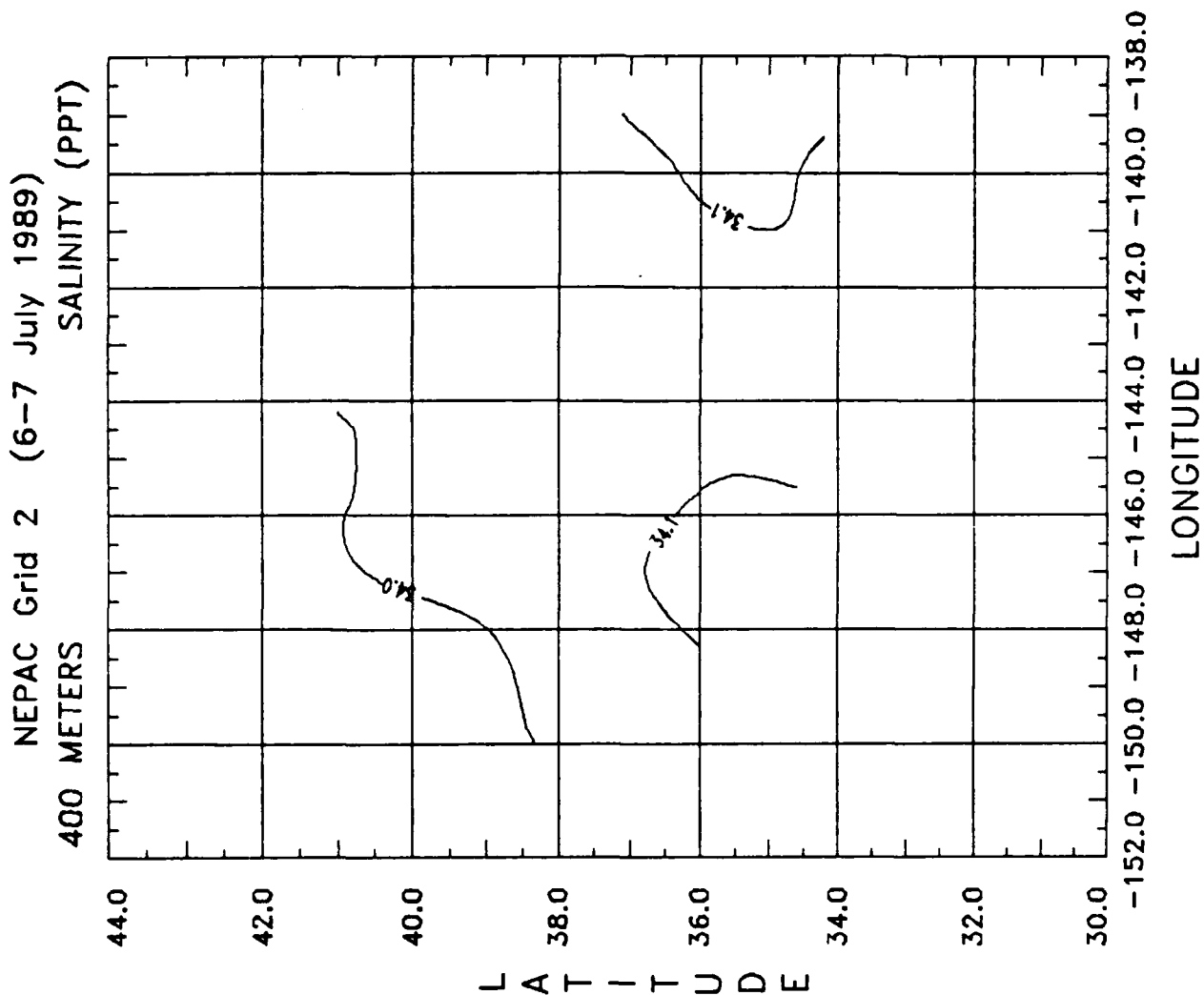


NOARL Code 331

12:34:48

4/17/90

dx=.3 .dy=.3

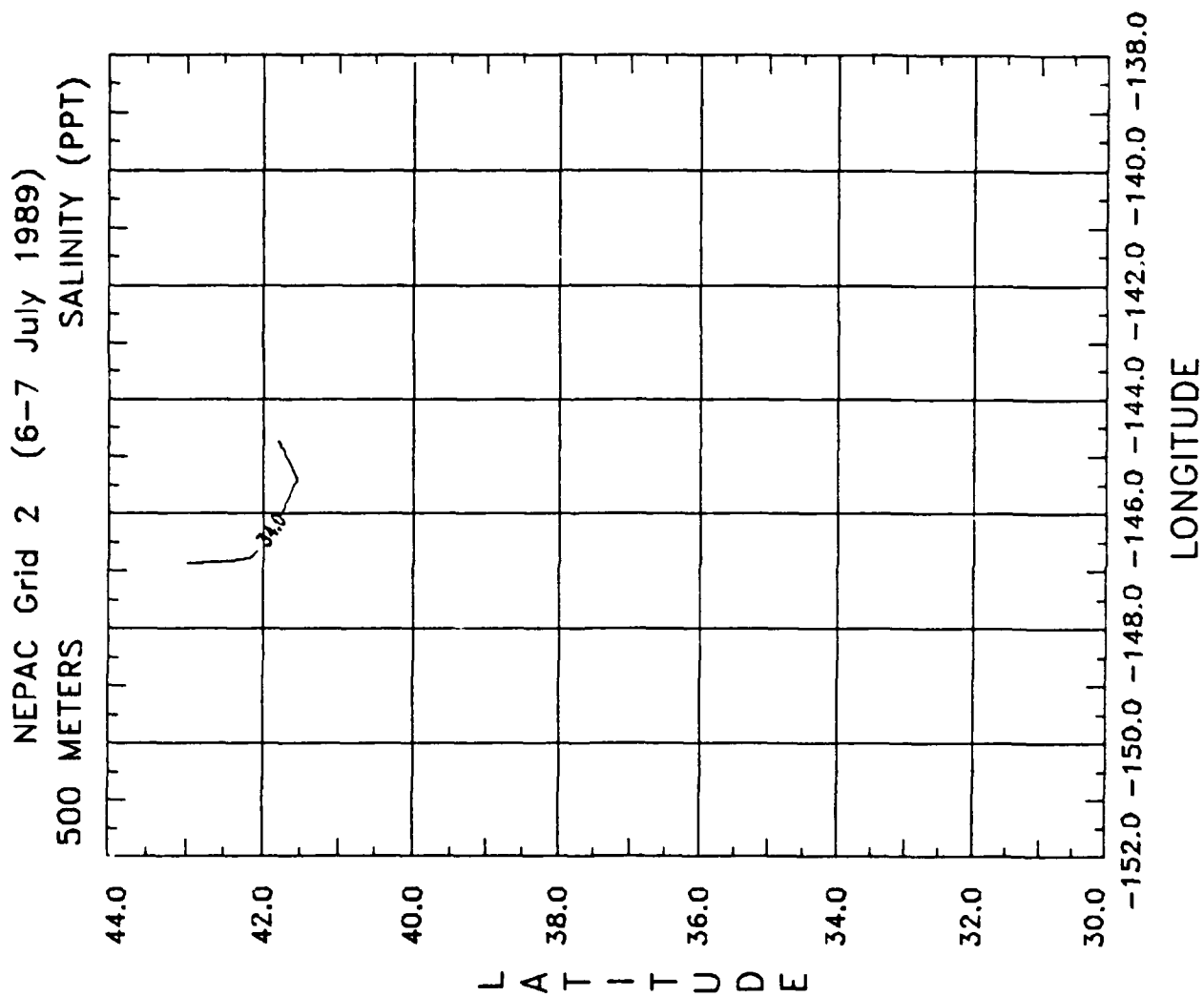


NOARL Code 331

12:35:23

4/17/90

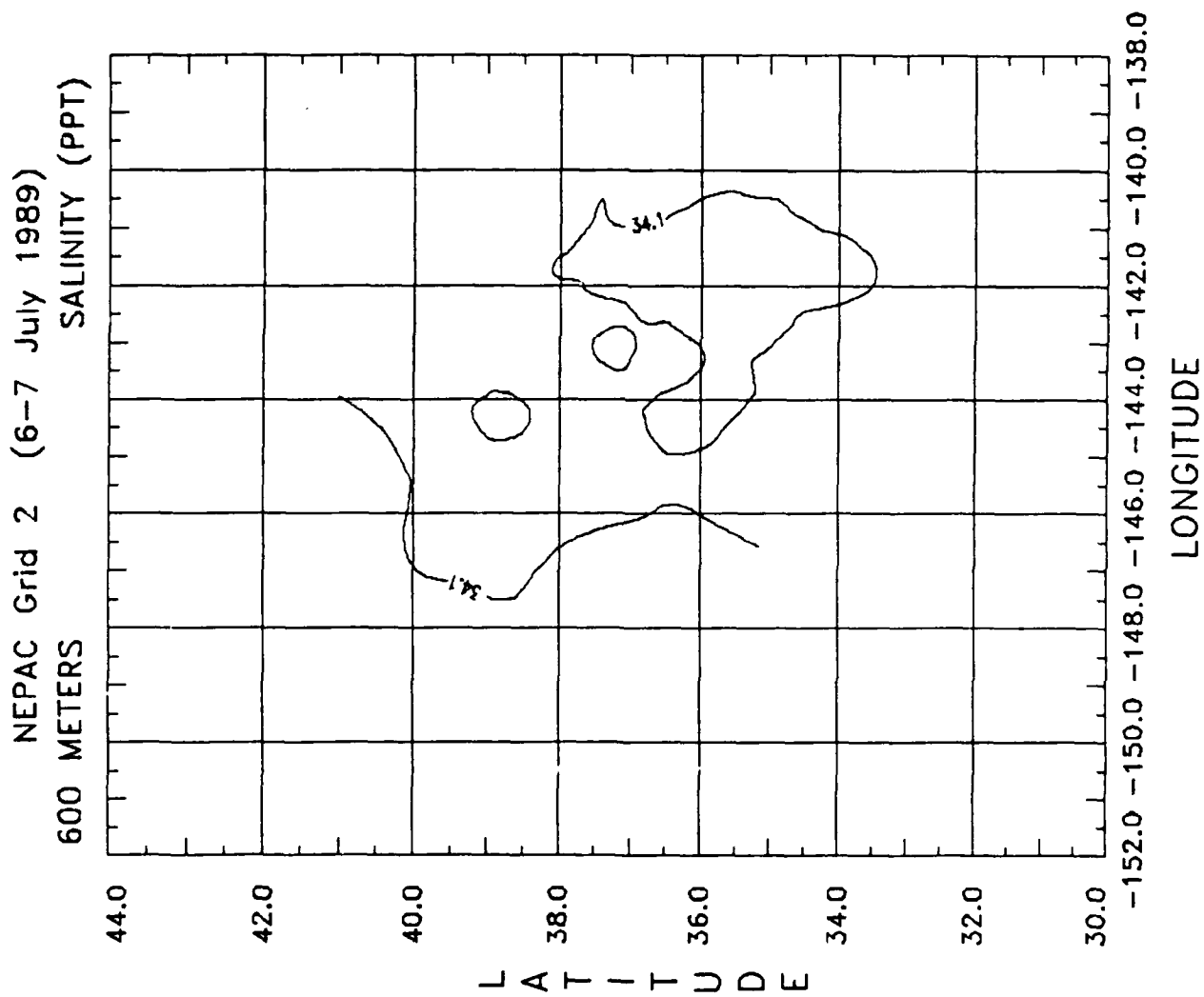
dx=.3 dy=.3



12:35:59

4/17/90

dx=.3 ,dy=.3

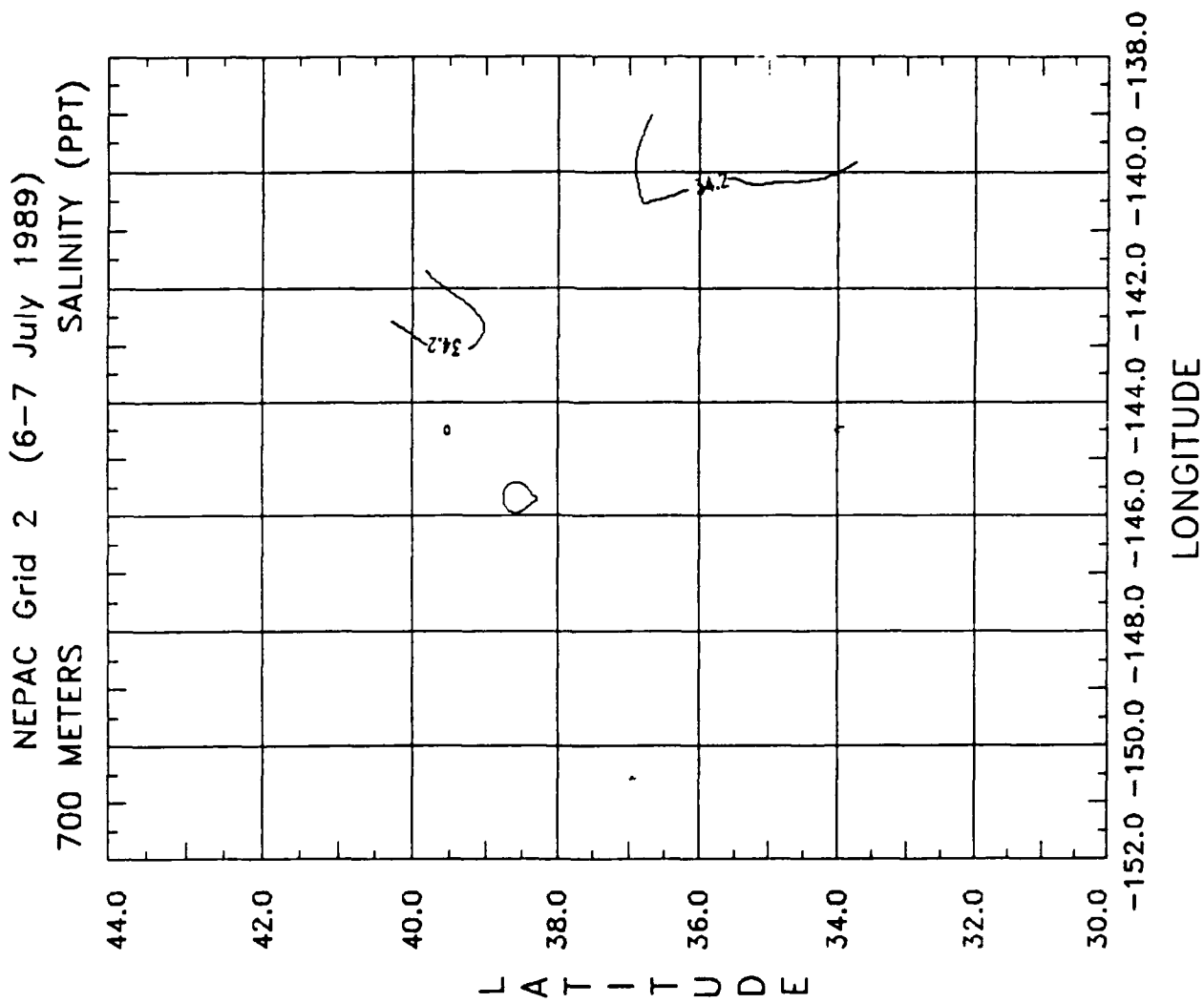


NOARL Code 331

12:36:36

4/17/90

dx=.3, dy=.3



NOARL Code 331

Appendix D.

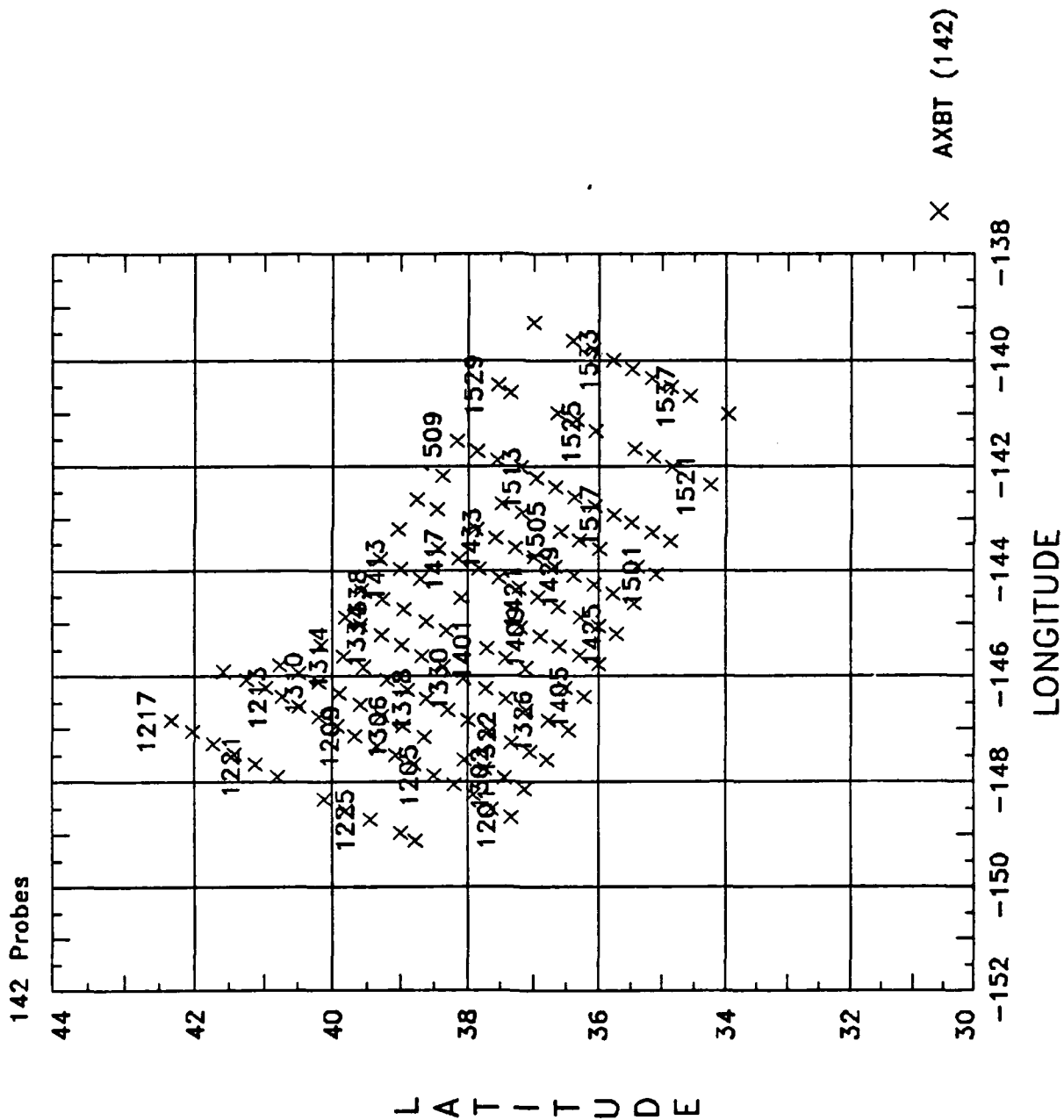
NEPAC Grid 2 (6 - 7 July 1989)

Computed Sound Speed Contours at Selected Depths

8:55:51

5/09/90

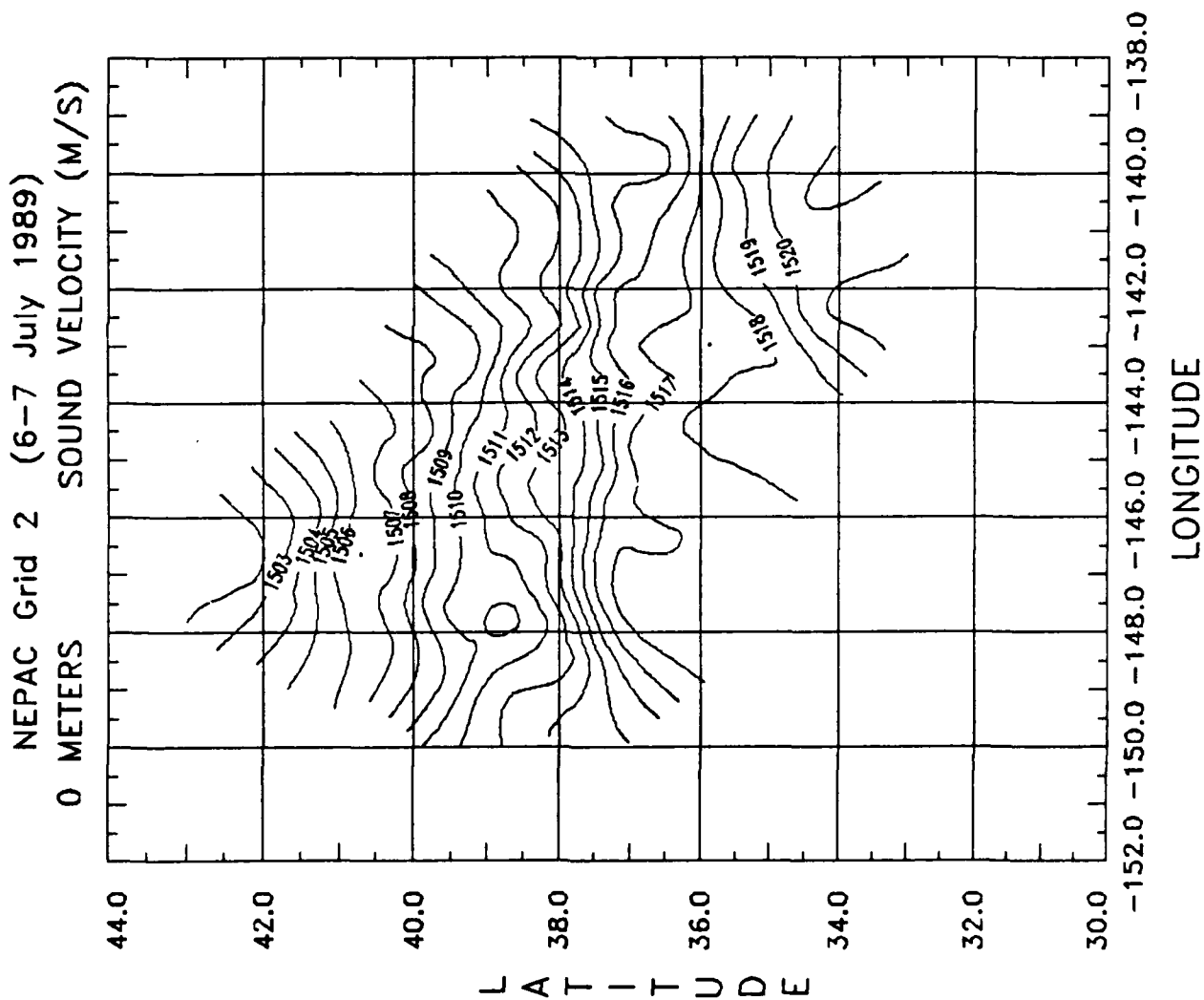
NEPAC Grid 2 (6-7 July 1989)



12:47:15

4/17/90

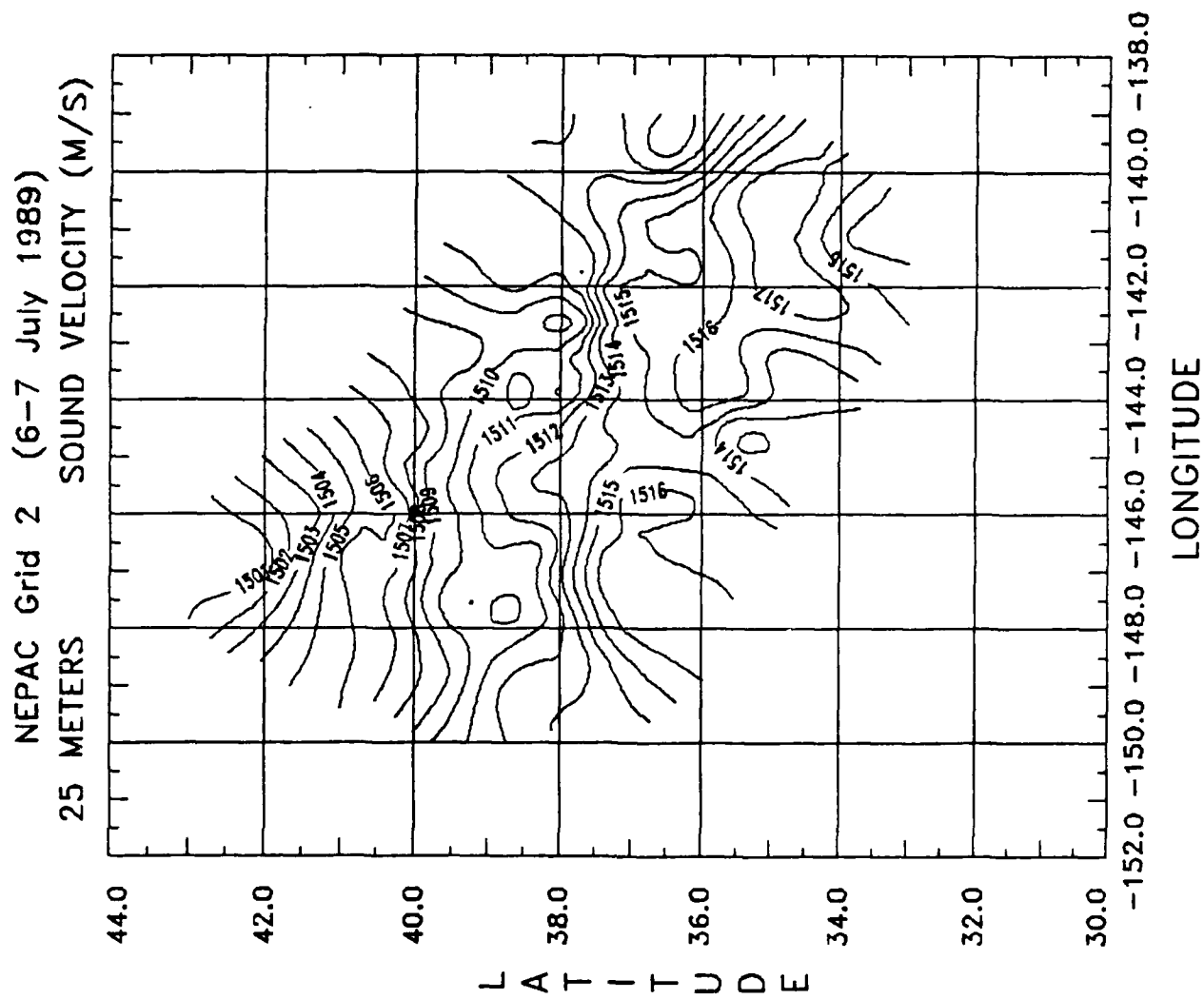
dx=.3 dy=.3



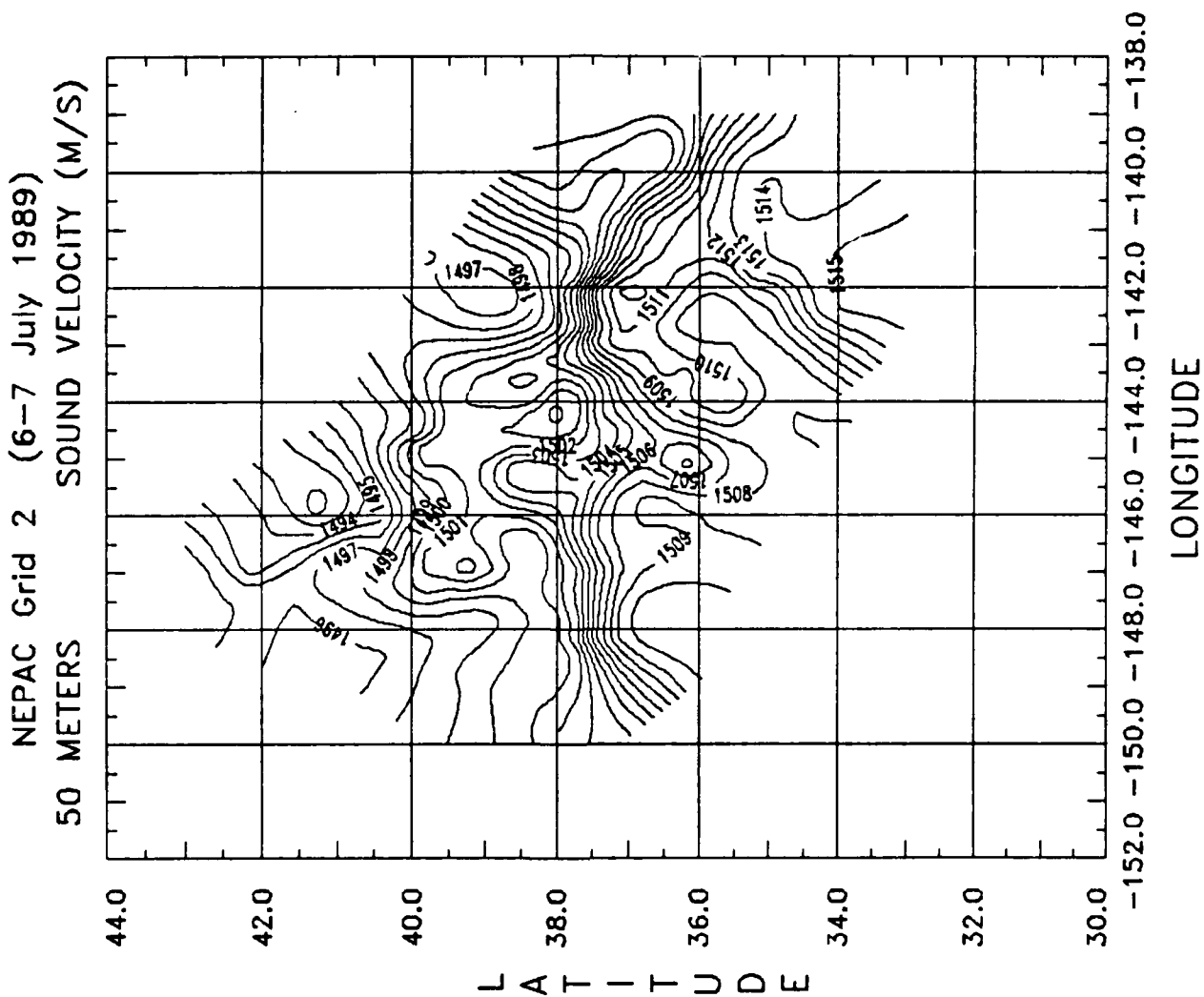
13:05:08

4/17/90

dx=.3, dy=.3



NOARL Code 331

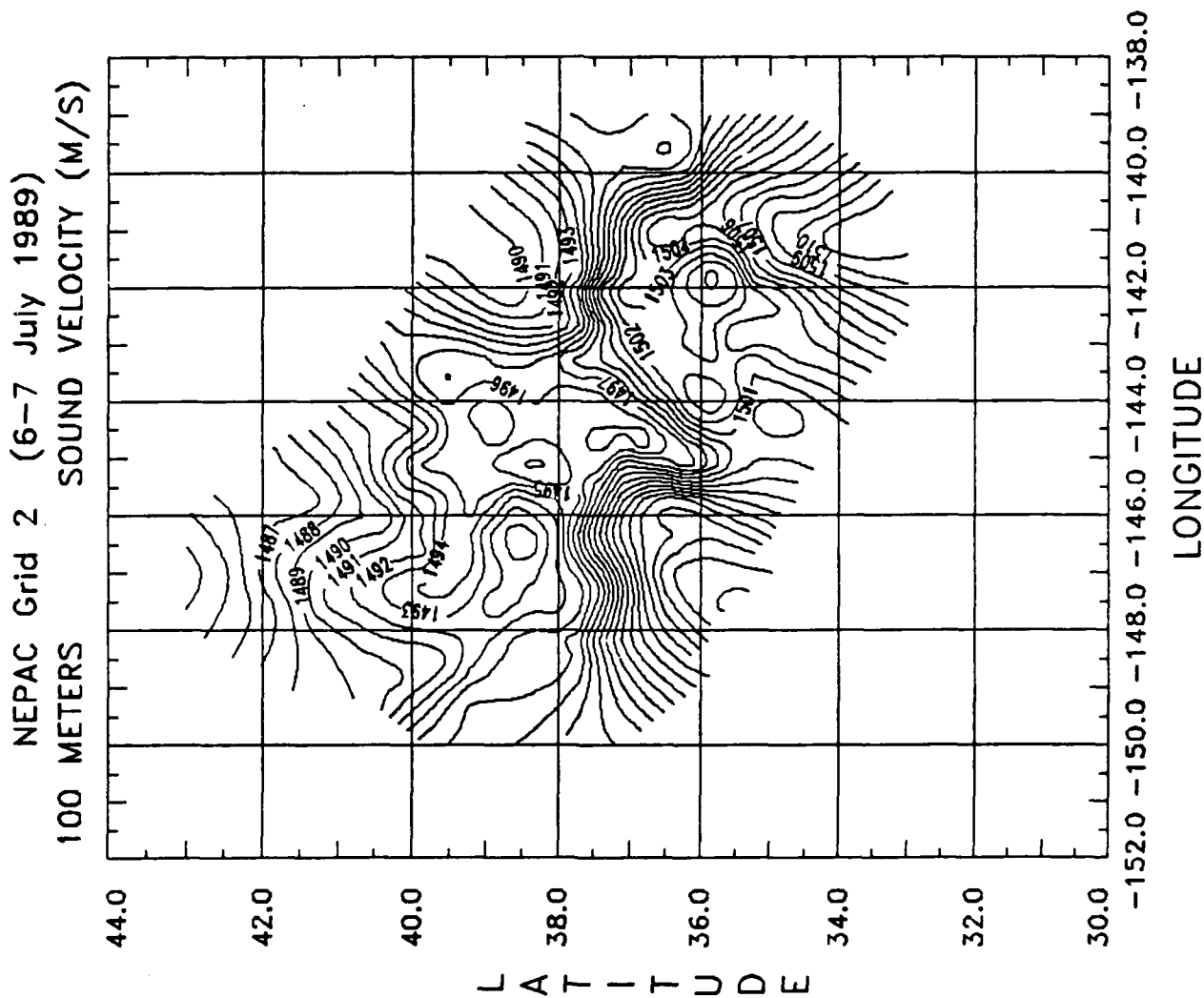


NOARL Code 331

12:56:14

4/17/90

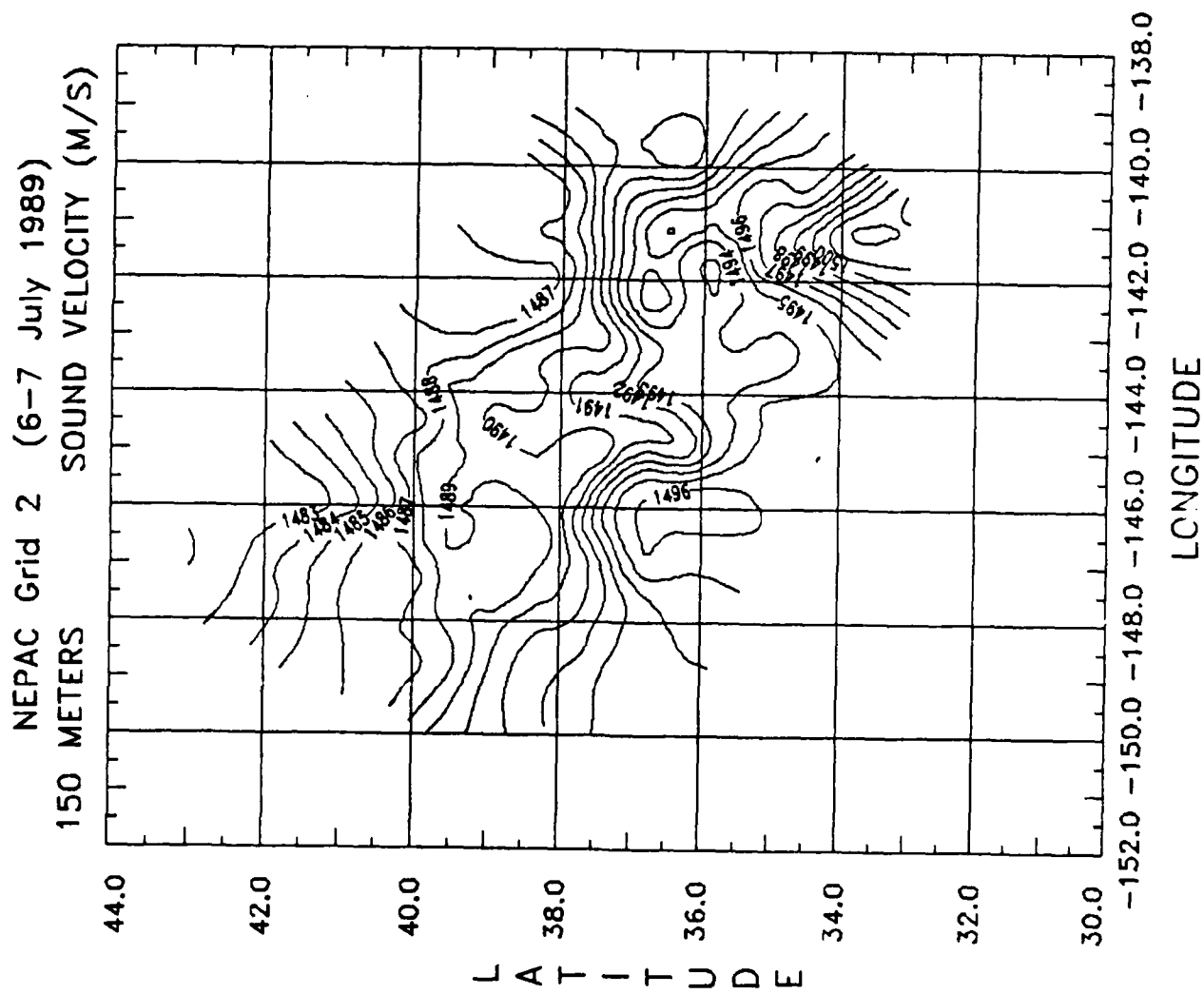
dx=.3 ,dy=.3



12:57:22

4/17/90

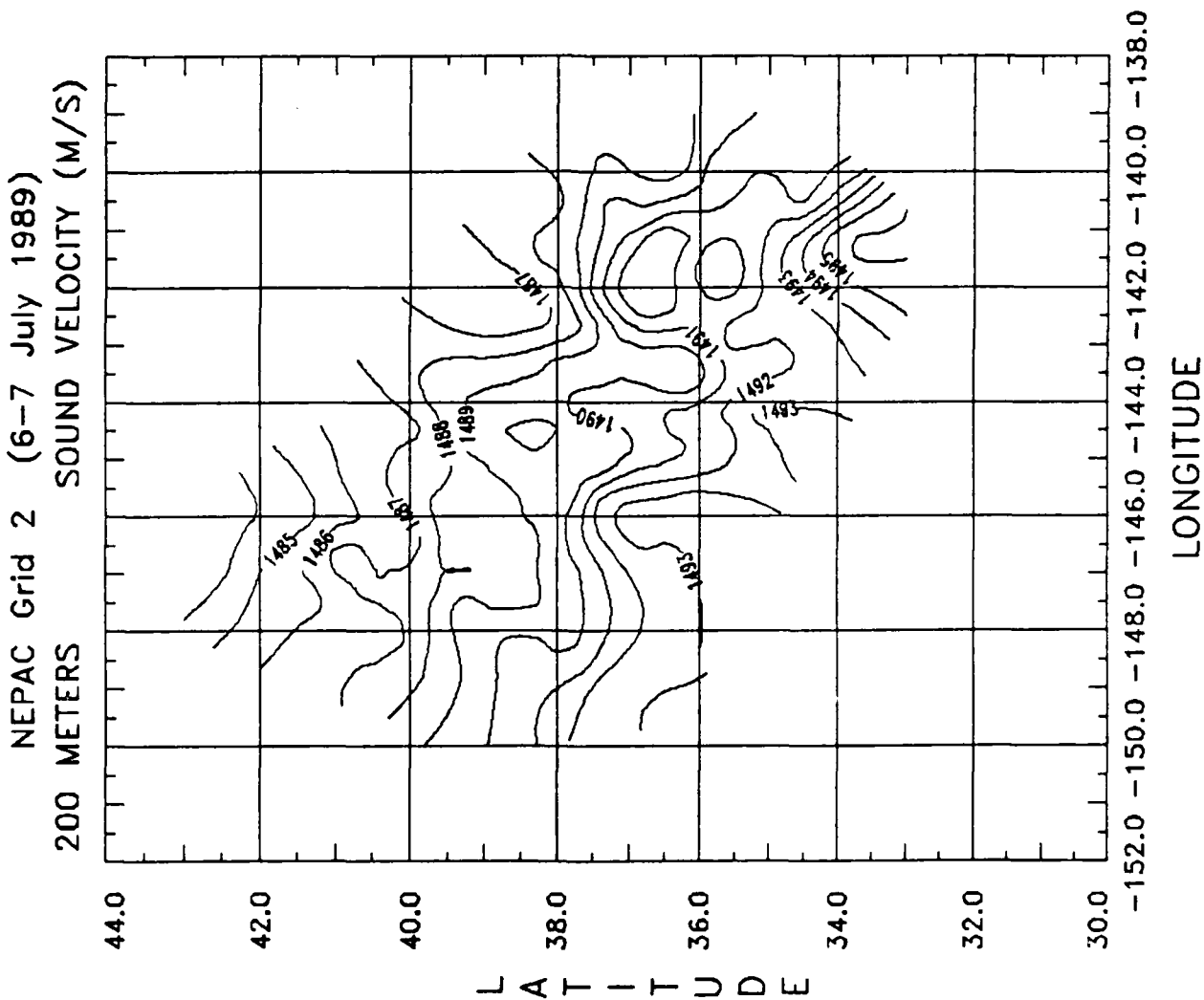
dx=.3, dy=.3

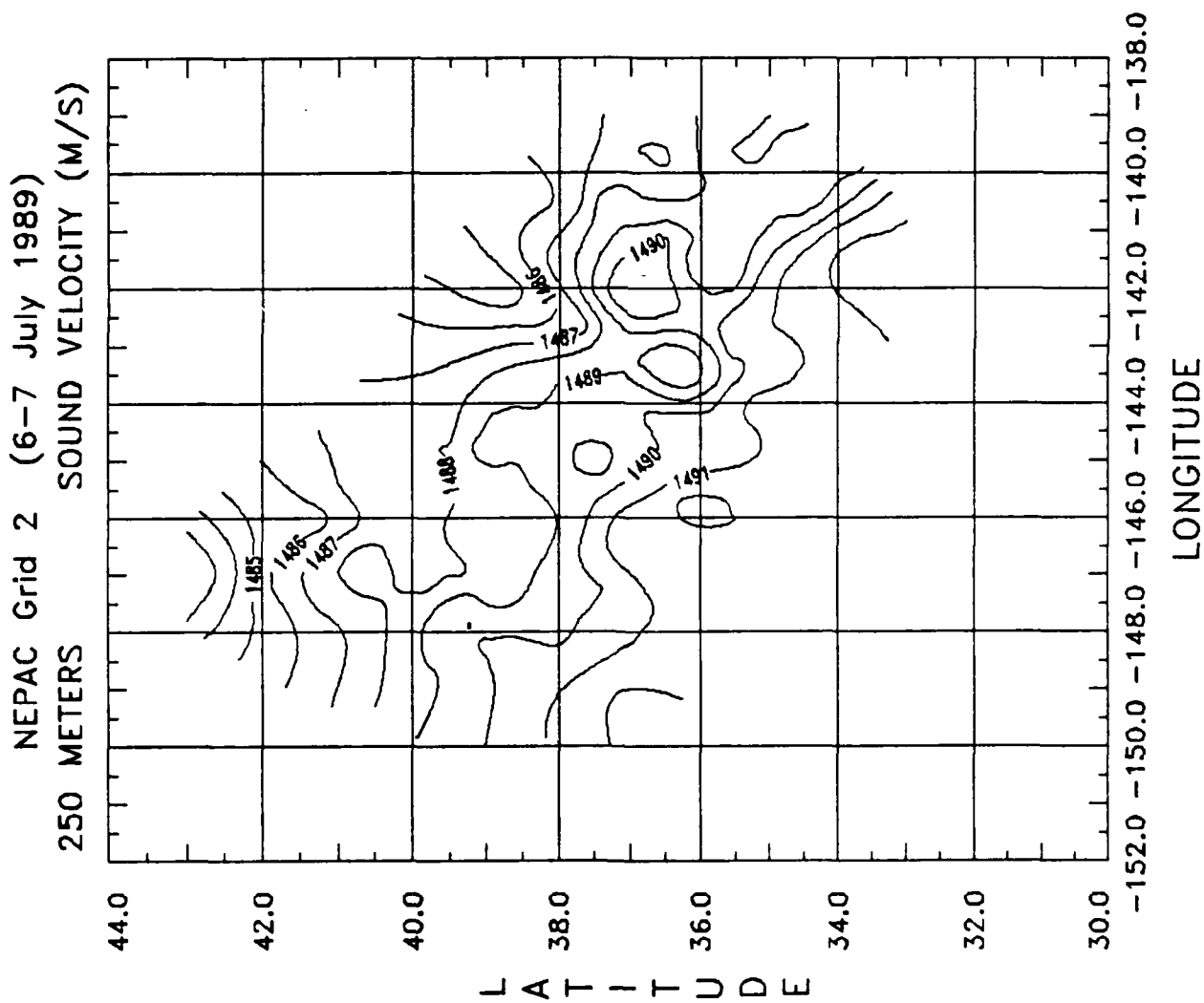


12:58:16

4/17/90

dx=.3, dy=.3

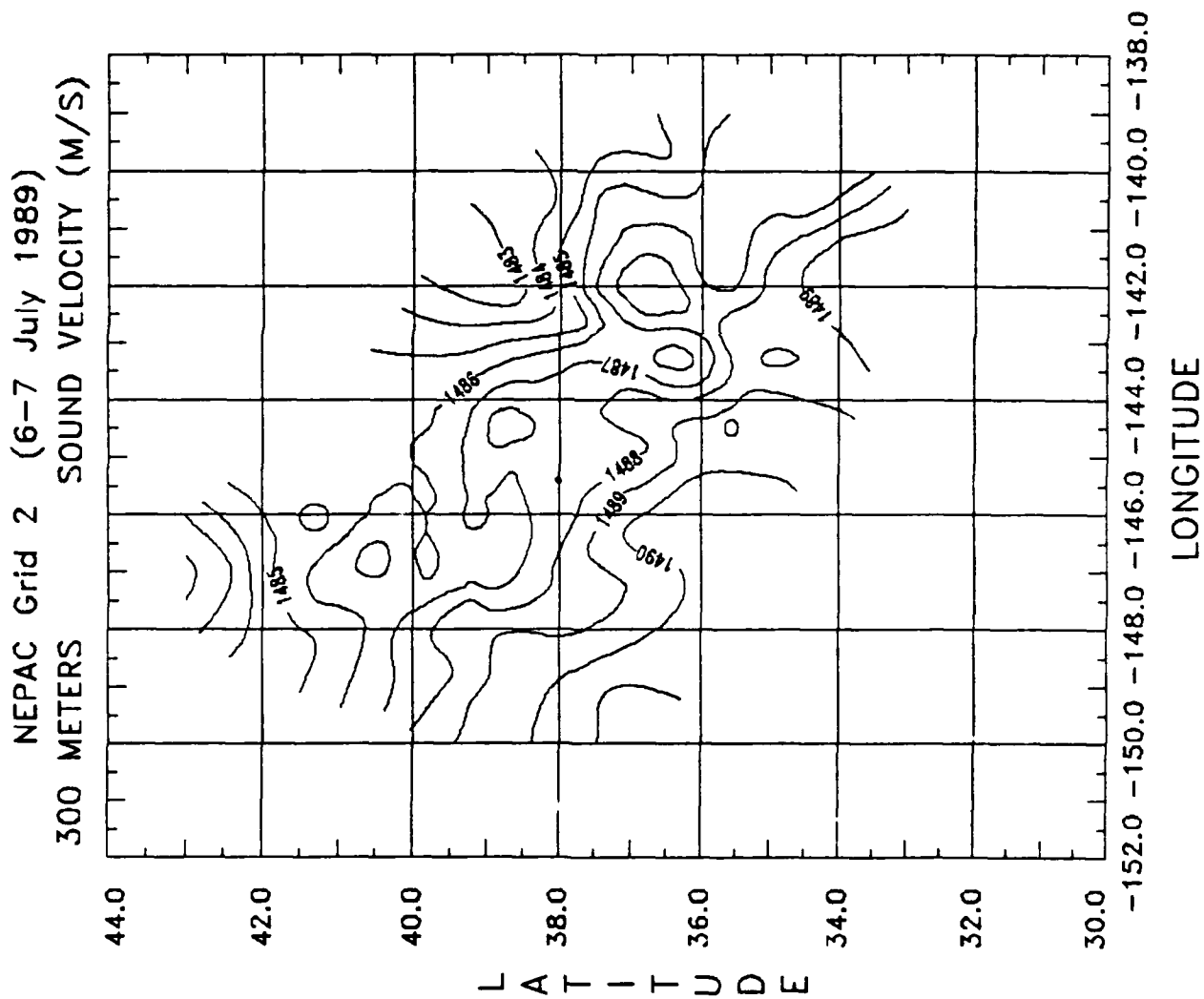




12:59:55

4/17/90

dx=.3, dy=.3

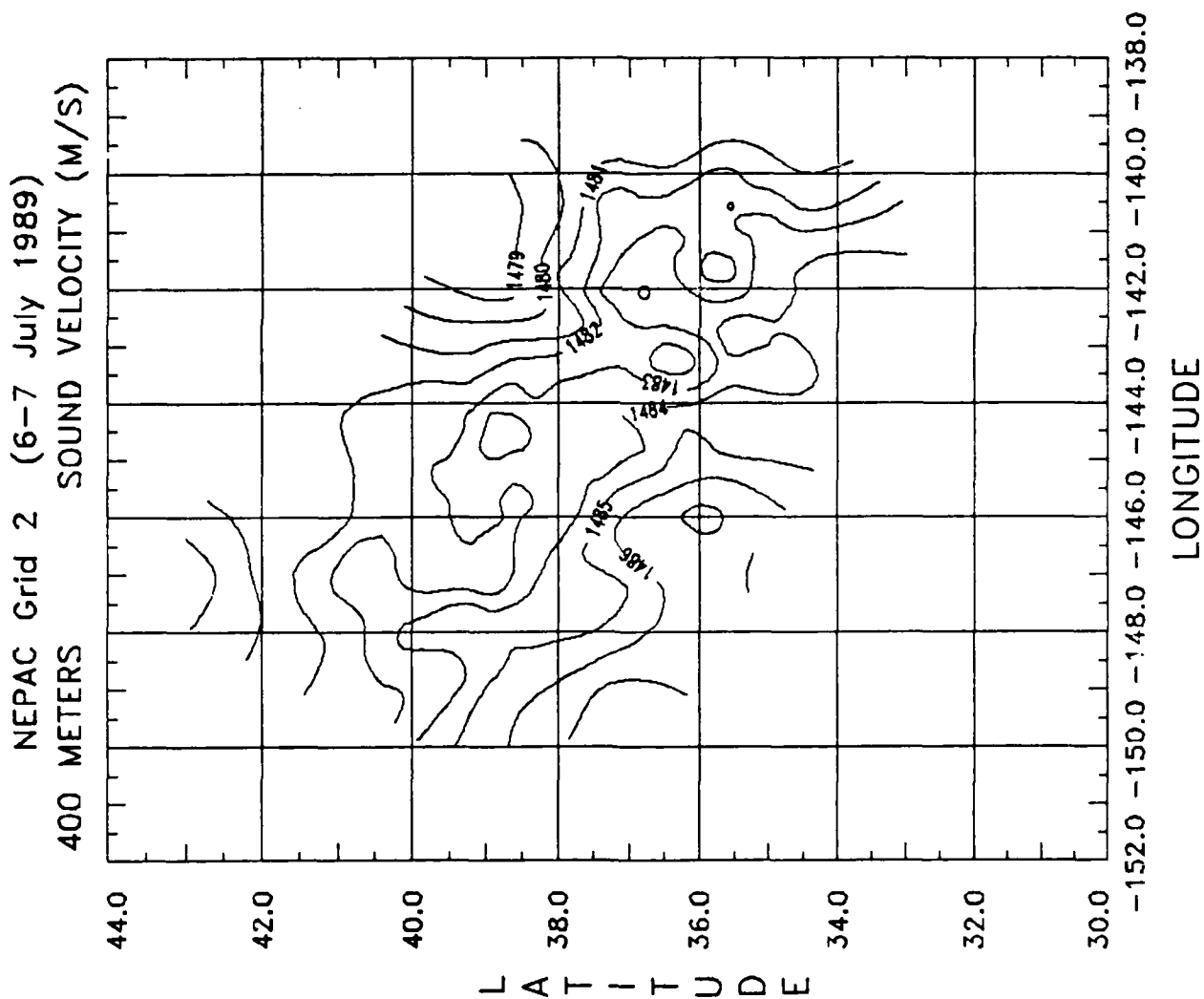


NOARL Code 331

13:00:44

4/17/90

dx=.3 dy=.3

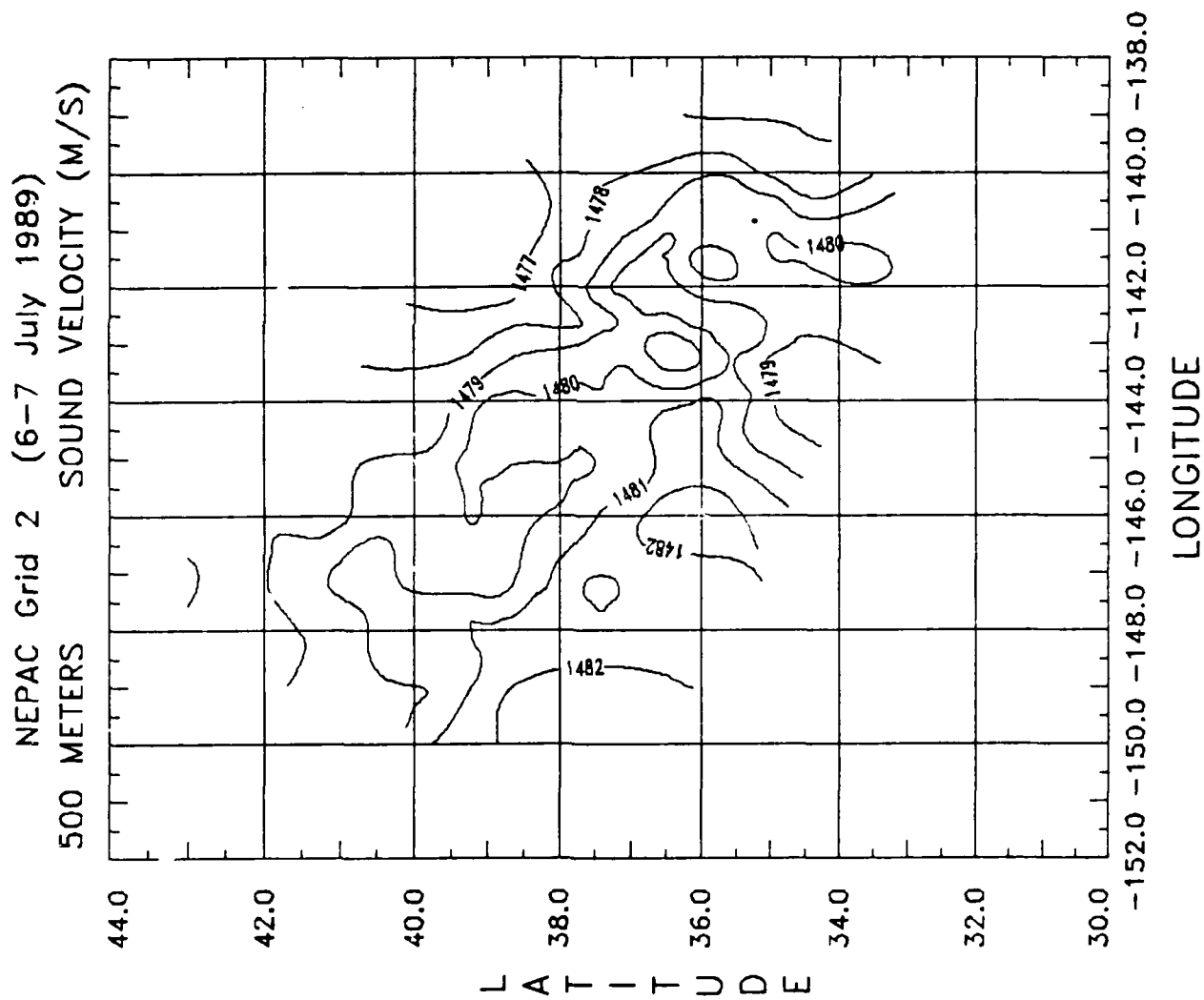


NOARL Code 331

13:01:32

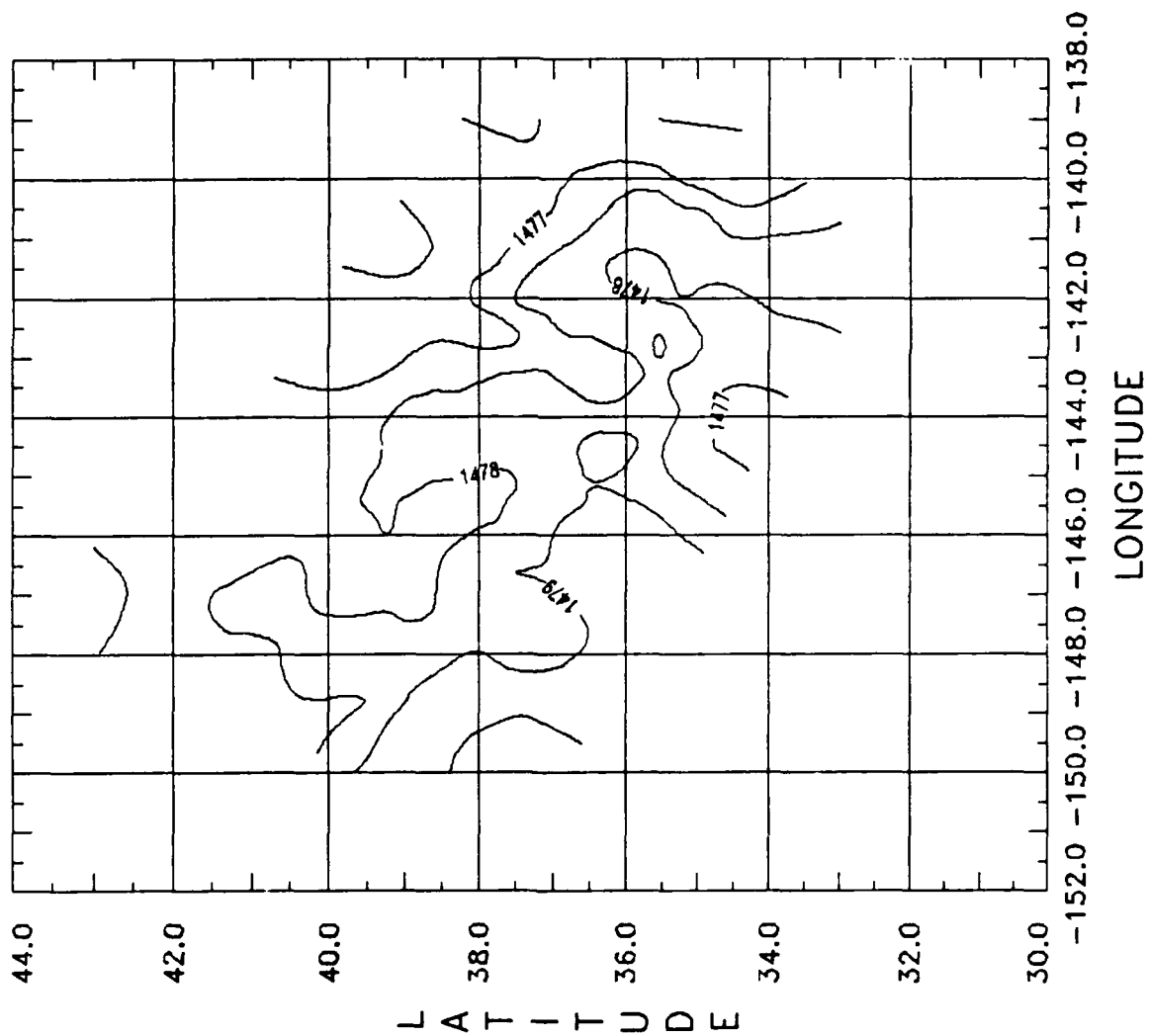
4/17/90

dx=.3, dy=.3



NEPAC Grid 2 (6-7 July 1989)

600 METERS SOUND VELOCITY (M/S)

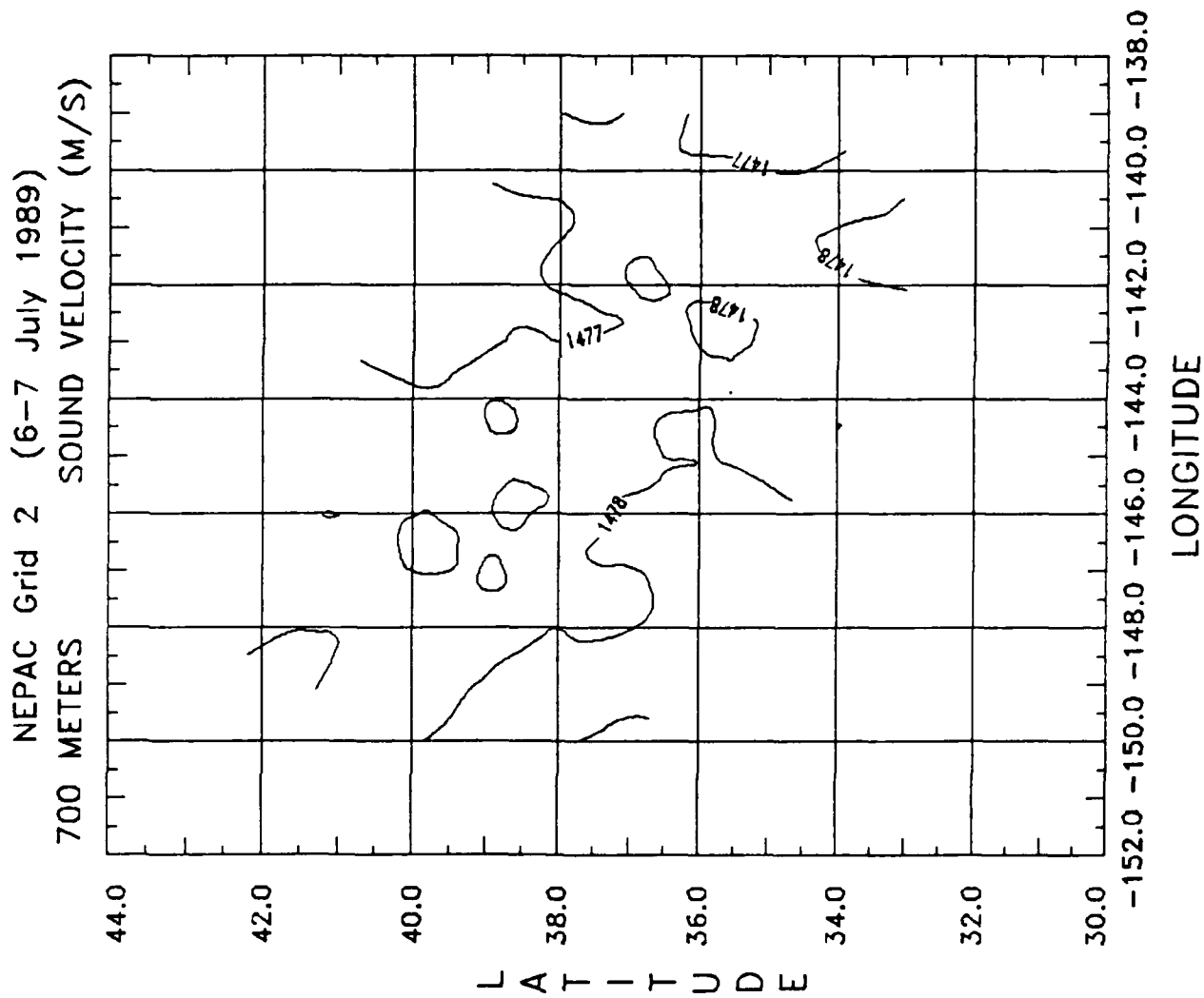


NOARL Code 331

13:02:58

4/17/90

dx=.3, dy=.3



Appendix E.

NEPAC Grid 3 (17 - 19 July 1989)

Temperature Contours at Selected Depths

07:10:6

156 Probes

LATITUDE

LONGITUDE

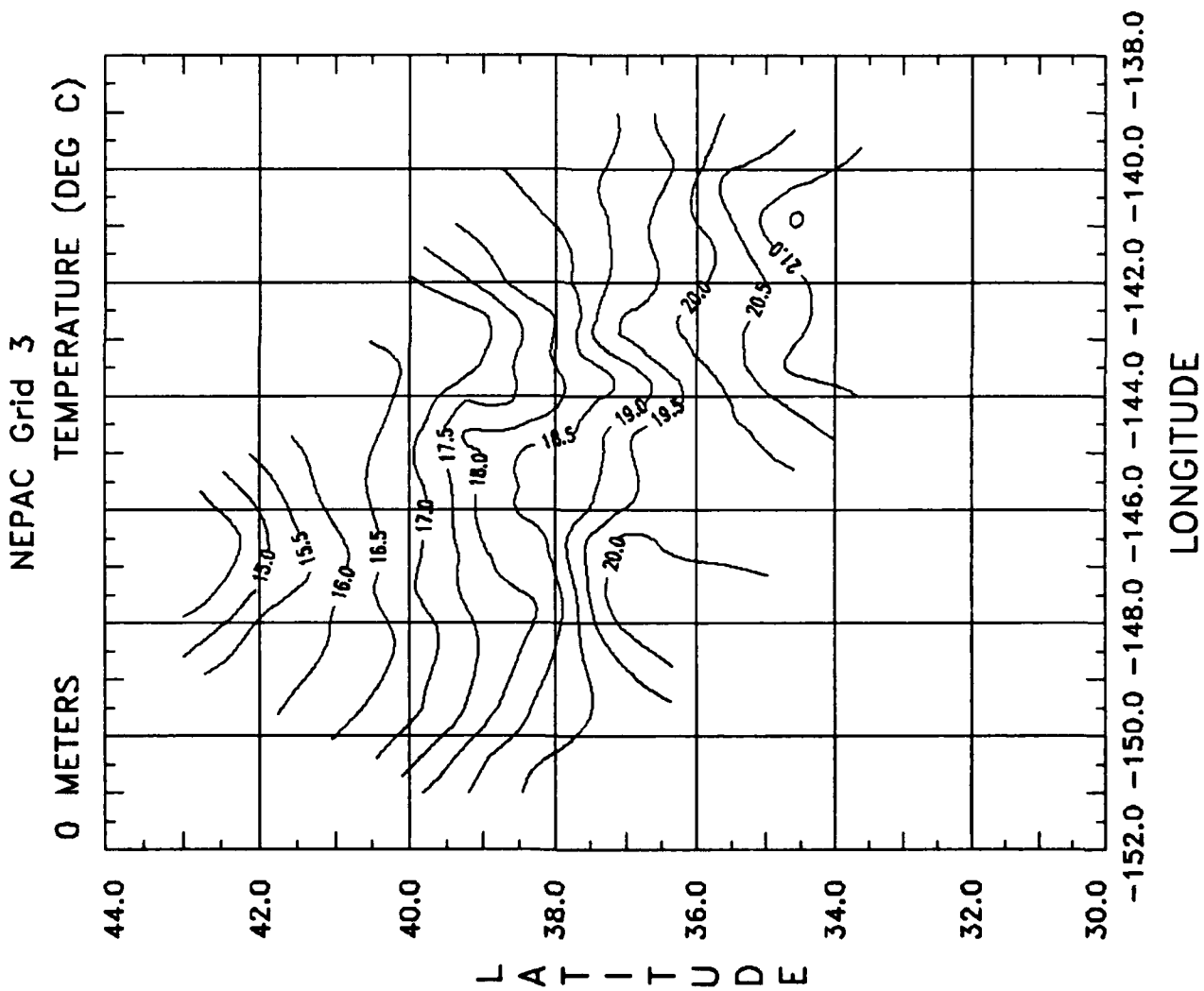
AXBT (156)

NOARL Code 331

7:53:56

2/12/90

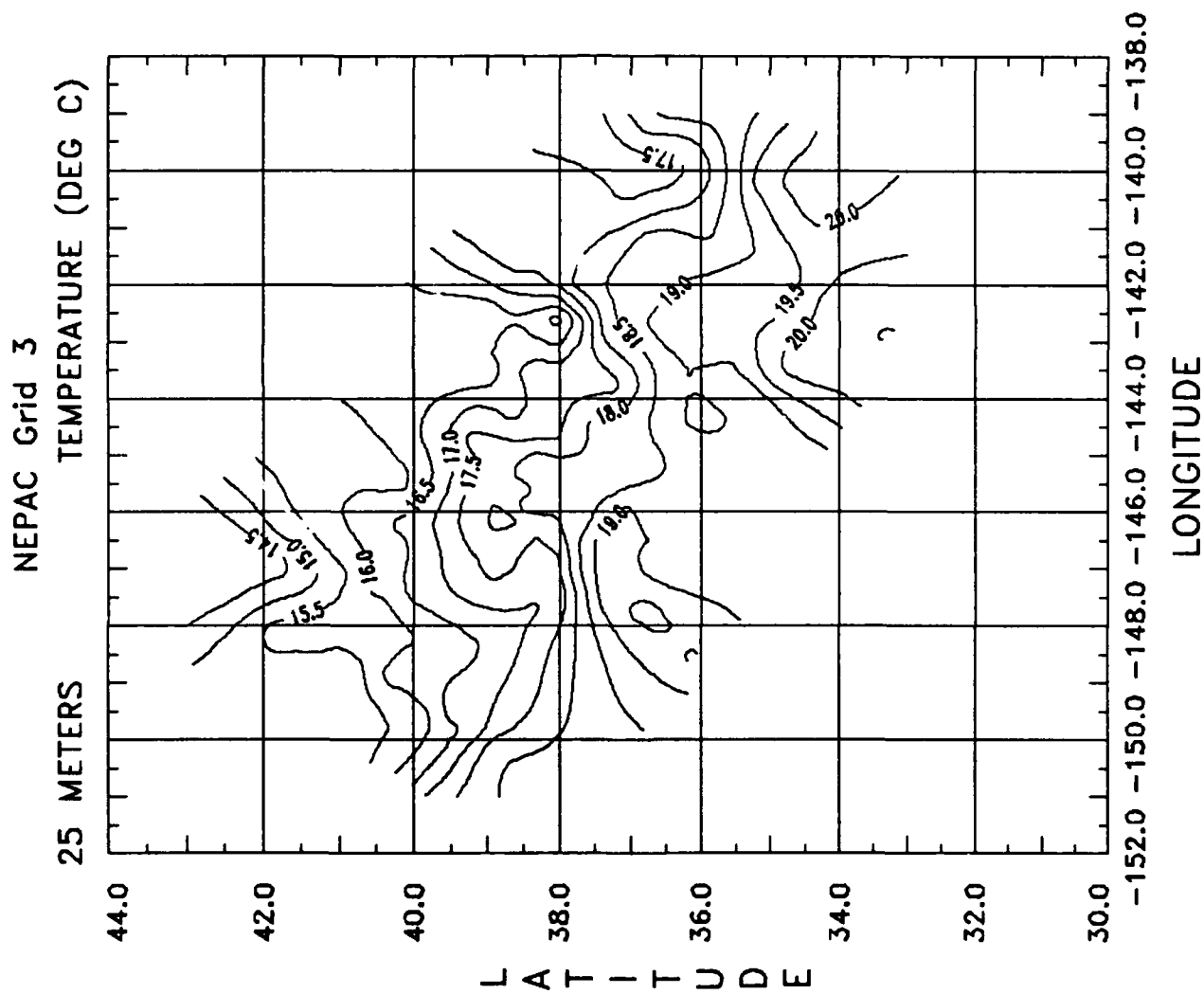
dx=.3, dy=.3



7:54:52

2/12/90

dx=.3 ,dy=.3

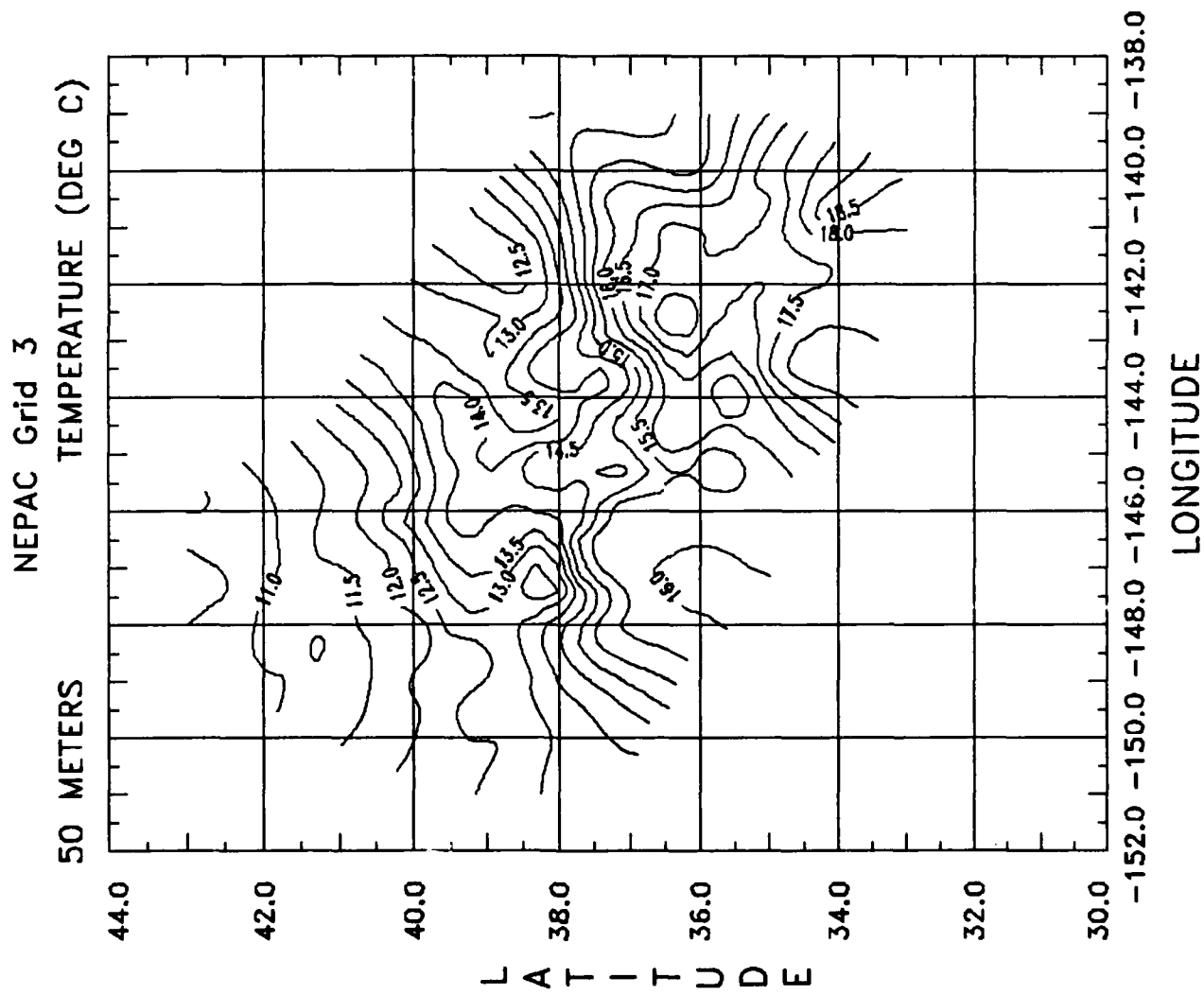


NOARL Code 331

7:55:51

2/12/90

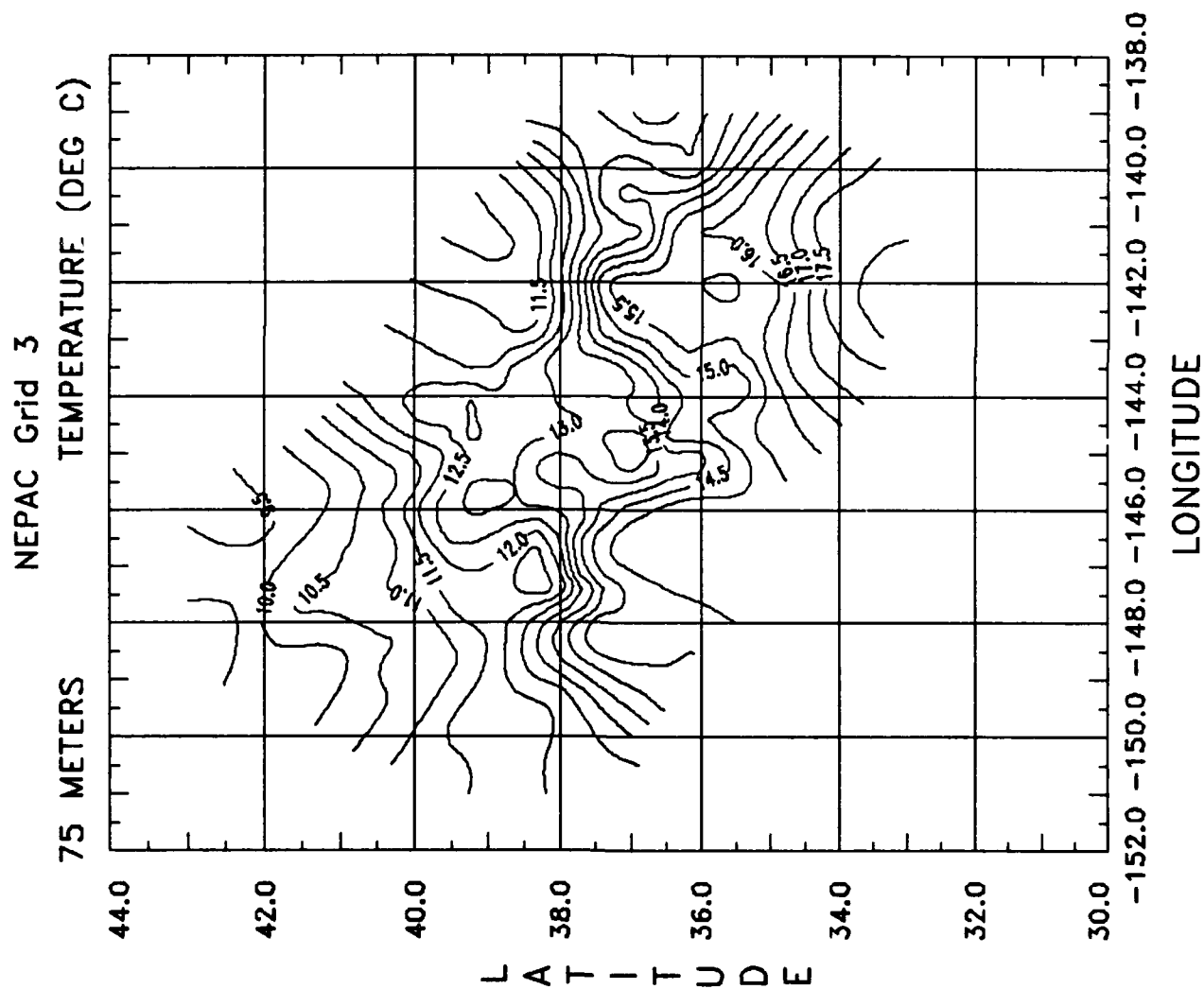
dx=.3 ,dy=.3



7:56:51

2/12/90

dx=.3, dy=.3

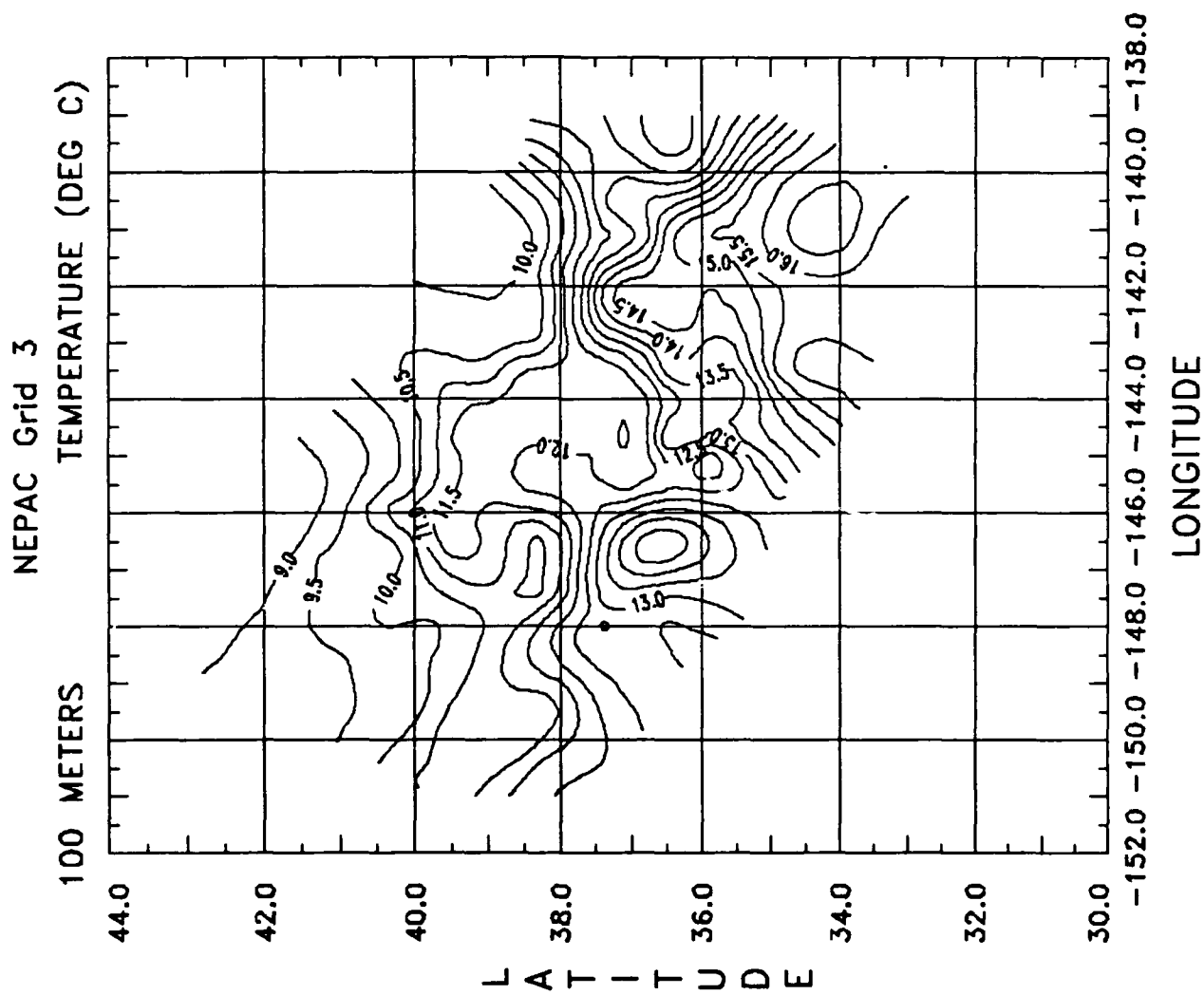


NOARL Code 331

8:15:54

2/12/90

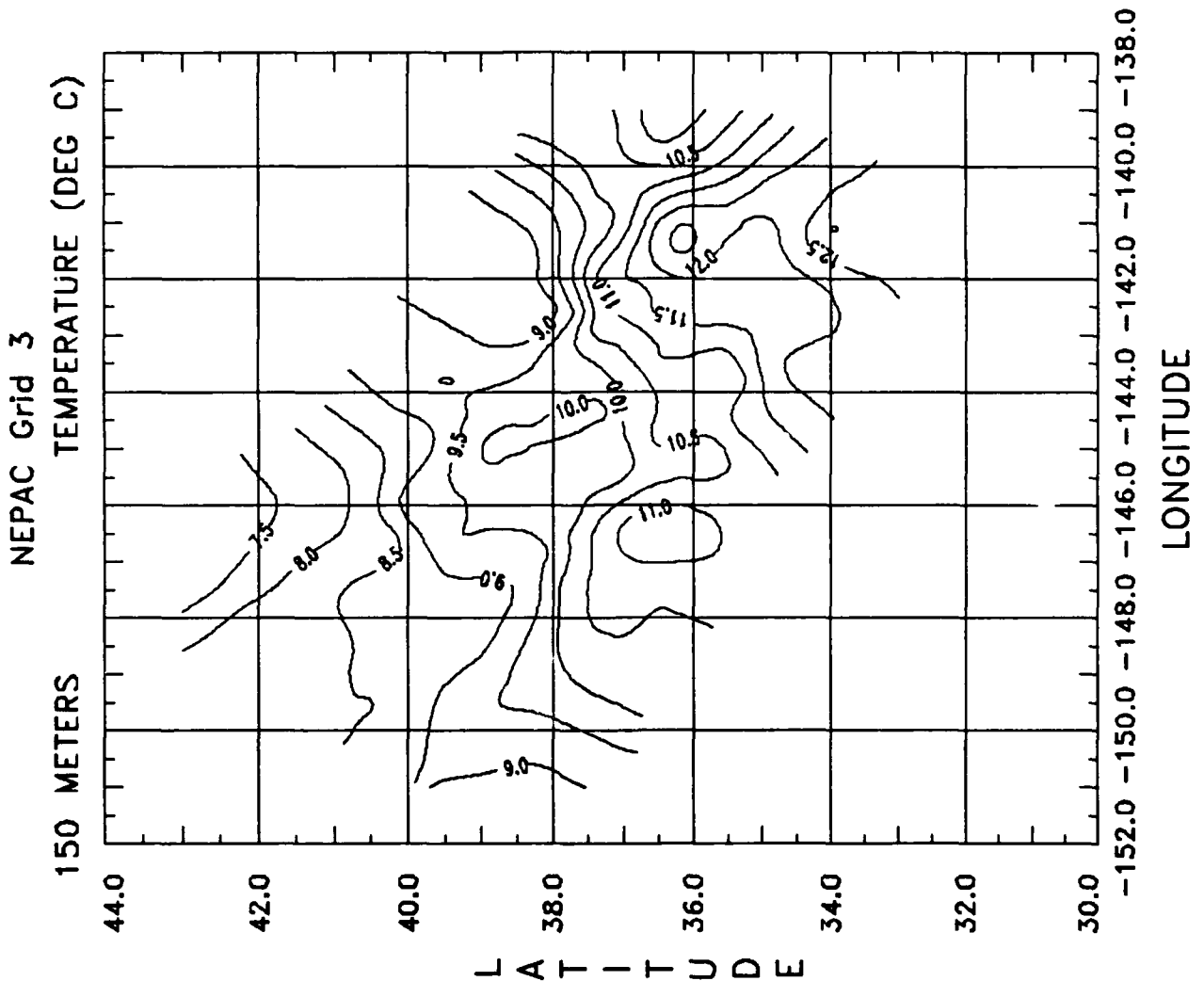
dx=.3, dy=.3



7:59:27

2/12/90

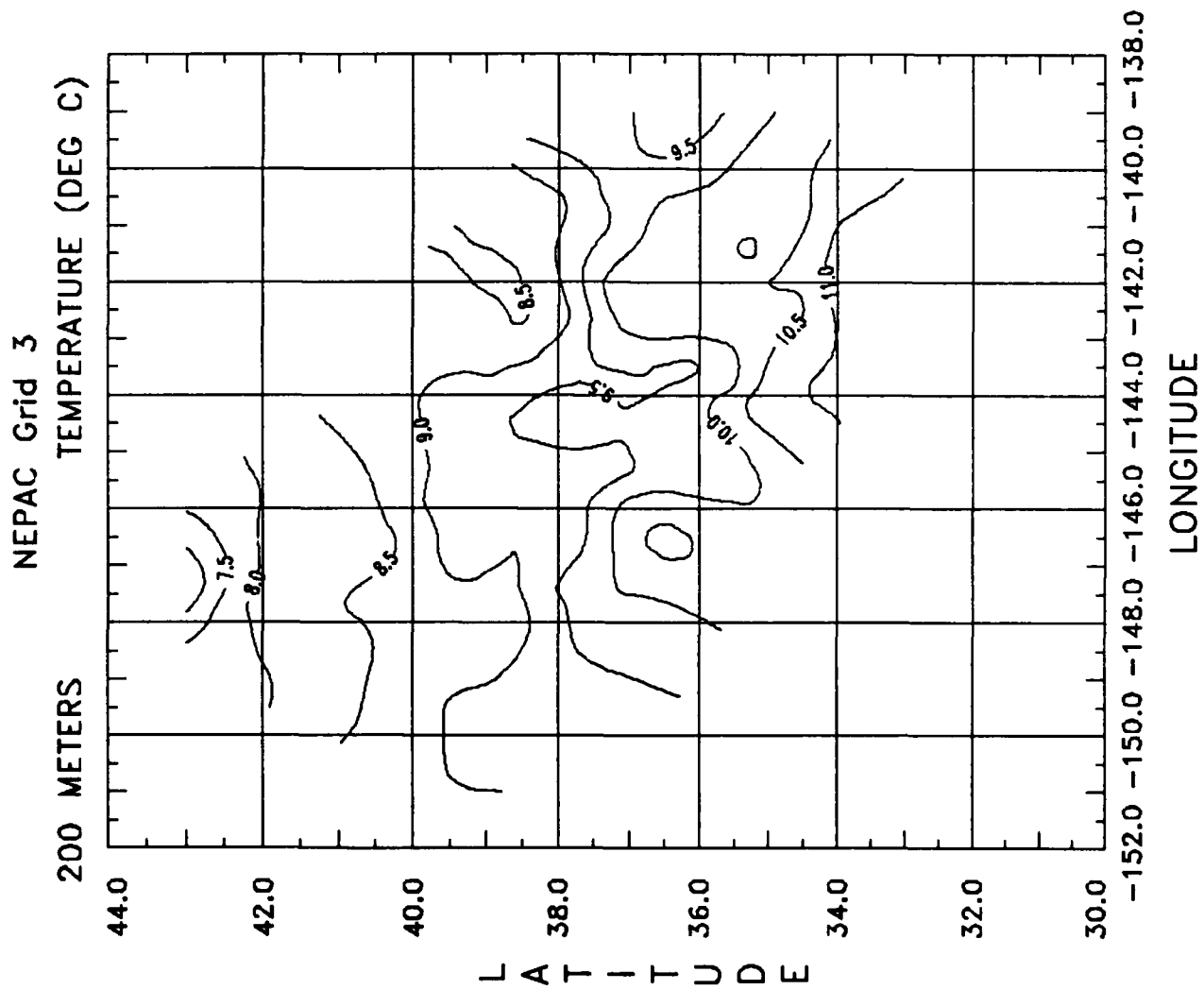
dx=.3, dy=.3



8:00:20

2/12/90

dx=.3 ,dy=.3

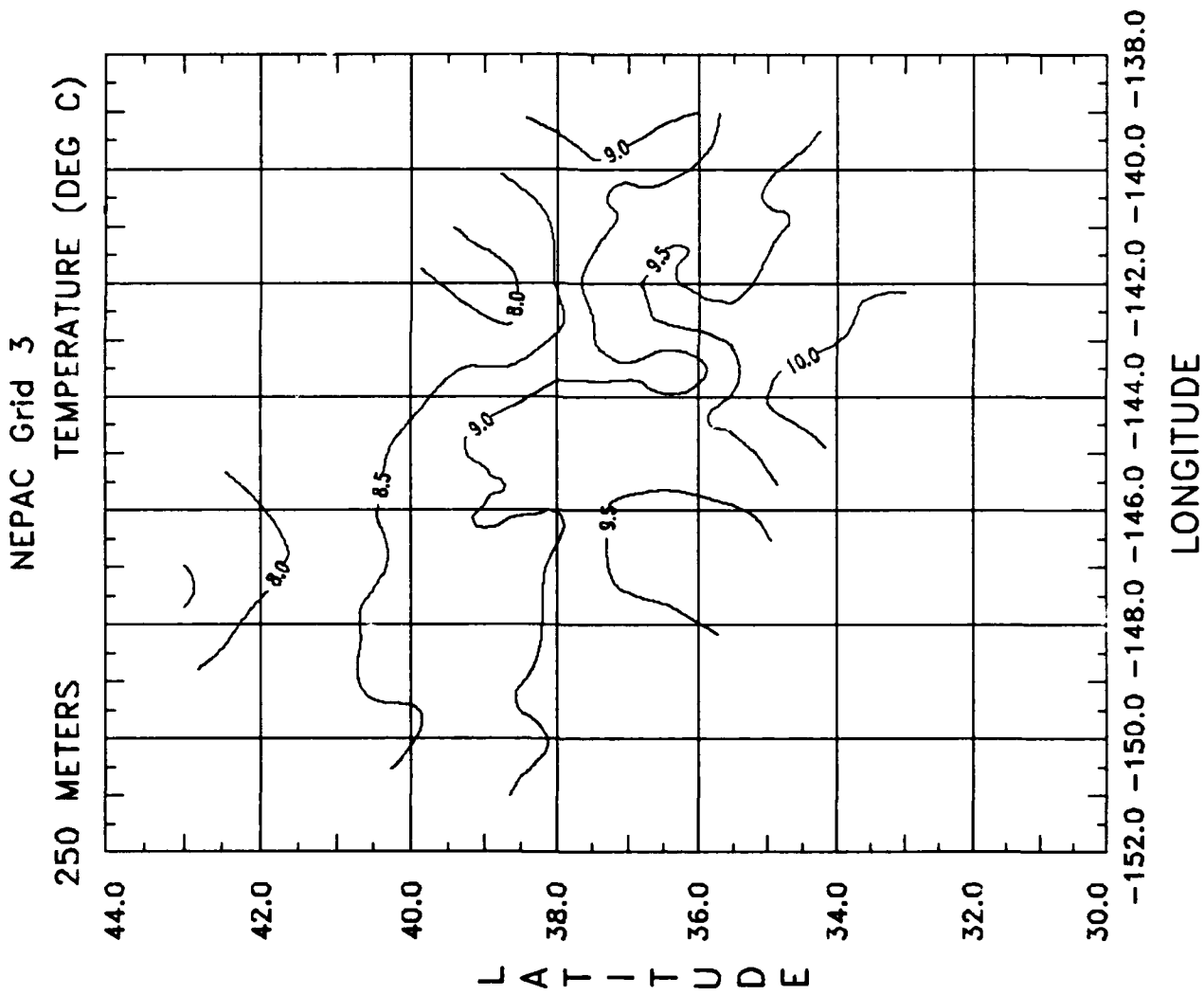


NOARL Code 331

8:01:12

2/12/90

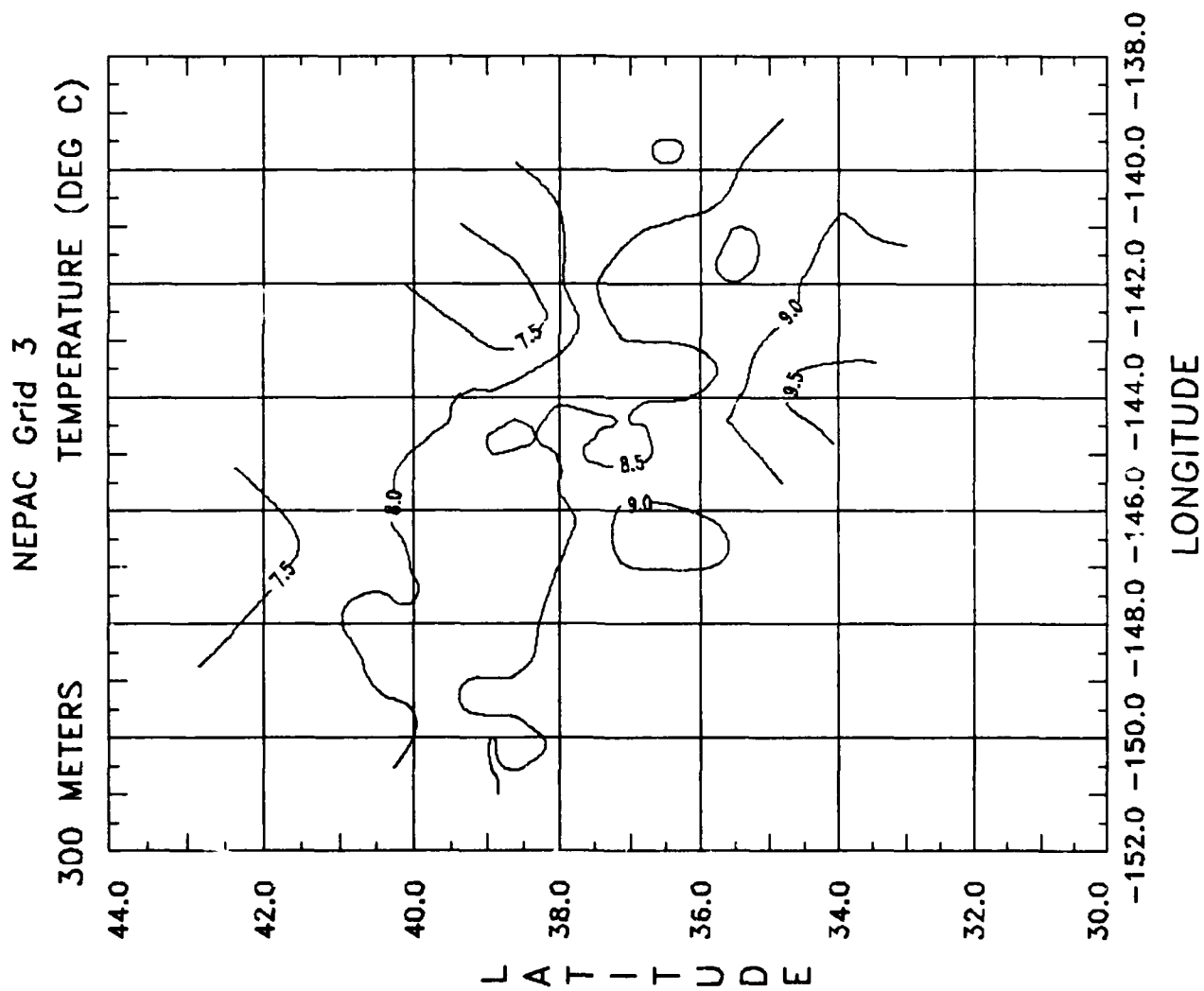
dx=.3 ,dy=.3



8:02:02

2/12/90

dx=.3, dy=.3

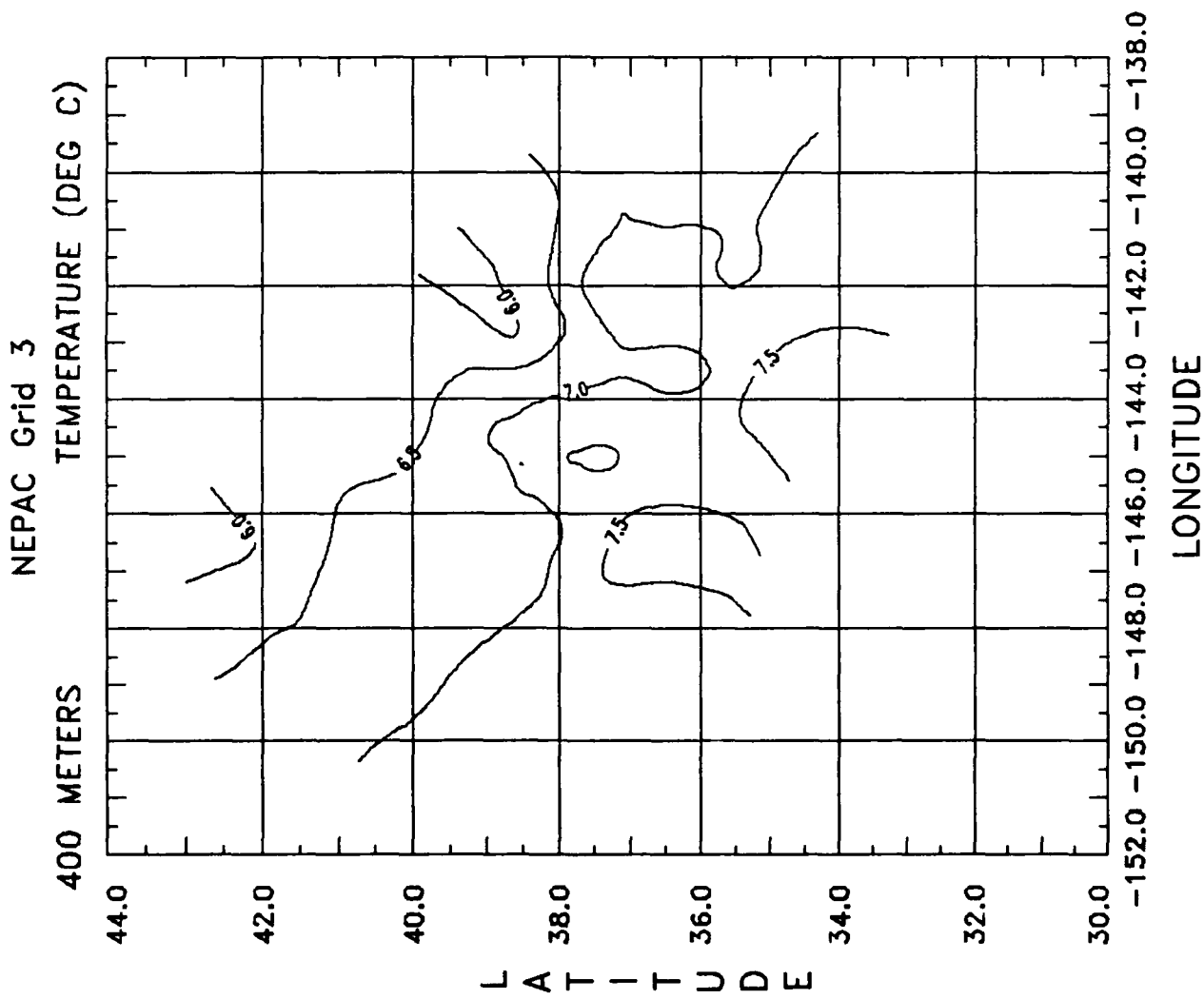


NOARL Code 331

8:02:52

2/12/90

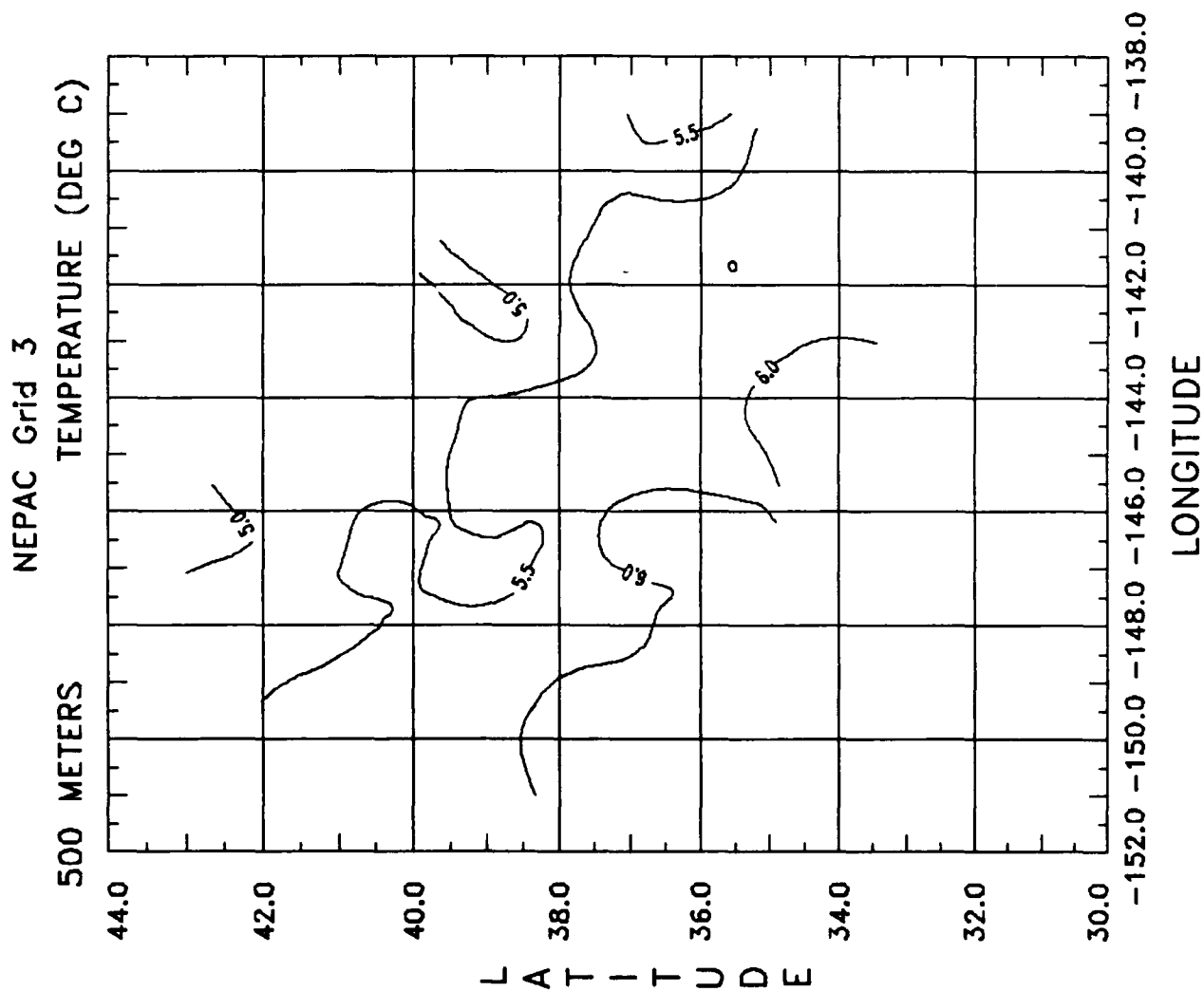
dx=.3 , dy=.3



8:03:41

2/12/90

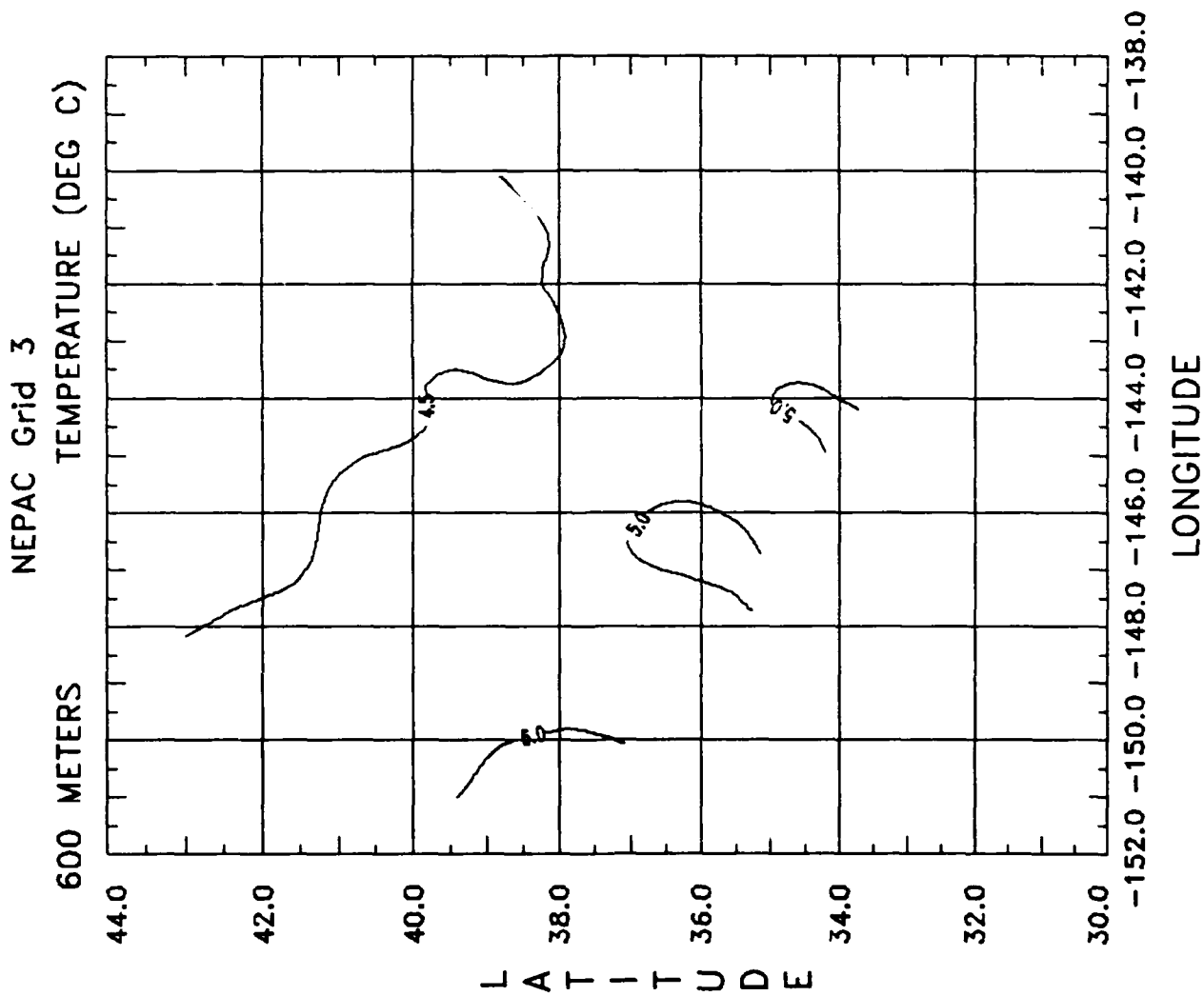
dx=.3, dy=.3



8:04:28

2/12/90

dx=.3, dy=.3

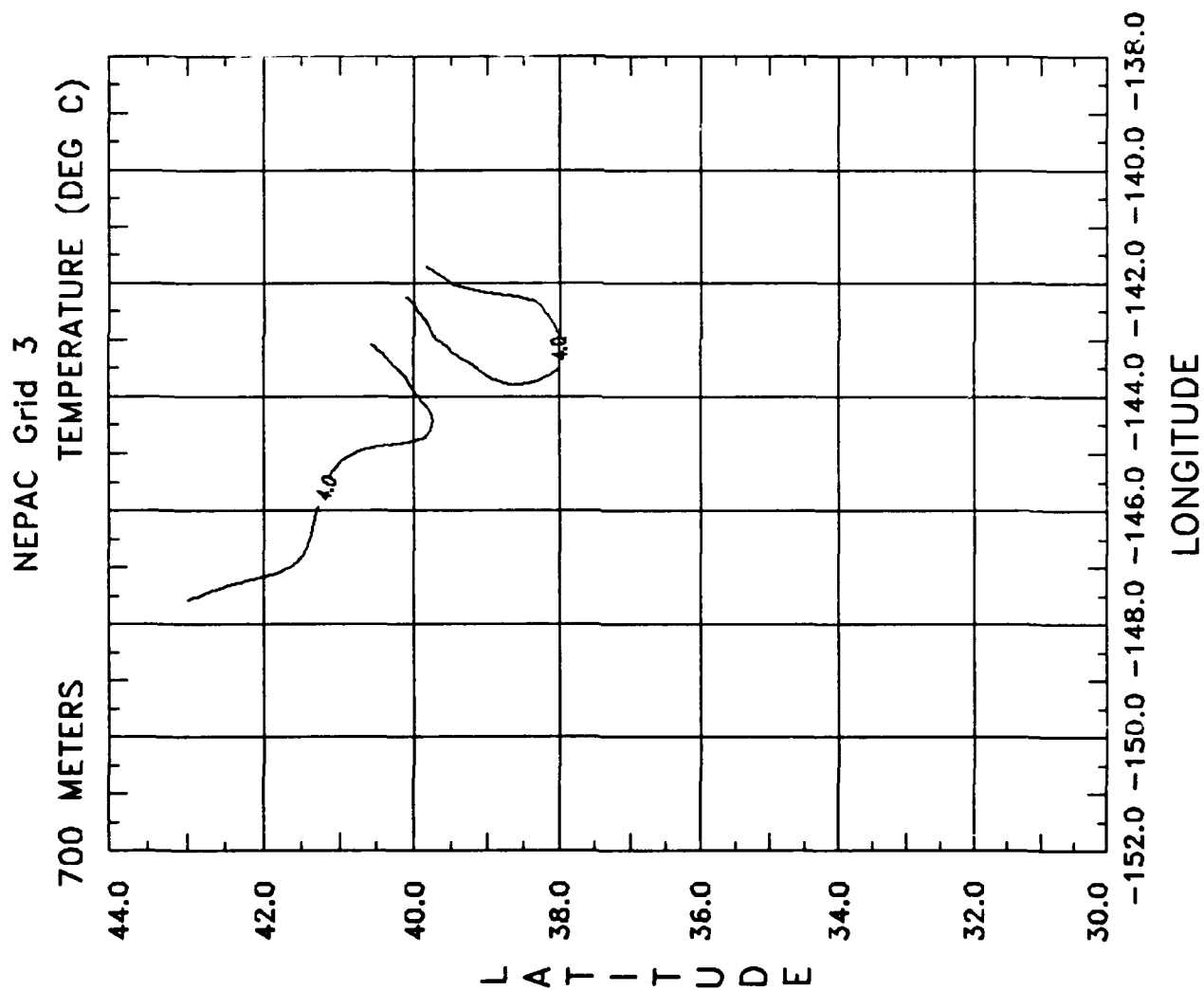


NOARL Code 331

8:05:12

2/12/90

dx=.3, dy=.3



NOARL Code 331

Appendix F.

NEPAC Grid 1 (25 - 28 June 1989)

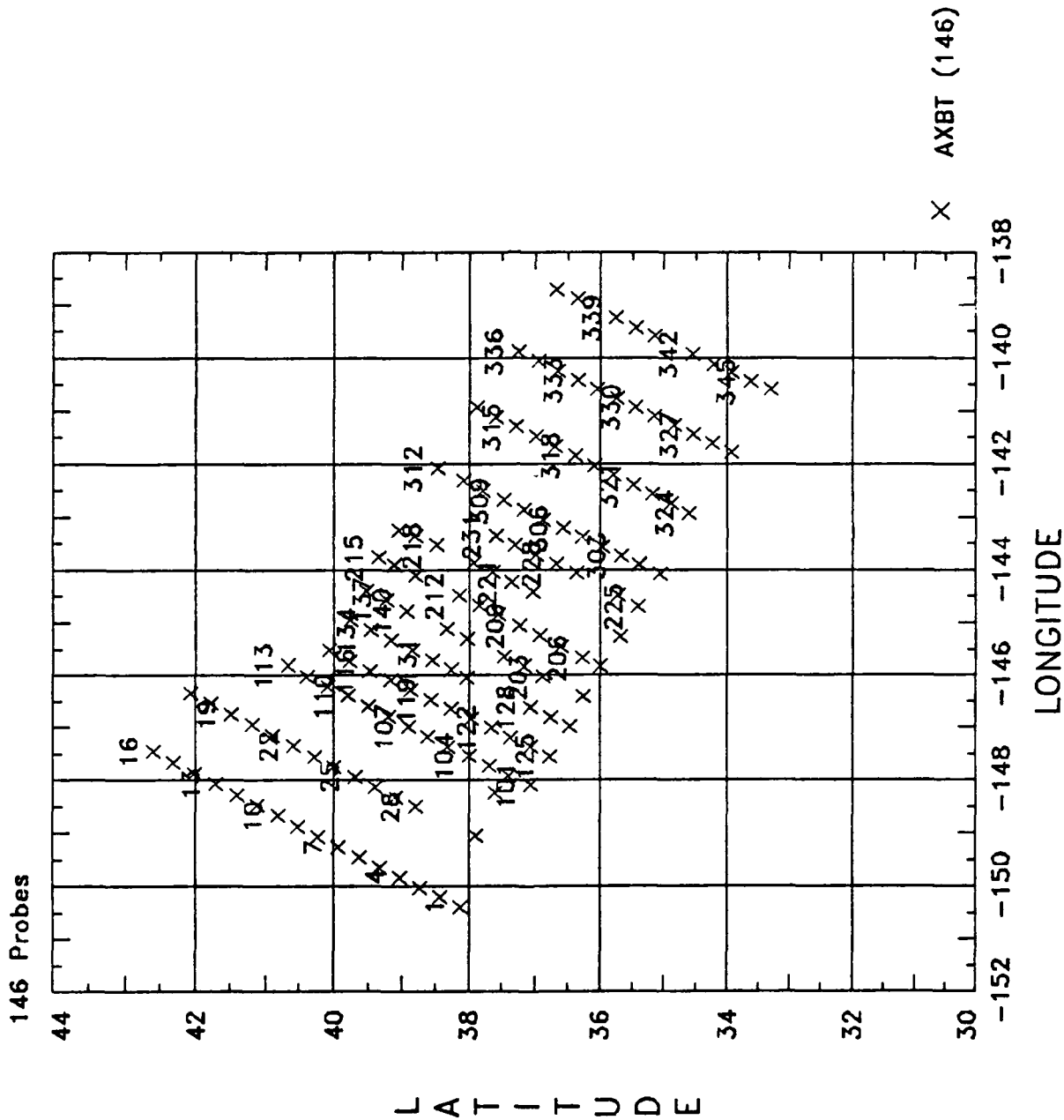
Temperature Contours along Selected Vertical Transects

Surface to 300 m

45:50:57

5/09/90

NEPAC Grid 1 (25-28 June 1989)



Observed Temperatures (deg C)
 GRID 1 TRACK B-a (101-113)

40.75, -145.50

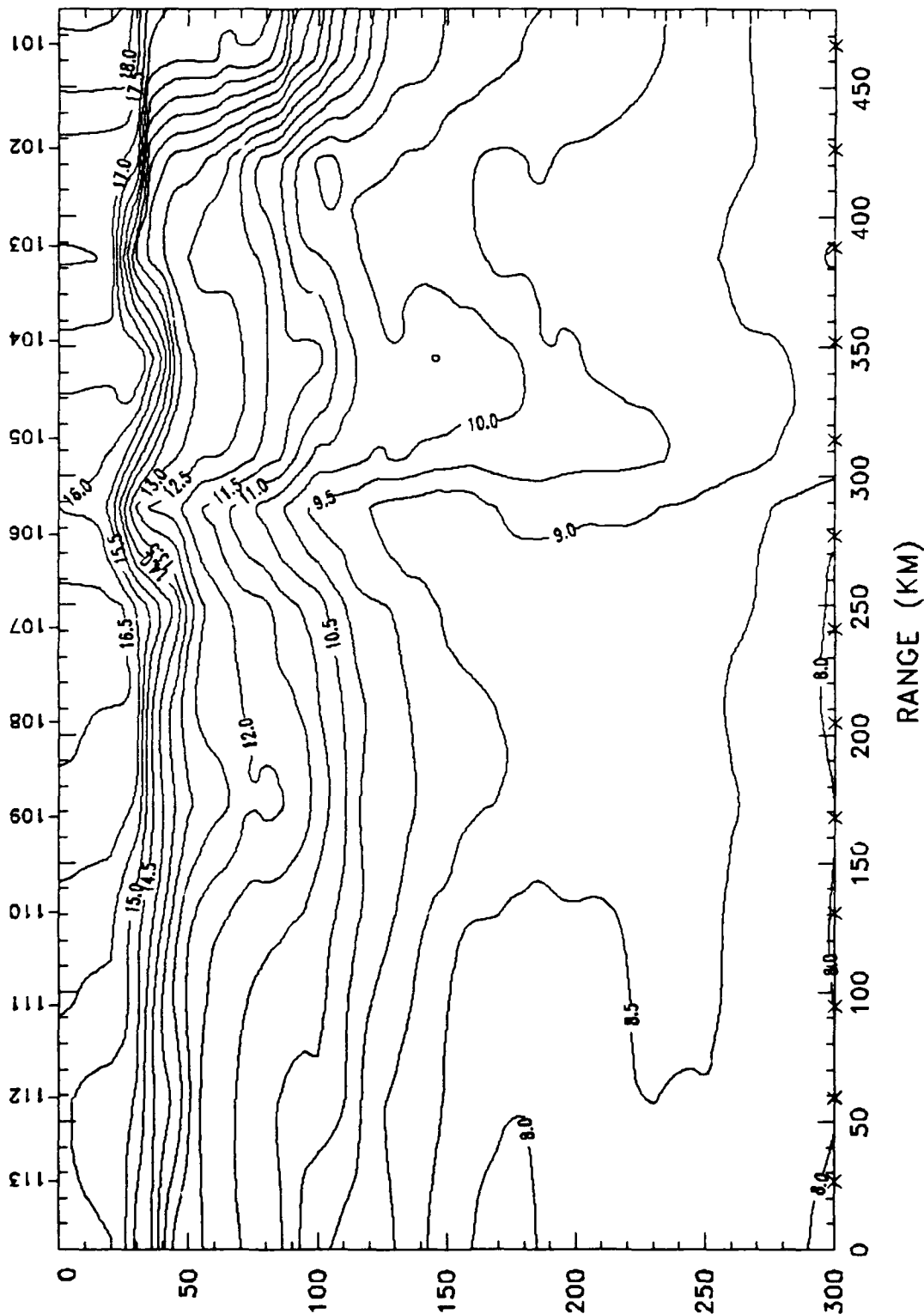
37.00, -148.25

15:07:02

D E P T H M

2/09/90

dx=19, dy= 5



LAT

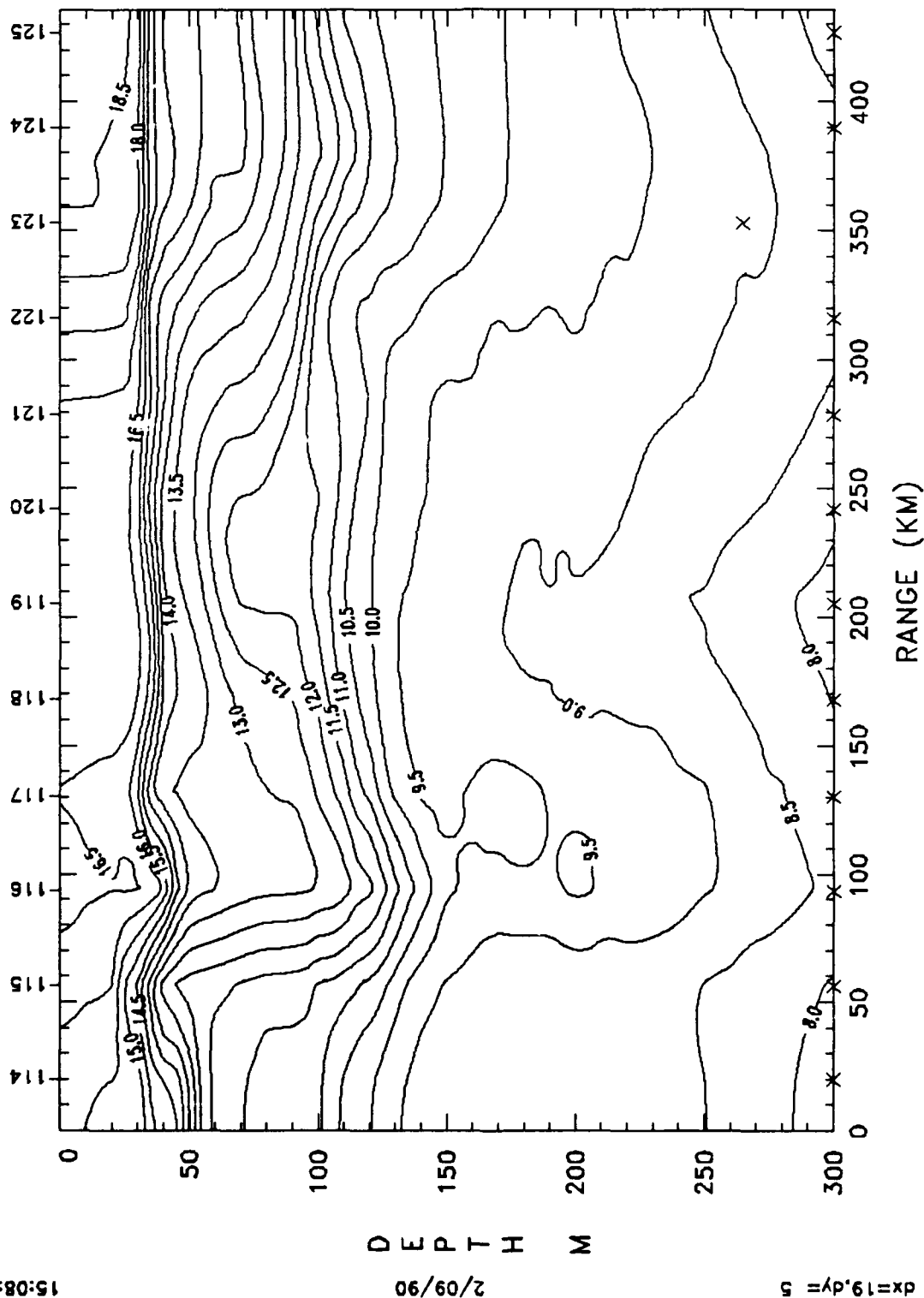
LONG -145.5

NOARL Code 331

Observed Temperatures (deg C)
 GRID 1 TRACK B-b (114-125) 36.75, -147.75

40.25, -145.50

15:08:23



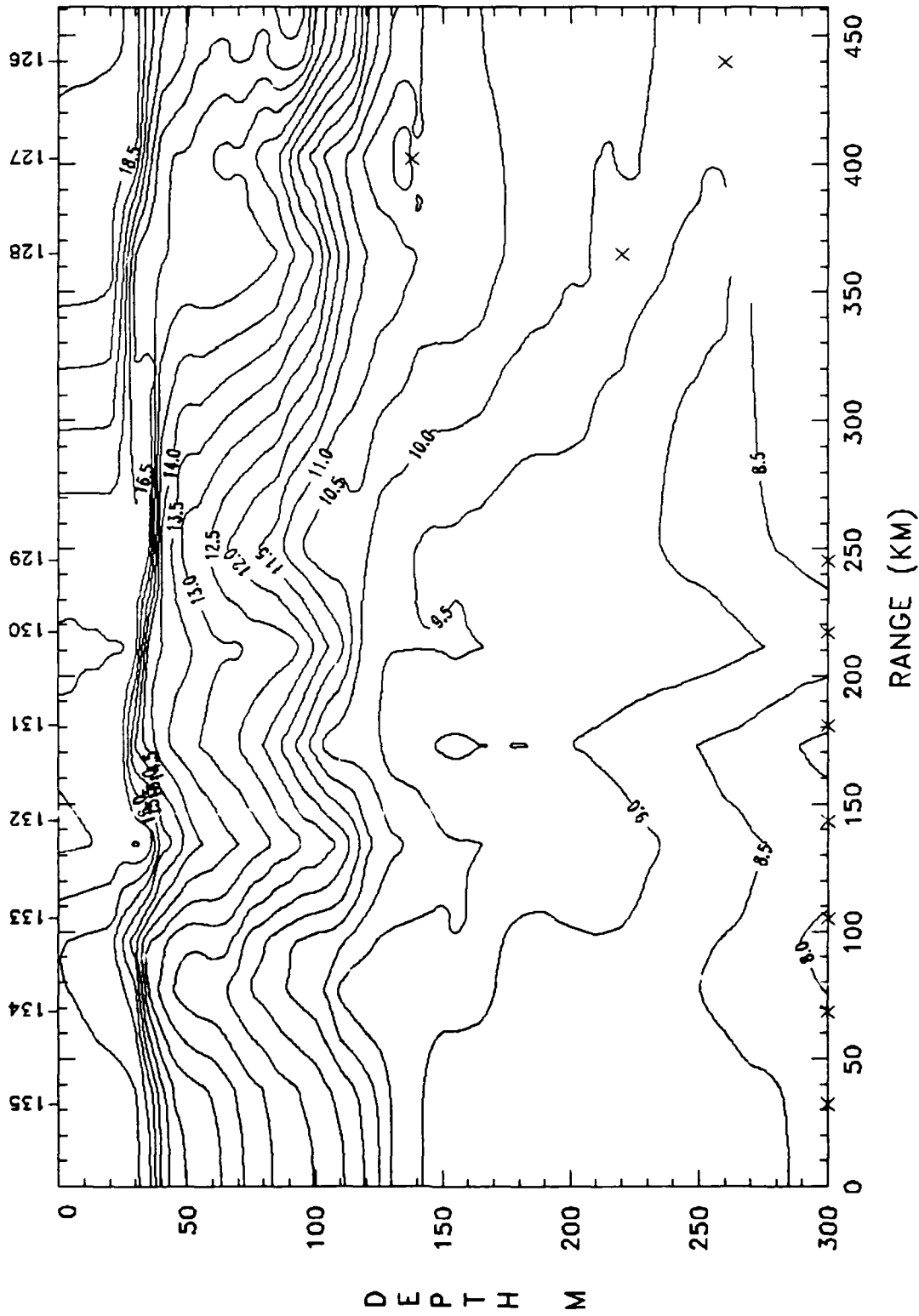
LAT 40.0 39.5 39.0 38.5 38.0 37.5 37.0
 LONG -145.5 -146.0 -146.5 -147.0 -147.5
 NOARL Code 331

DEPTH M

2/09/90

dx=19.4y=5

Observed Temperatures (deg C)
 GRID 1 TRACK B-c (126-135)
 40.00, -144.75 36.25, -147.00



LAT 40.0 39.5 39.0 38.5 38.0 37.5 37.0 36.5
 LONG -145.0 -145.5 -146.0 -146.5 -147.0

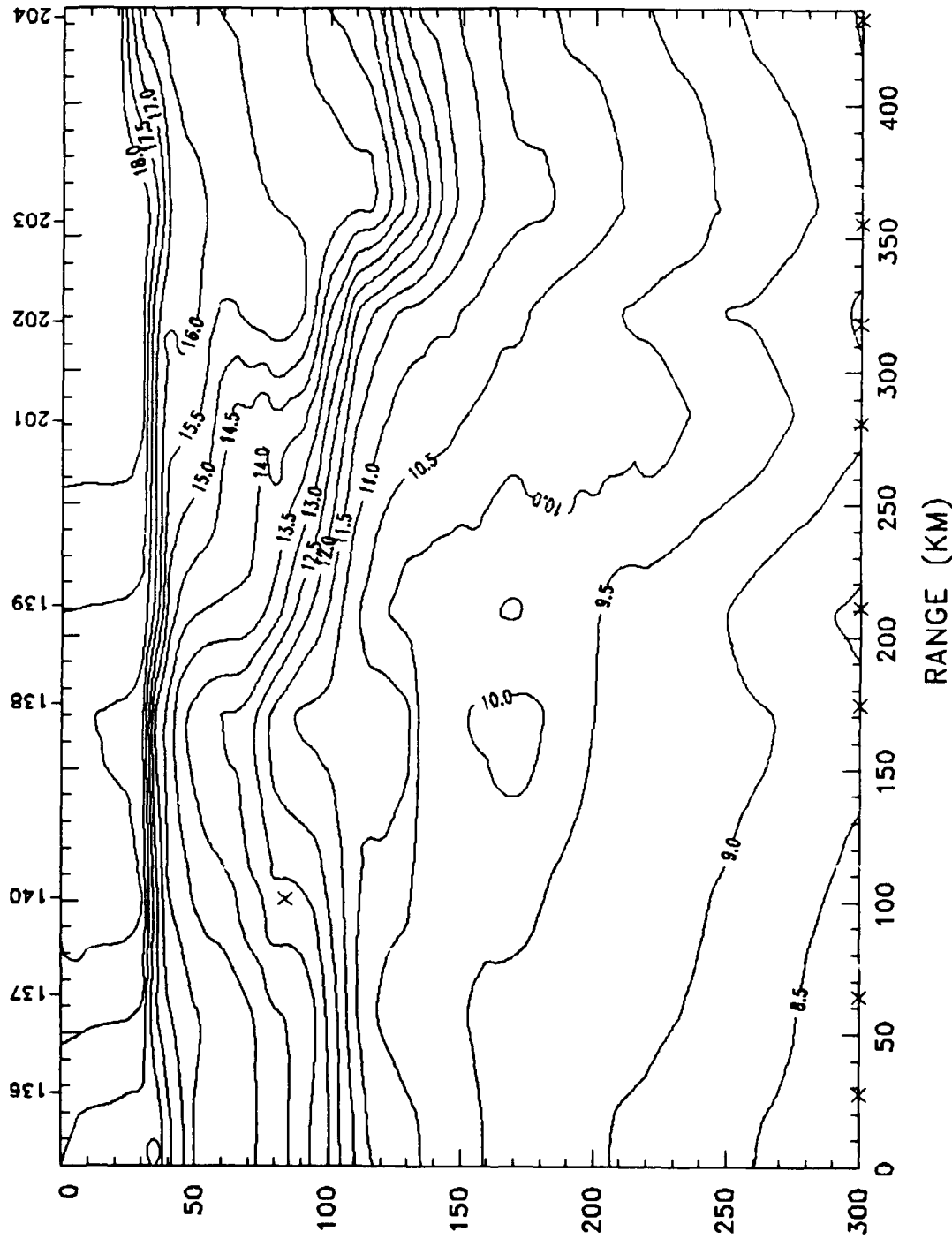
Observed Temperatures (deg C)
 GRID 1 TRACK B-d (136-204)

39.75,-144.25

36.25,-146.50

15:11:19

2/09/90
 DEPTH M



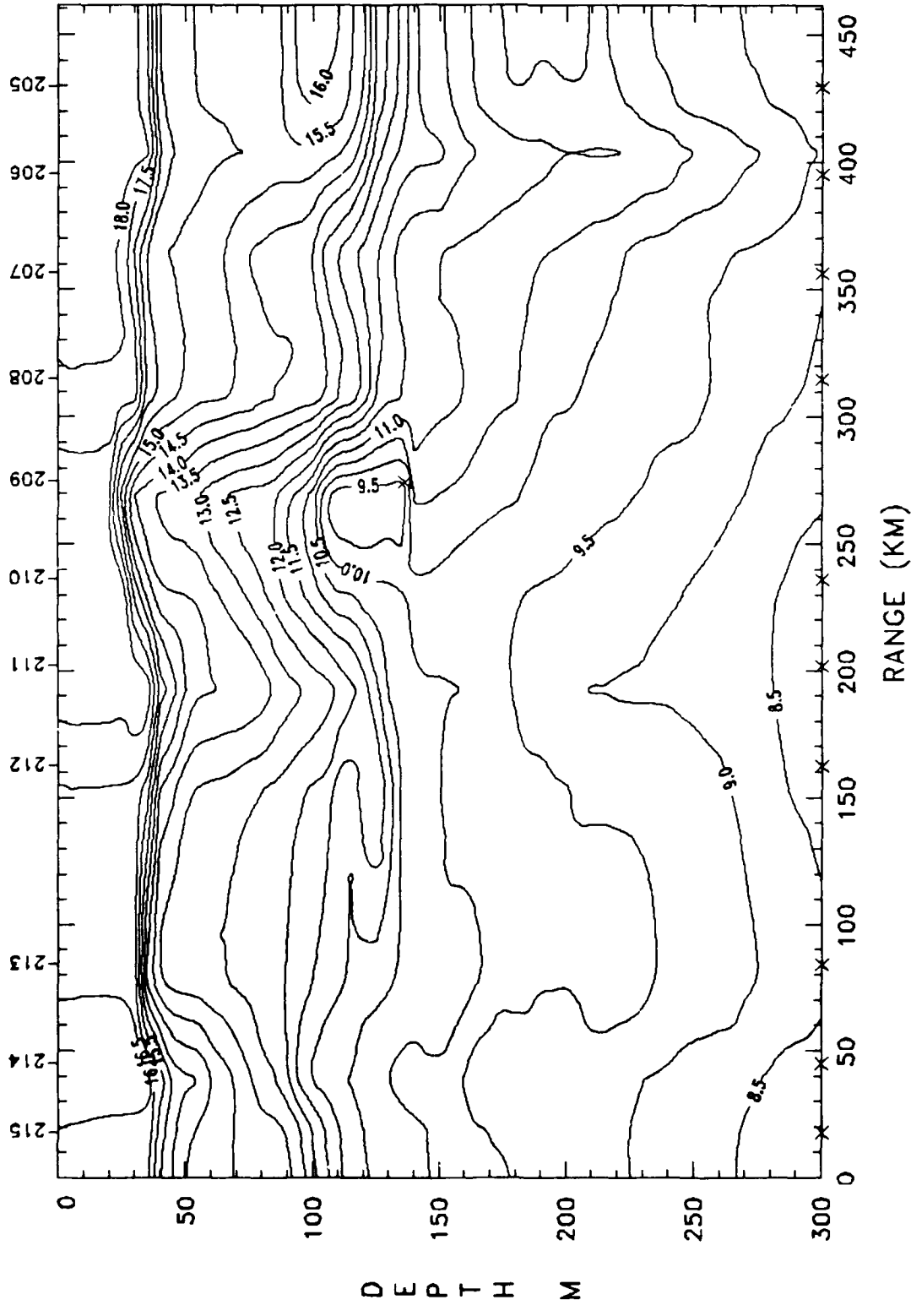
LAT 39.5 39.0 38.5 38.0 37.5 37.0 36.5
 LONG -144.5 -145.0 -145.5 -146.0 -146.5

NOARL Code 331

Observed Temperatures (deg C)
 GRID 1 TRACK C-a (205-215) 35.75, -146.00

39.50, -143.75

15:12:39



LAT 39.5 39.0 38.5 38.0 37.5 37.0 36.5 36.0
 LONG -144.0 -144.5 -145.0 -145.5 -146.0

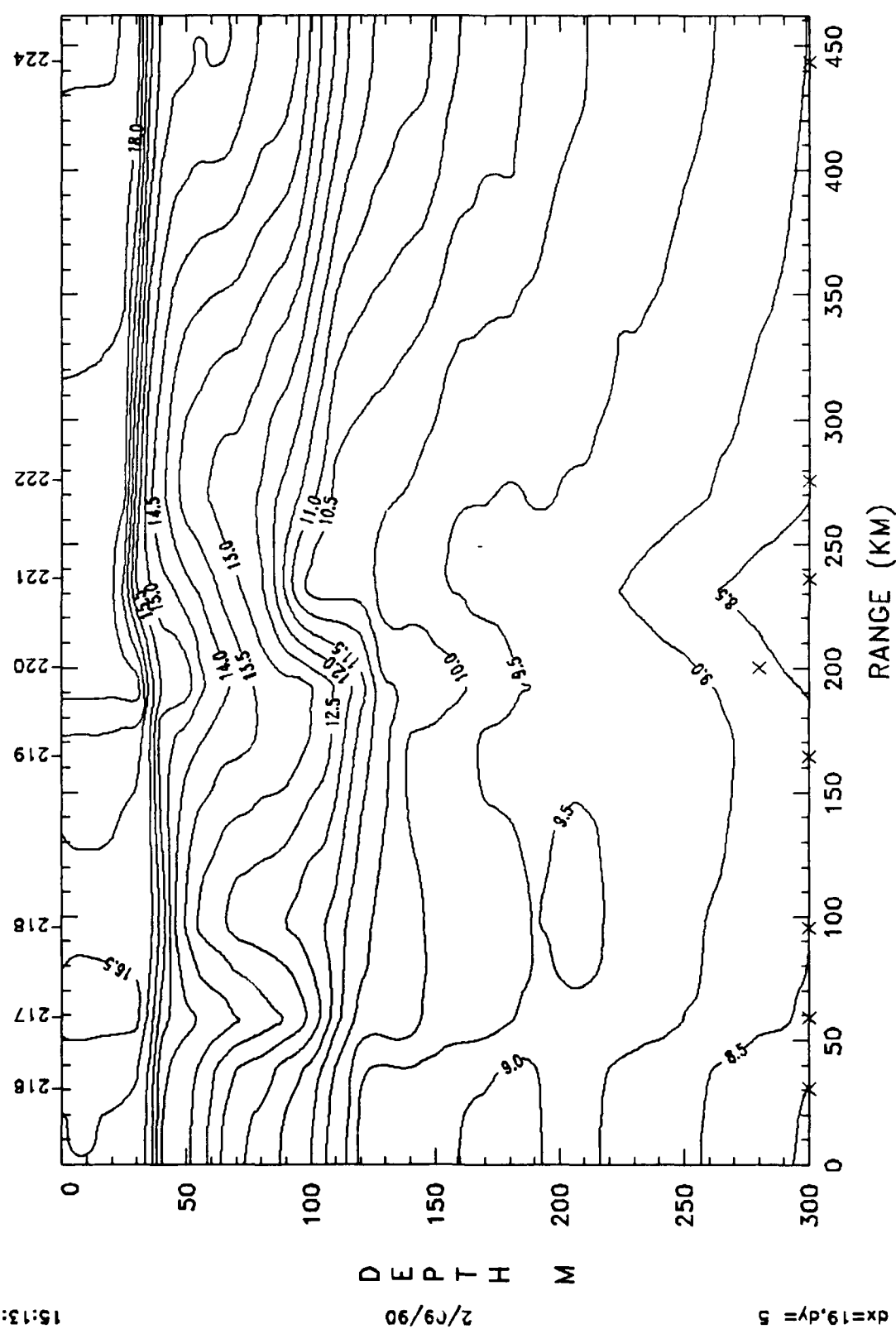
dx=19.dy=5

2/09/90
 DEPTH M

Observed Temperatures (deg C)
 GRID 1 TRACK C-b (216-224) 35.50,-145.25

39.25,-143.00

15:13:59



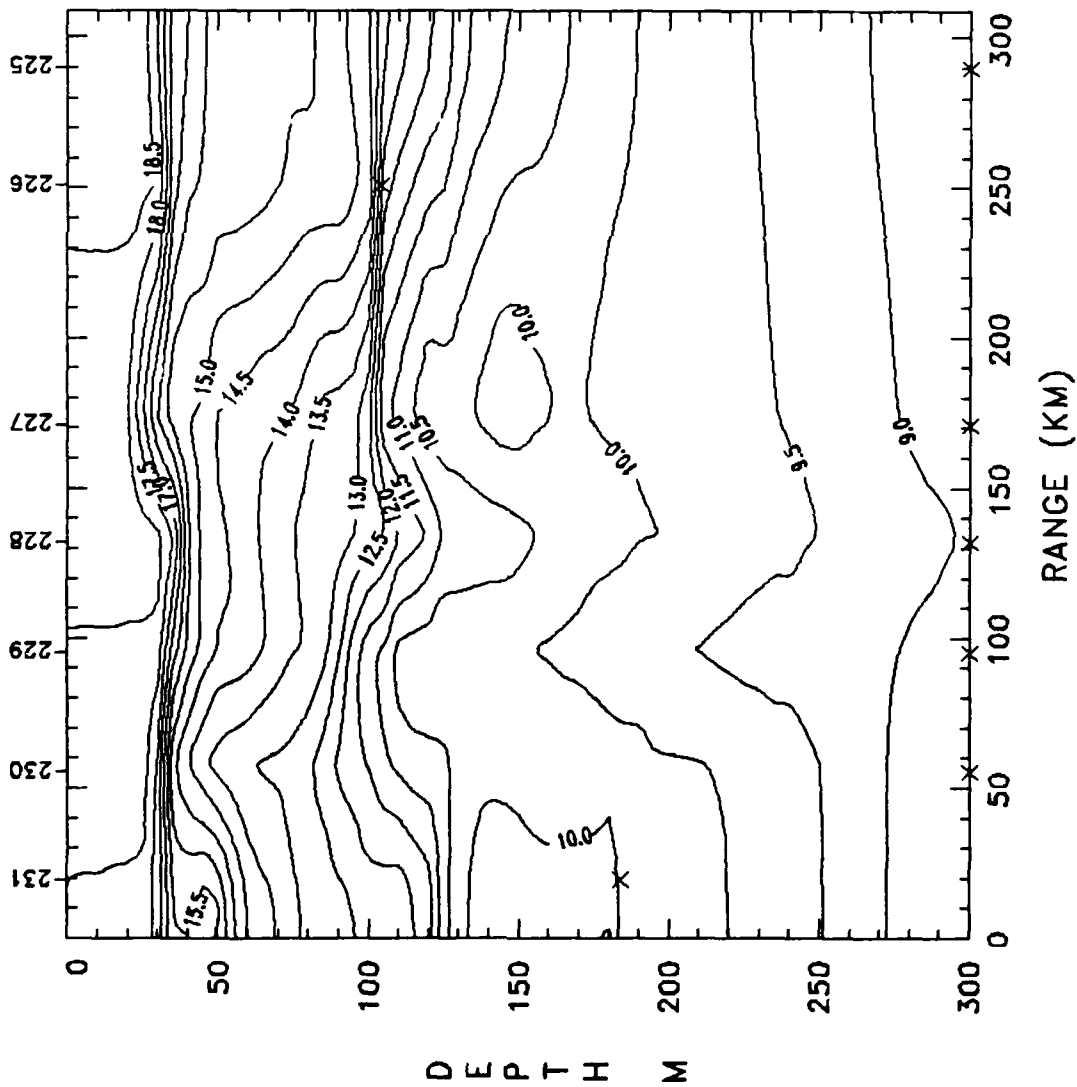
LAT 39.0 39.5
 LONG -143.0 -145.0
 NOARL Code 331

Observed Temperatures (deg C)
 37.75,-143.25 GRID 1 TRACK C-c (225-231) 35.25,-144.75

15:15:12

2/09/90

dx=19,dy=5



LAT 37.5 37.0 36.5 36.0 35.5
 LONG -143.5 -144.0 -144.5

NOA RL Code 331

Observed Temperatures (deg C)
 GRID 1 TRACK D1-a (301-312)

35.00, -144.25

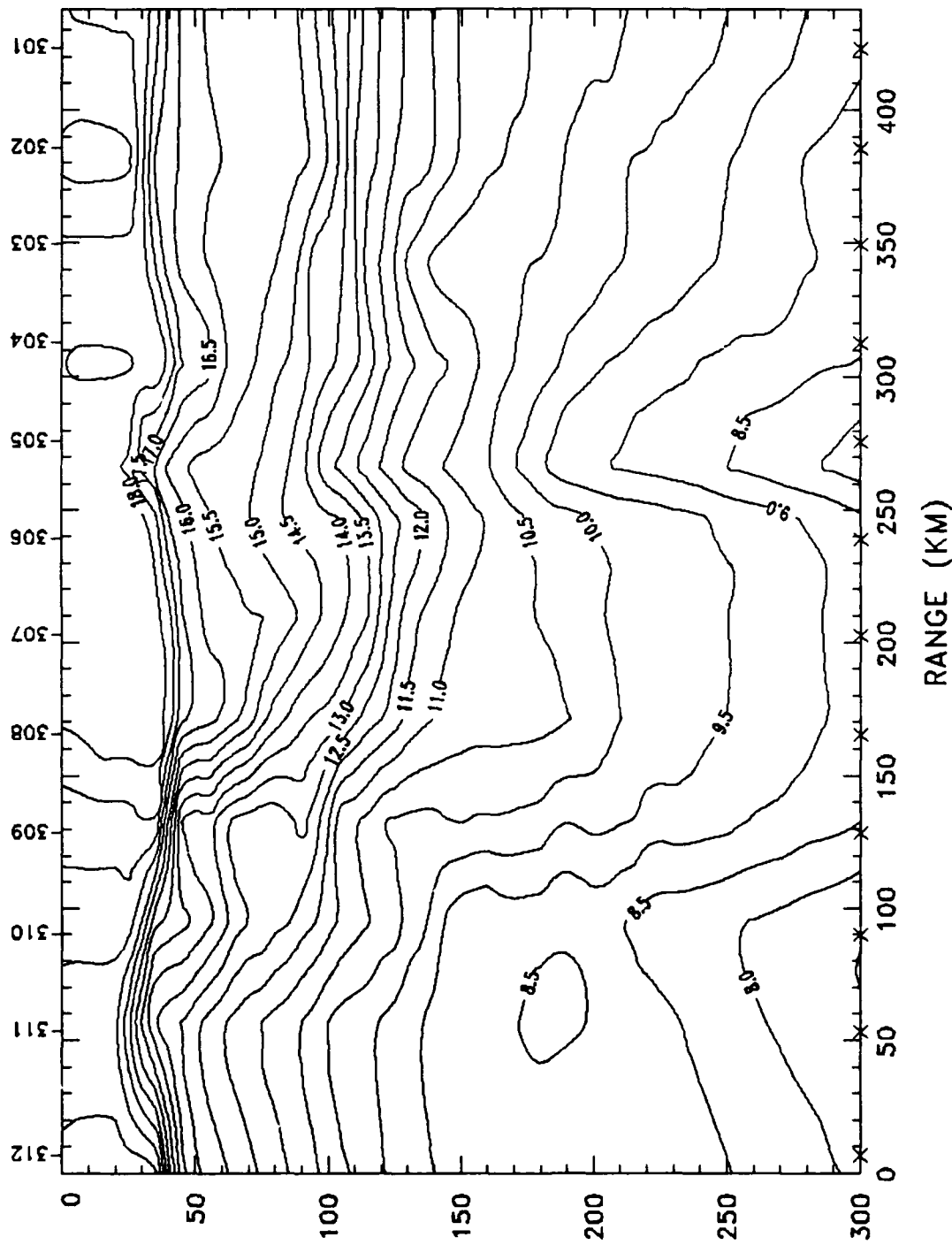
38.50, -142.00

15:16:23

D E P T H M

2/09/90

dx=19, dy=5



LAT 38.5 38.0 37.5 37.0 36.5 36.0 35.5 35.0
 LONG -142.0 -142.5 -143.0 -143.5 -144.0

NOARL Code 331

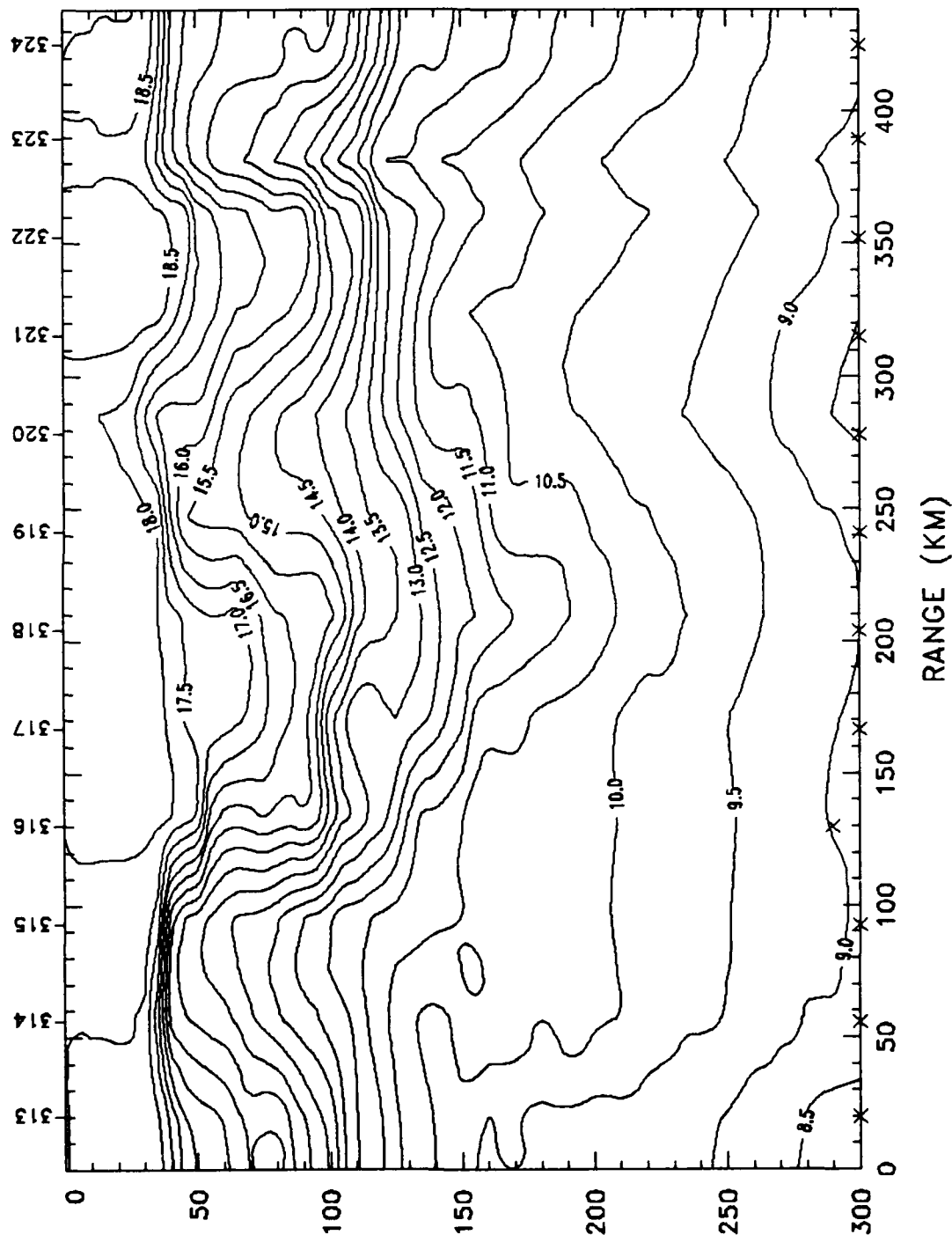
Observed Temperatures (deg C)
 GRID 1 TRACK D1-b (313-324)
 38.00,-140.75 34.50,-143.00

15:17:45

DEPTH M

2/09/90

dx=19,dy=5



LAT 38.0 37.5 37.0 36.5 36.0 35.5 35.0 34.5
 LONG -141.0 -141.5 -142.0 -142.5 -143.0

NOARL Code 331

Observed Temperatures (deg C)
 GRID 1 TRACK D1-c (325-336) 33.75,-142.00

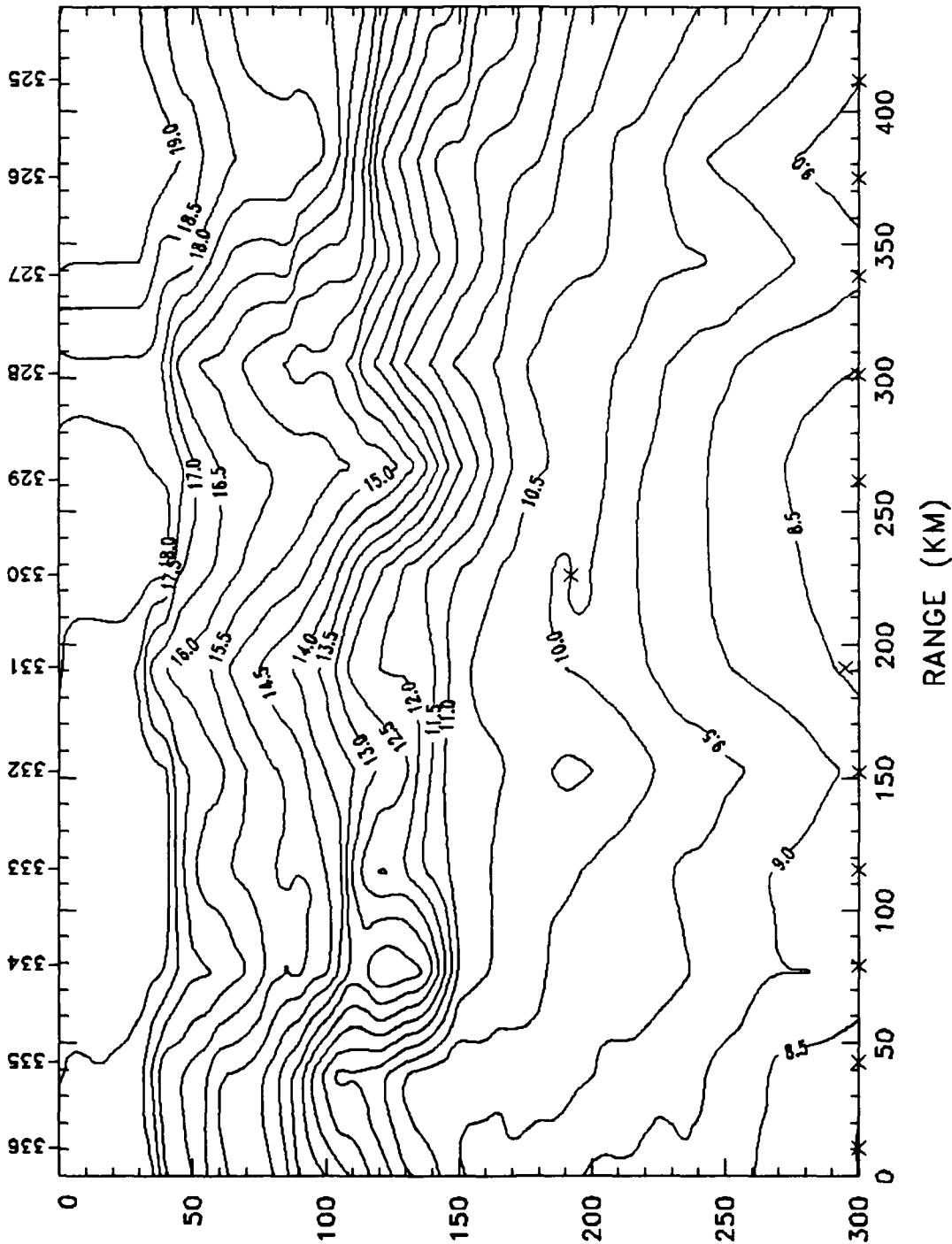
37.25,-139.75

15:19:08

DEPTH M

2/09/90

dx=19,dy=5



LAT 37.0 36.5 36.0 35.5 35.0 34.5 34.0
 LONG -140.0 -140.5 -141.0 -141.5 -142.0

NOARL Code 331

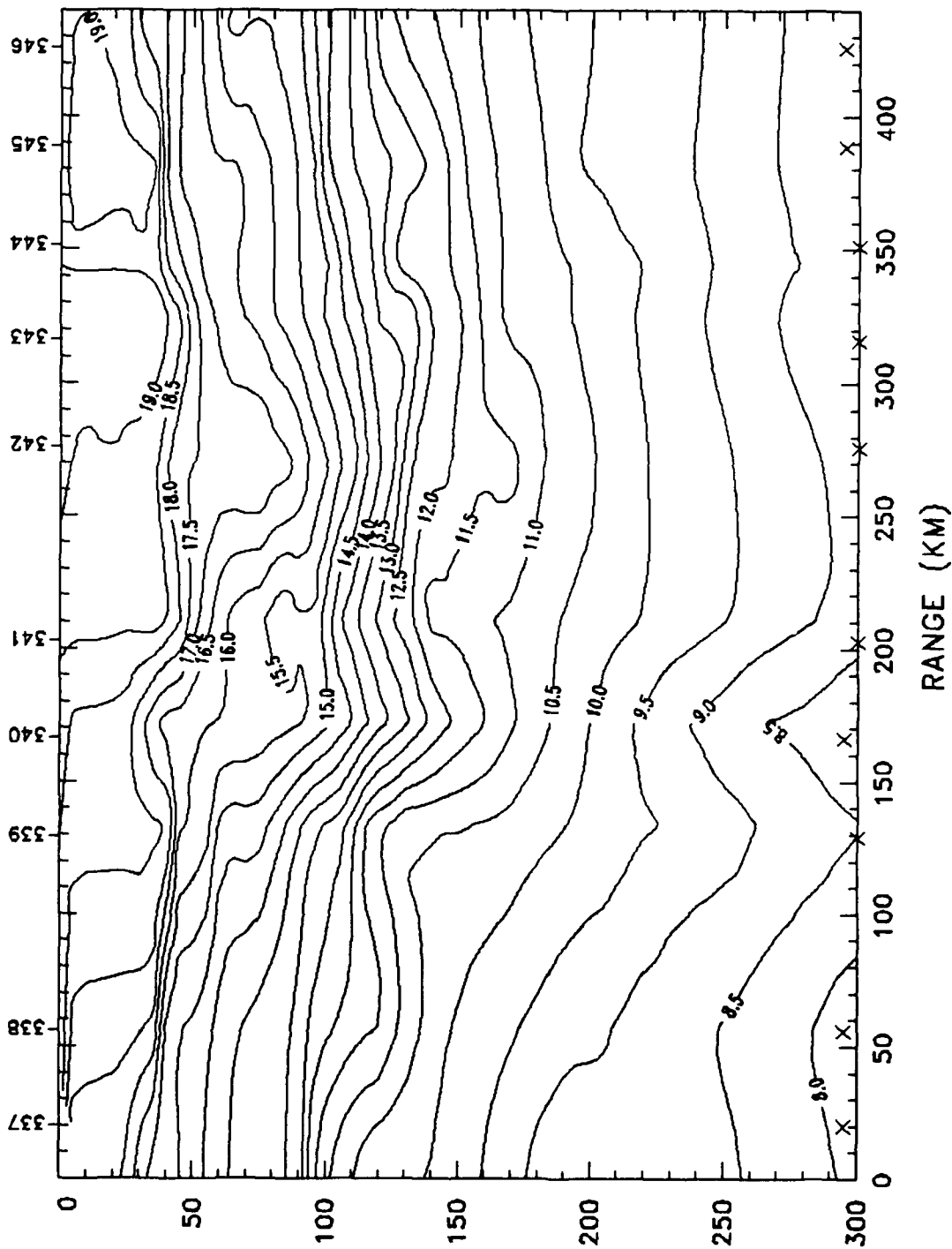
Observed Temperatures (deg C)
 GRID 1 TRACK D1-d (337-346)

36.75, -138.50 33.25, -140.75

15:20:29

2/09/90
 DEPT H M

dx=19,dy=5



LAT 36.5 36.0 35.5 35.0 34.5 34.0 33.5
 LONG -138.5 -139.0 -139.5 -140.0 -140.5

Appendix G

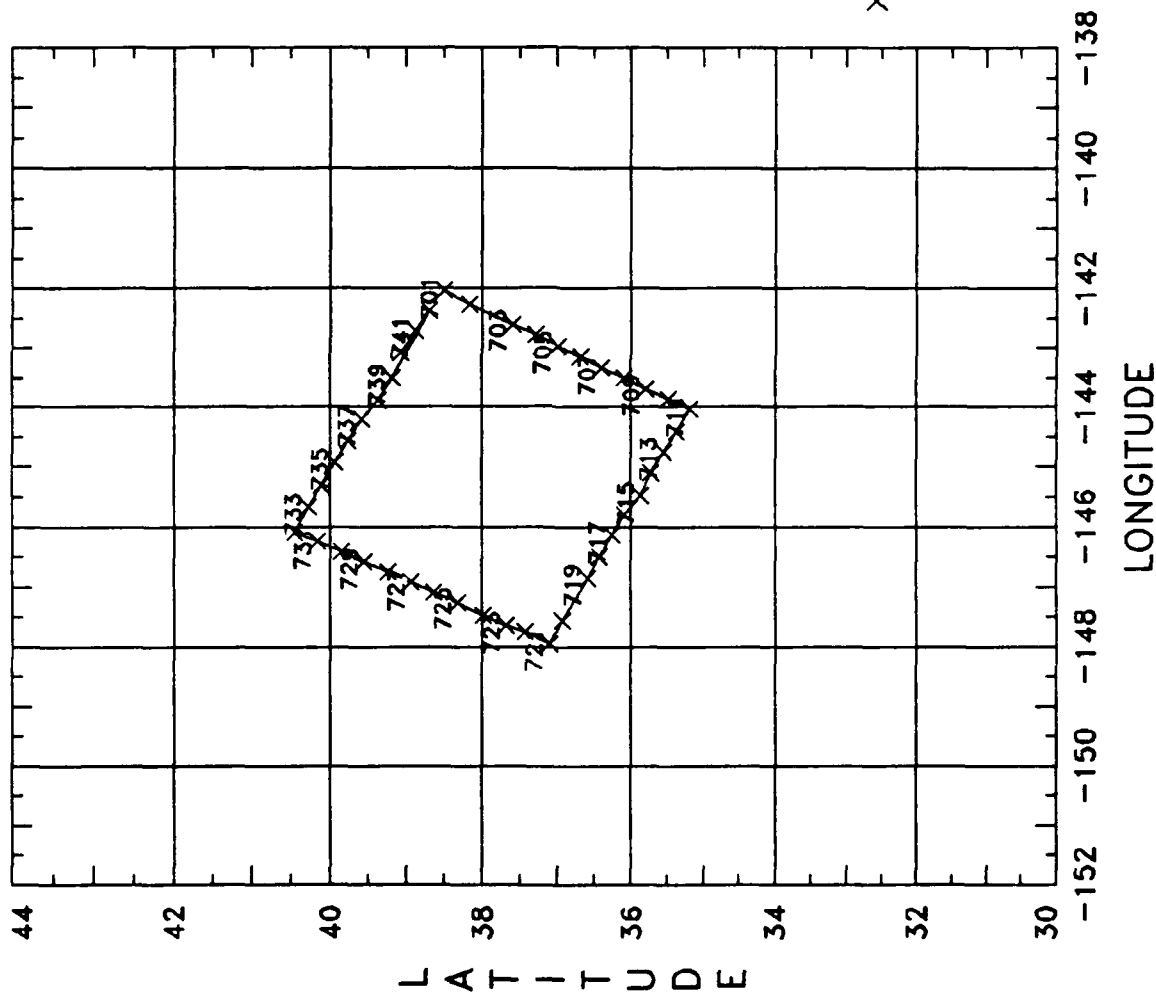
NEPAC Boundary Flight 1 (30 June 1989)

Vertical Temperature Contours along All 4 Sides

Surface to 300 m

NEPAC Boundary 1

42 Probes

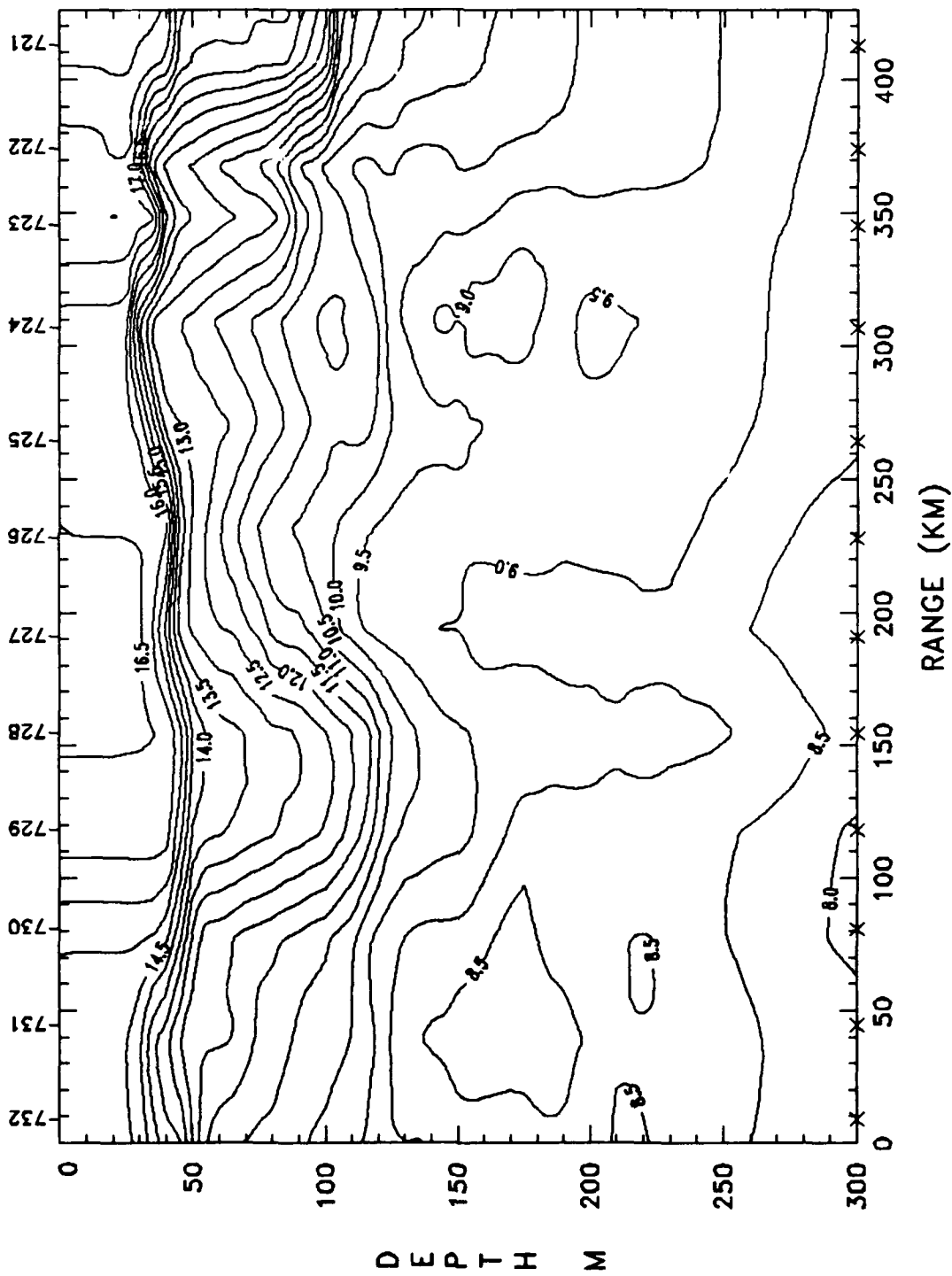


NOARL Code 331

Observed Temperatures (deg C)
 BNDRY #1 TRACK BN-a (721-732) 37.00,-148.00

40.50,-146.00

16:03:42



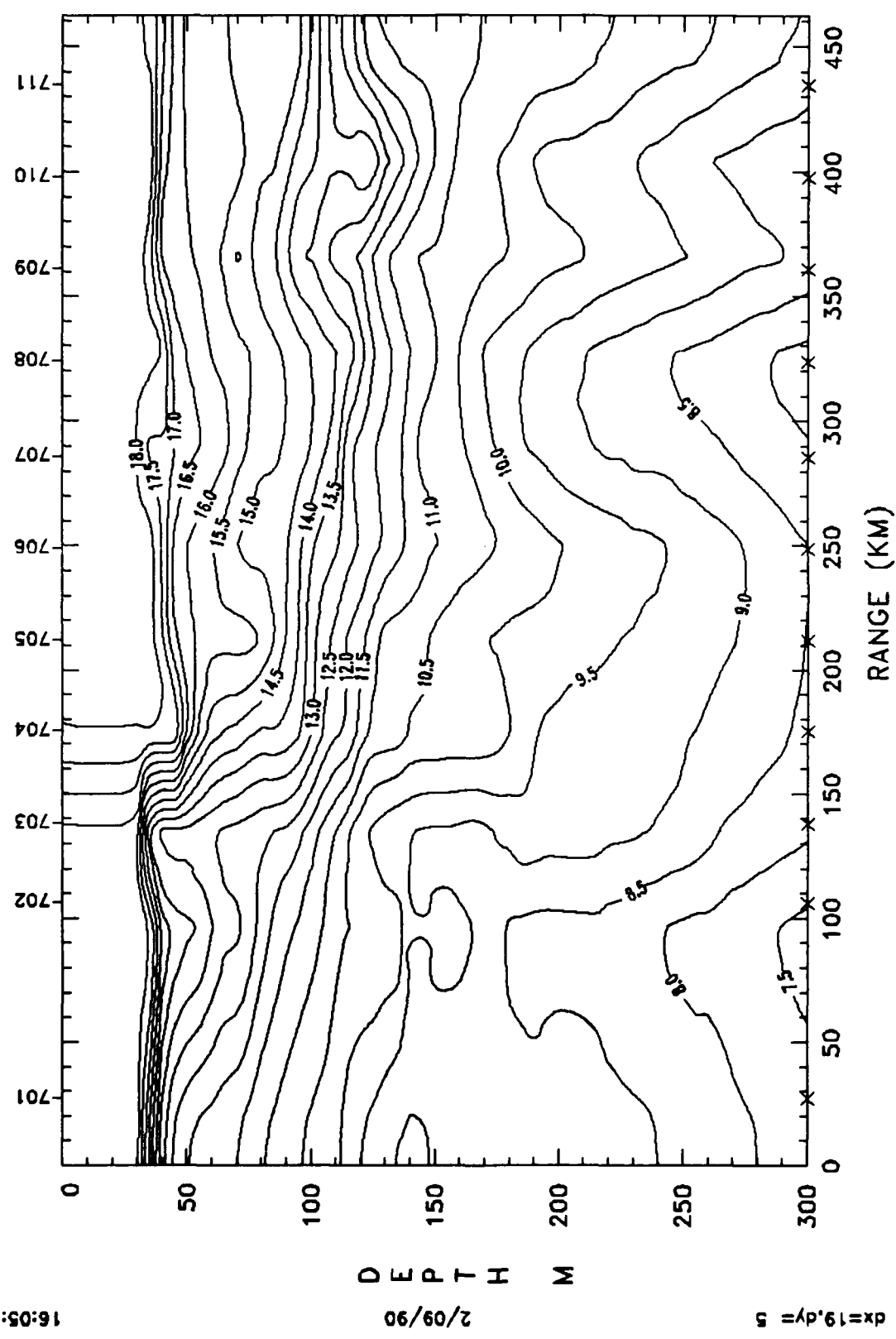
LAT 40.5 40.0 39.5 39.0 38.5 38.0 37.5 37.0
 LONG -146.0 -146.5 -147.0 -147.5 -148.0

NOARL Code 331

Observed Temperatures (deg C)
 BNDRY #1 TRACK BN-b (701-711) 35.00,-144.25

38.75,-142.00

16:05:03



LAT 38.5 38.0 37.5 37.0 36.5 36.0 35.5 35.0
 LONG -142.0 -142.5 -143.0 -143.5 -144.0 -144.5
 NOARL Code 331

Observed Temperatures (deg C)
 BNDRY #1 TRACK BN-c (711-721) 35.00,-144.00

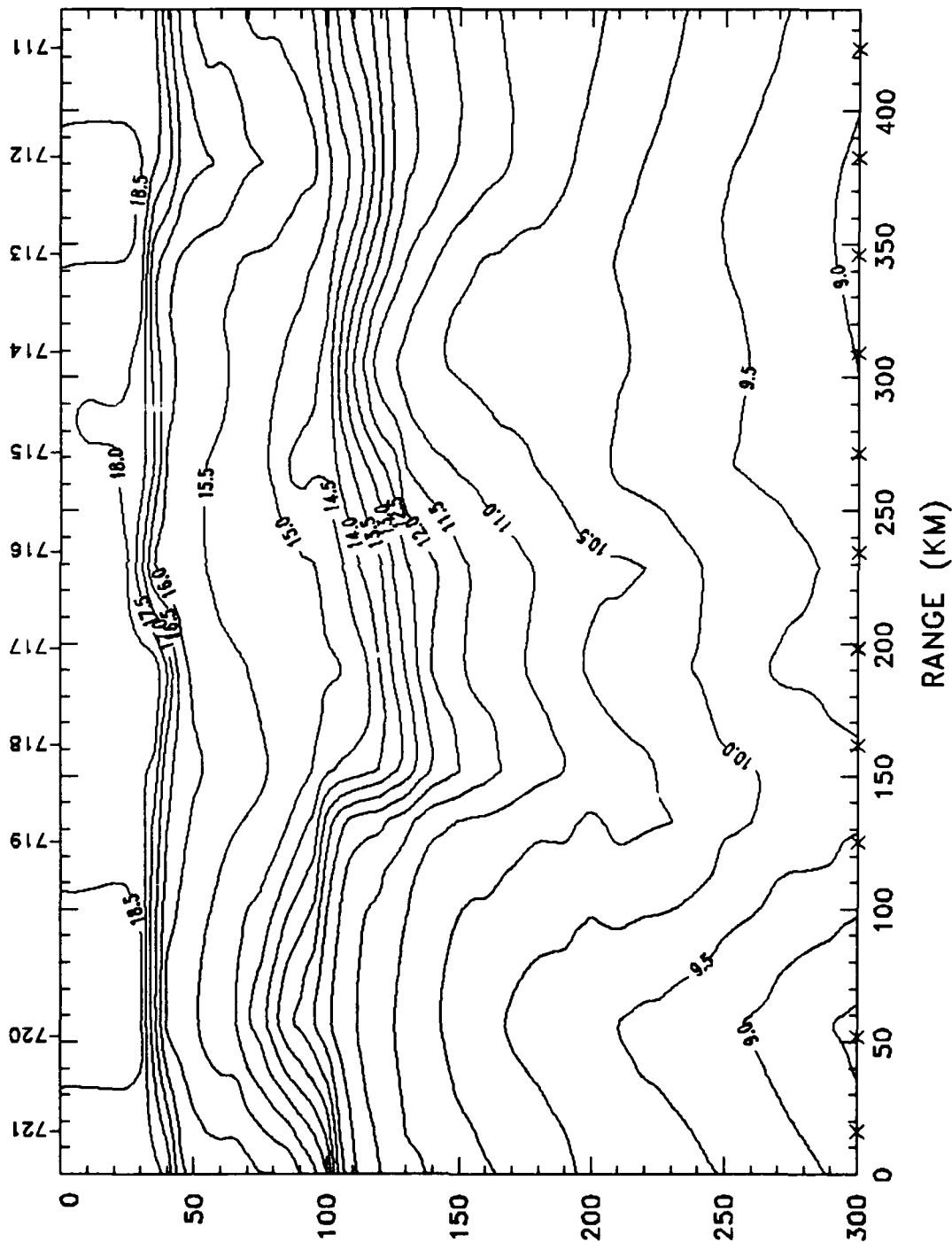
37.25,-148.00

16:06:23

D E P T H M

2/09/90

dx=19,dy=5



LAT 37.0 36.5 36.0 35.5 35.0
 LONG -148.0 -147.5 -147.0 -146.5 -146.0 -145.5 -145.0 -144.5 -144.0
 NOARL Code 331

Observed Temperatures (deg C)
 BNDRY #1 TRACK BN-d (732-742)

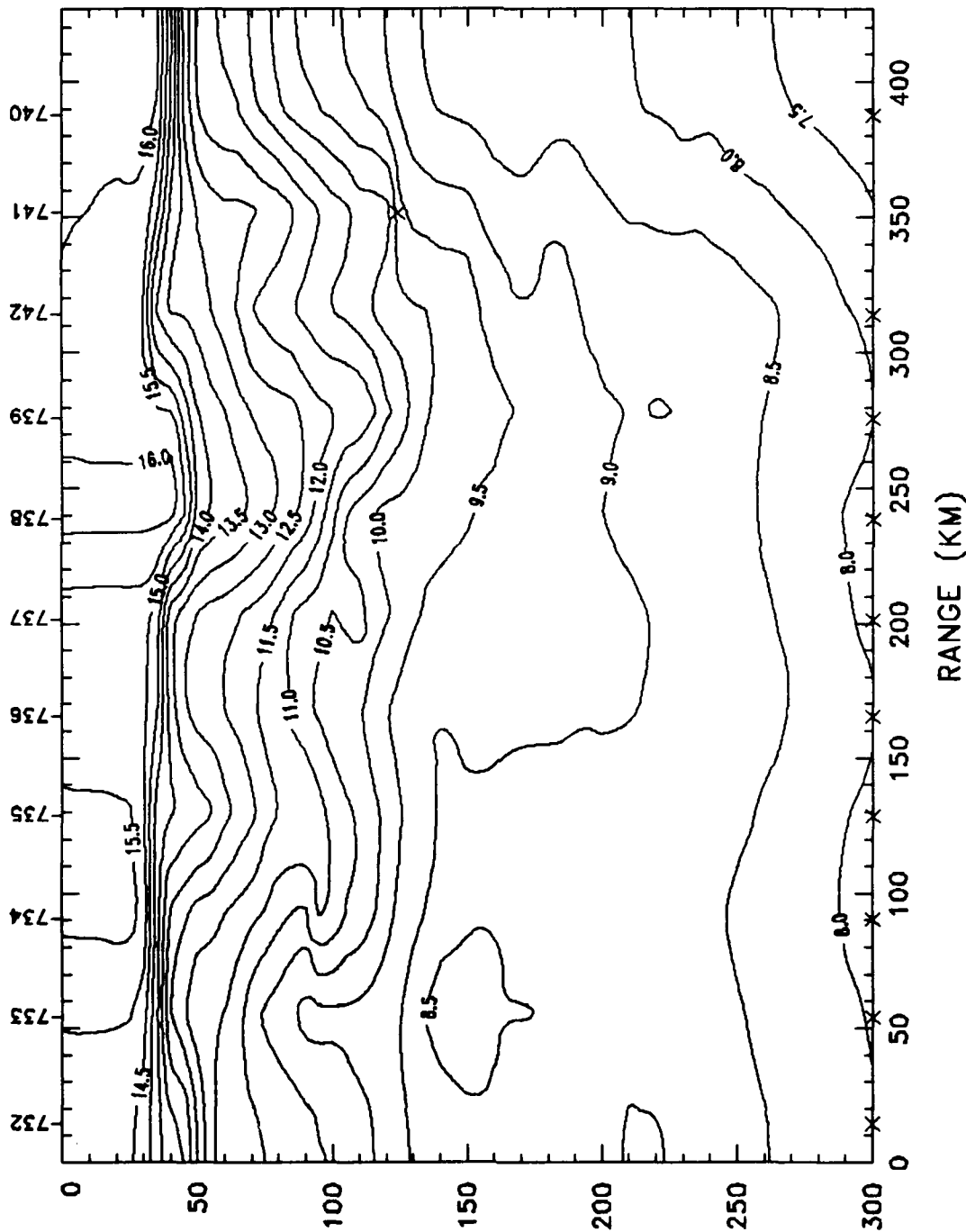
40.50,-146.25 38.50,-142.00

16:07:40

D E P T H M

2/09/90

dx=18,dy=5



LAT 40.5 38.5
 LONG -146.0 -142.0

NOARL Code 331

Appendix H.

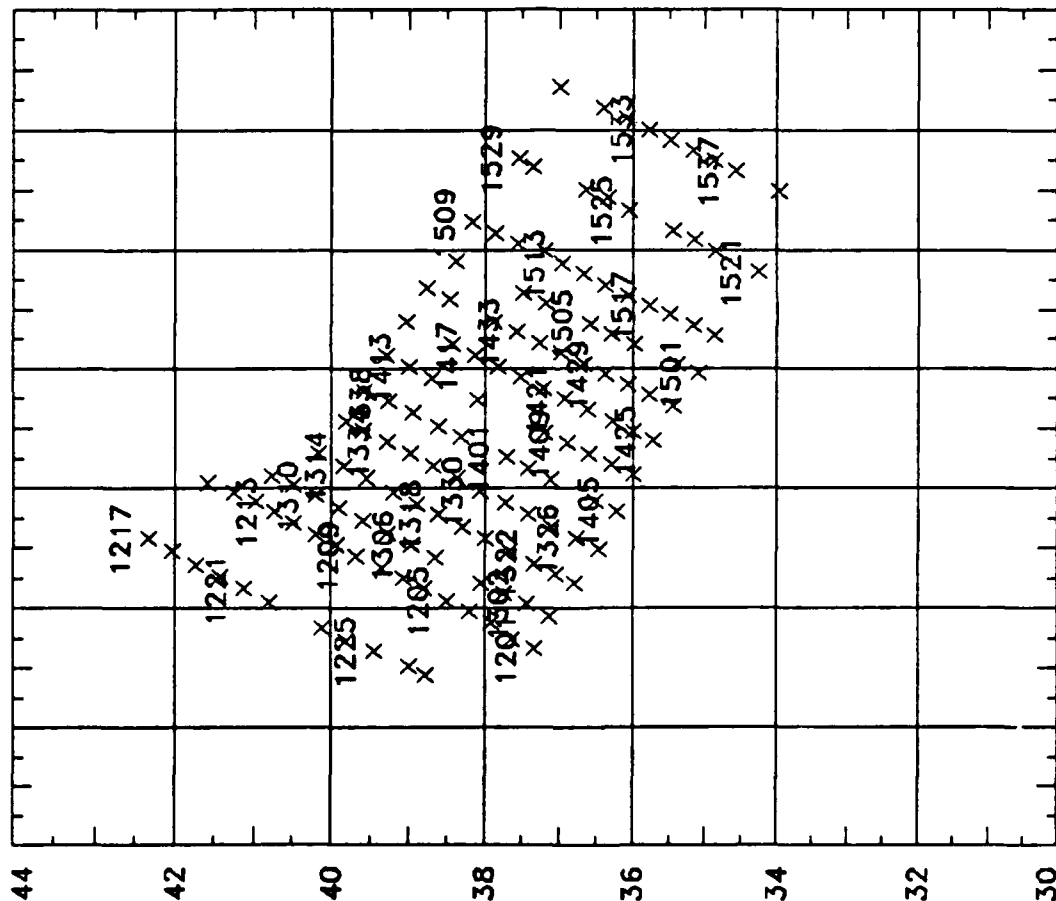
NEPAC Grid 2 (6 - 7 July 1989)

Temperature Contours along Selected Vertical Transects

Surface to 300 m

NEPAC Grid 2 (6-7 July 1989)

142 Probes



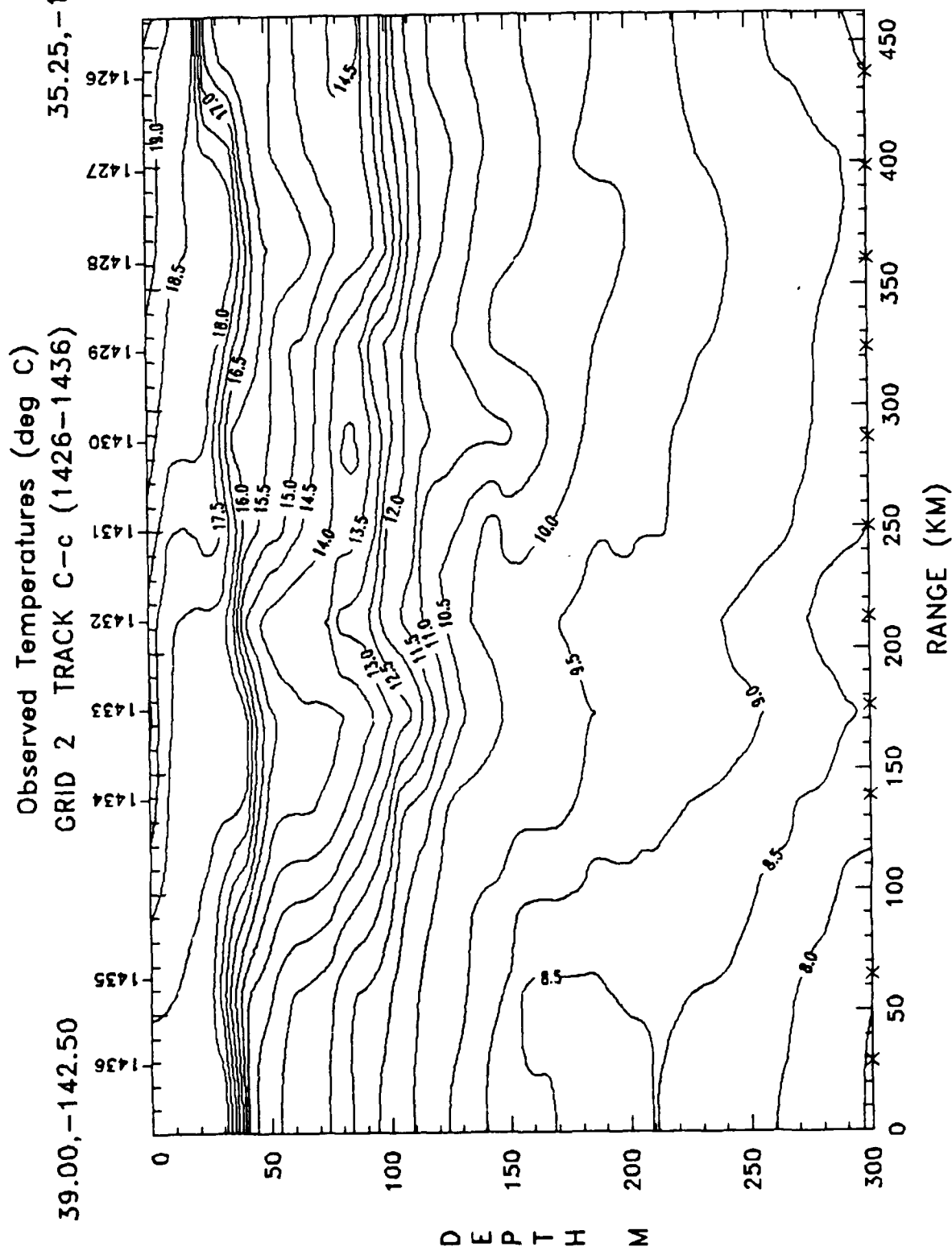
AXBT (142)

LONGITUDE

NOARL Code 331

Observed Temperatures (deg C) GRID 2 TRACK C-c (1426-1436)

39.00,-142.50 35.25,-144.75



LAT 39.0 38.5 38.0 37.5 37.0 36.5 36.0 35.5
LONG -142.5 -143.0 -143.5 -144.0 -144.5

Observed Temperatures (deg C)
 GRID 2 TRACK C-b (1415-1425)

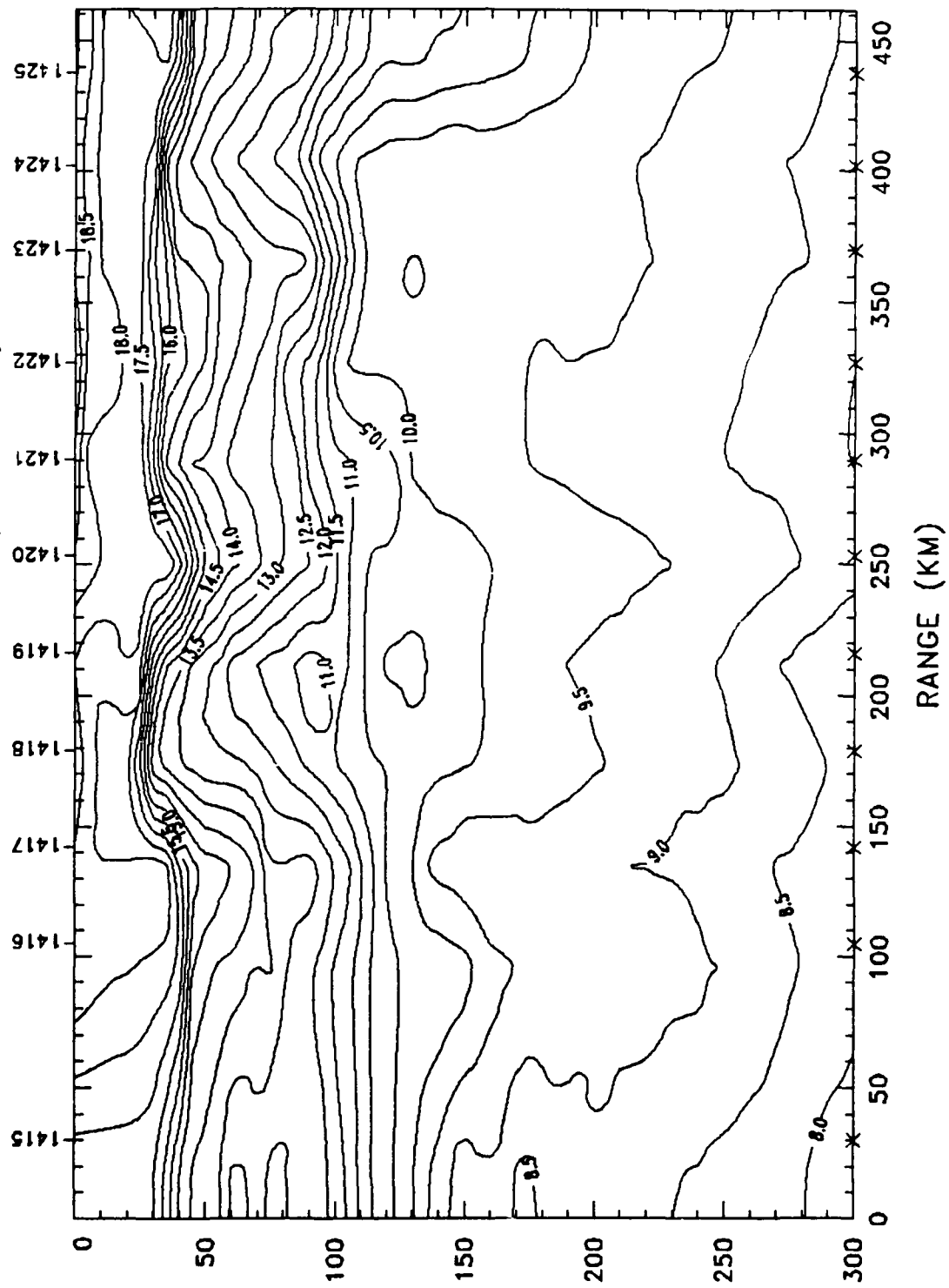
39.25, -143.00 35.50, -145.25

15:33:33

D E P T H M

2/09/90

dx=19,dy=5



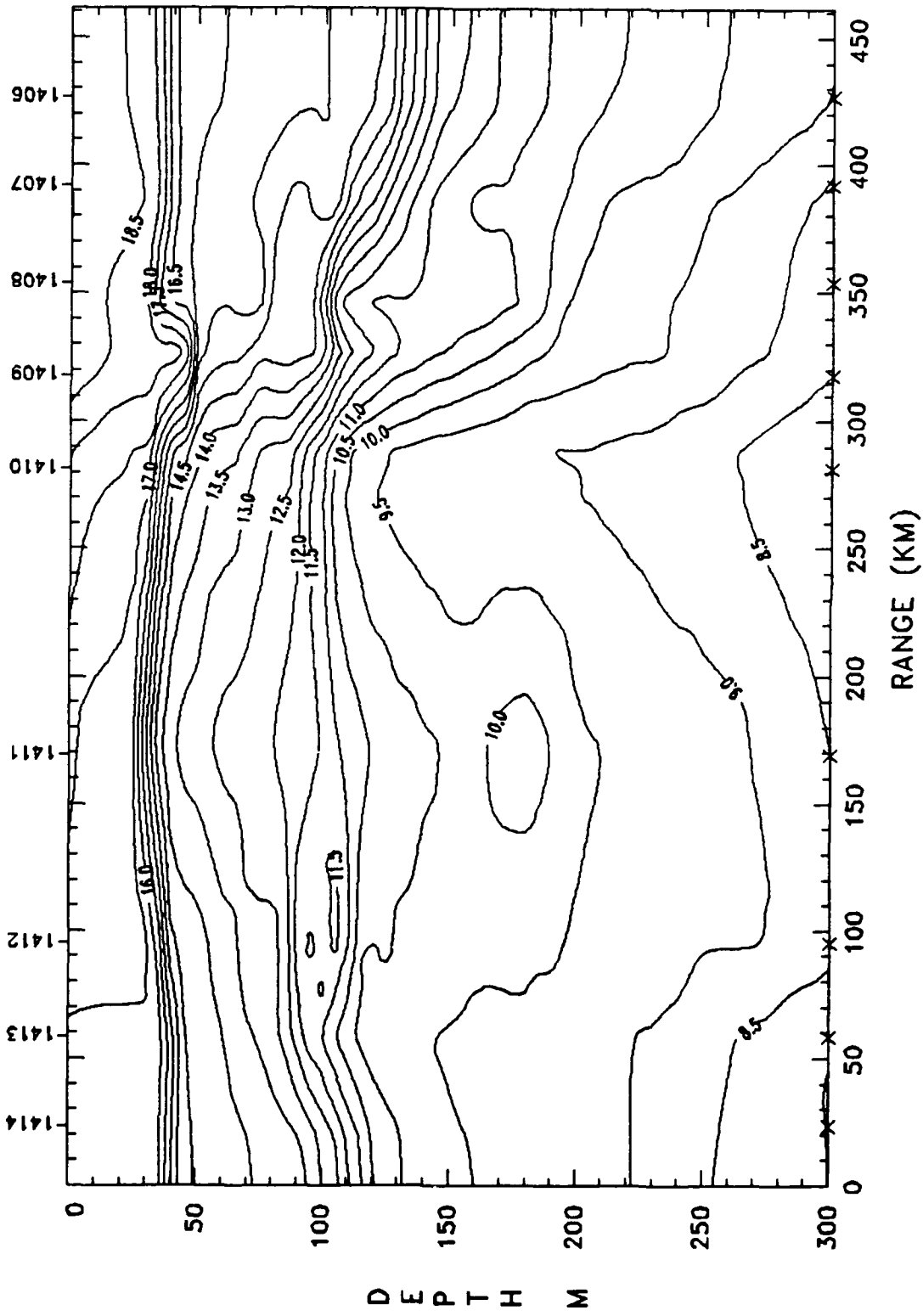
LAT 39.0 38.5 38.0 37.5 37.0 36.5 36.0 35.5
 LONG -143.0 -143.5 -144.0 -144.5 -145.0

NOARL Code 331

Observed Temperatures (deg C)
 GRID 2 TRACK C-a (1406-1414)

35.75,-146.00

39.50,-143.75



15:32:12

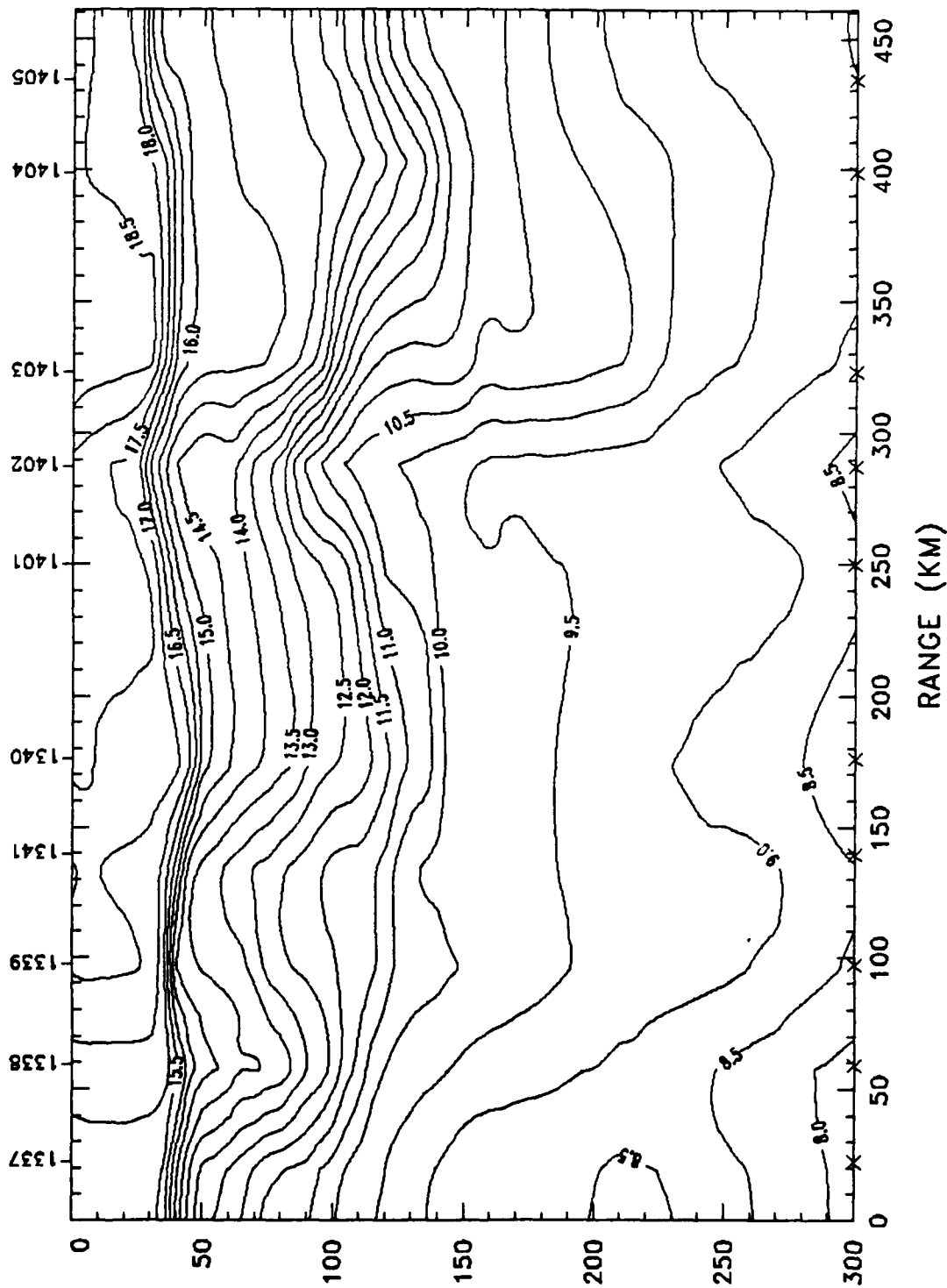
2/09/90

dx=19,dy=5

Observed Temperatures (deg C)
 GRID 2 TRACK B-d (1337-1405)

39.75,-144.25

36.00,-146.50



LAT 39.5 39.0 38.5 38.0 37.5 37.0 36.5 36.0
 LONG -144.5 -145.0 -145.5 -146.0 -146.5

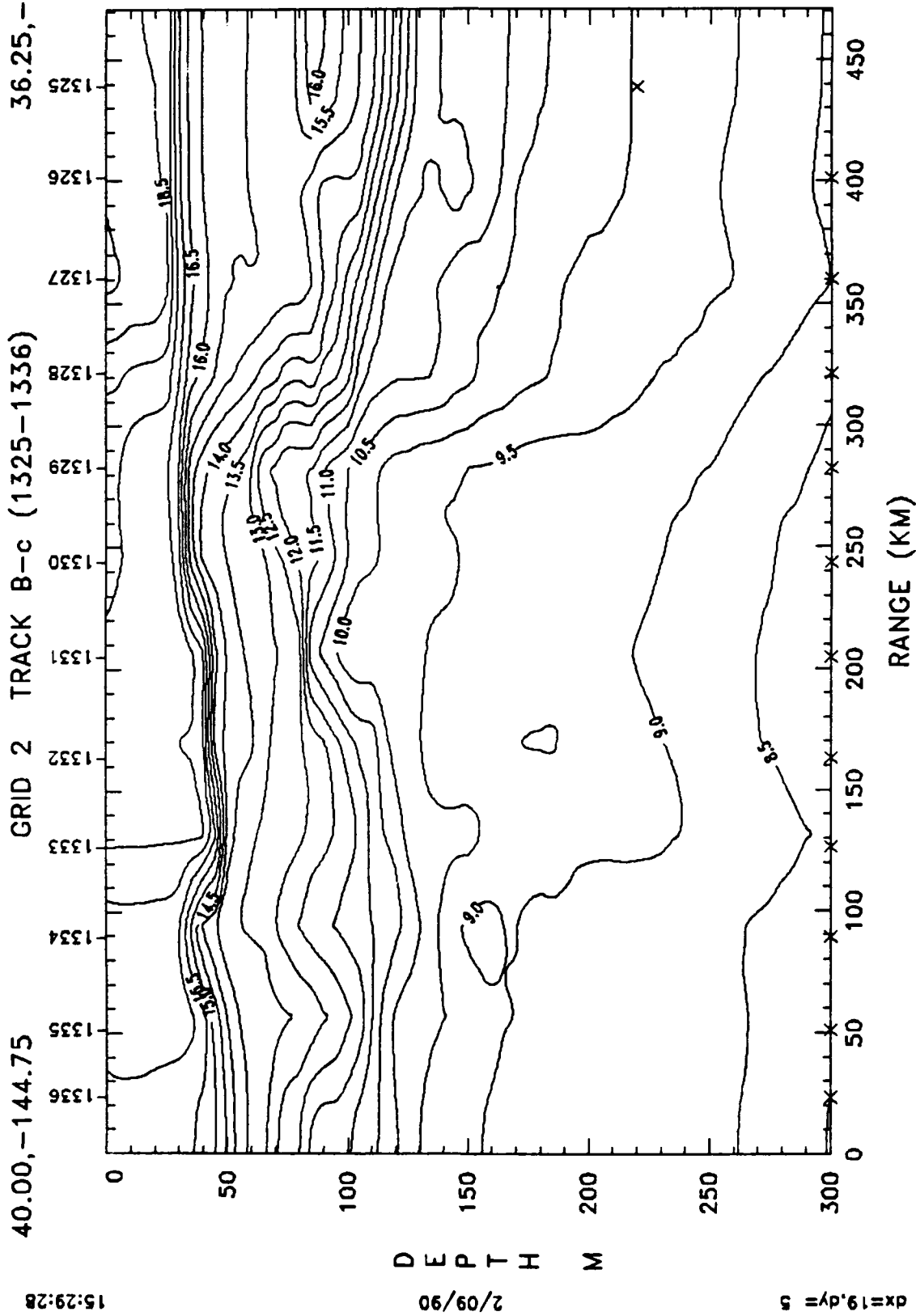
NOARL Code 331

15:30:51

2/09/90

dx=19,dy=5

Observed Temperatures (deg C)
 GRID 2 TRACK B-c (1325-1336)

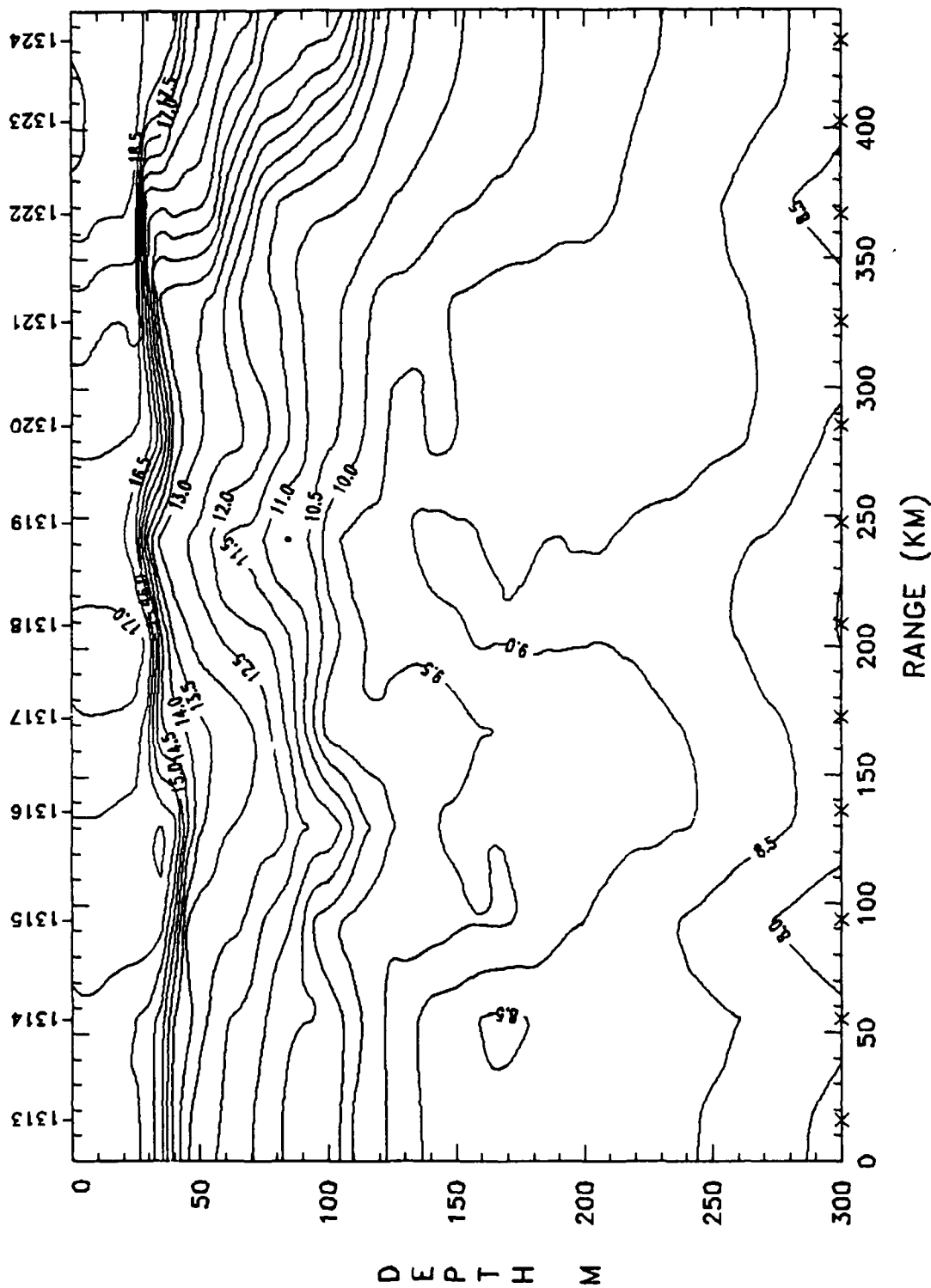


LAT 40.0 39.5 39.0 38.5 38.0 37.5 37.0 36.5
 LONG -145.0 -145.5 -146.0 -146.5 -147.0
 NOARL Code 331

Observed Temperatures (deg C)
 GRID 2 TRACK B-b (1313-1324)

40.25, -145.25 36.75, -147.75

15:28:08



DEPTH M

2/09/90

dx=18, dy=5

LAT 40.0 39.5 39.0 38.5 38.0 37.5 37.0
 LONG -145.5 -146.0 -146.5 -147.0 -147.5

NOARL Code 331

Observed Temperatures (deg C)

GRID 2 TRACK B-a (1301-1312)

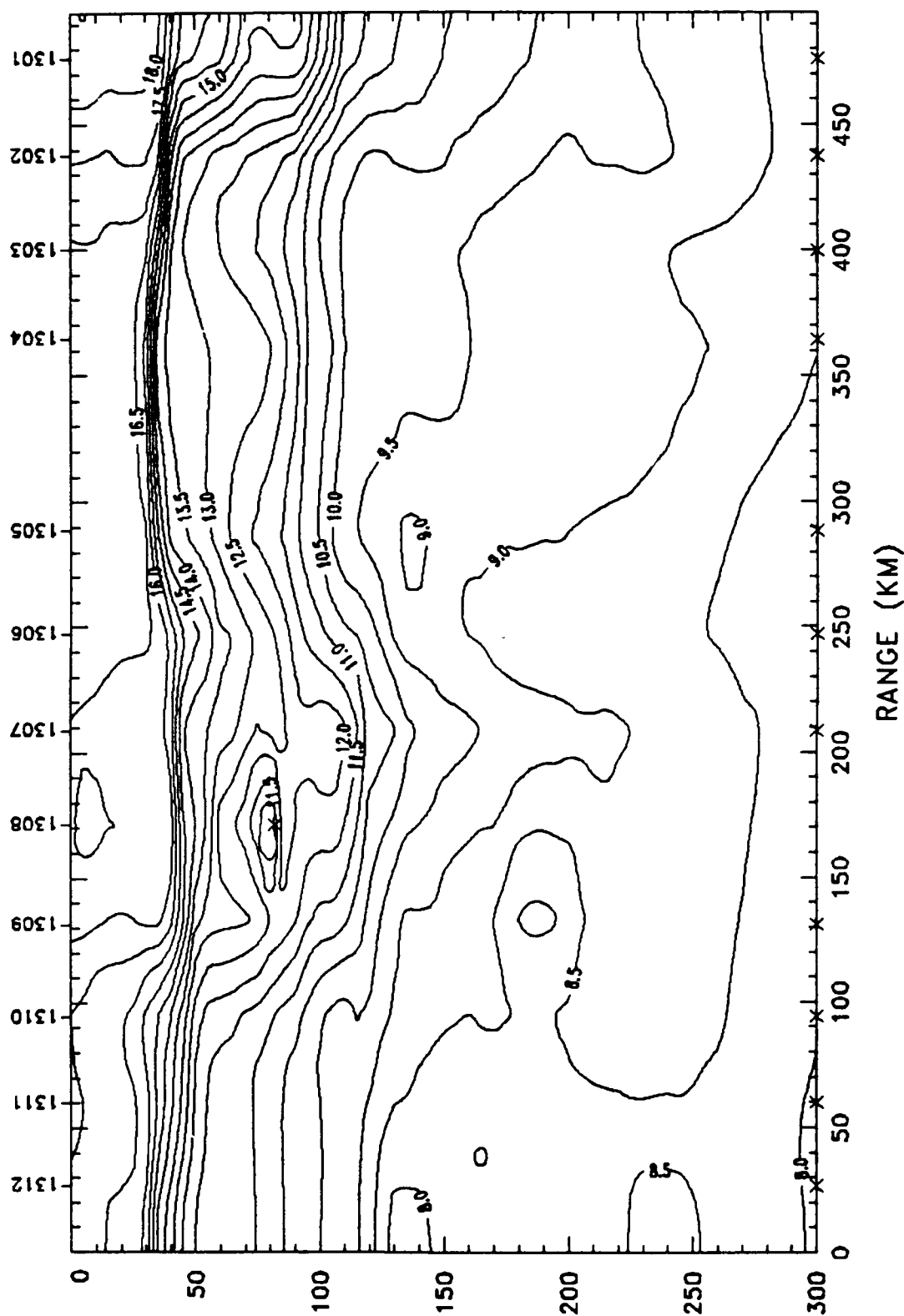
41.00, -145.75

37.00, -148.25

15:26:45

2/09/90

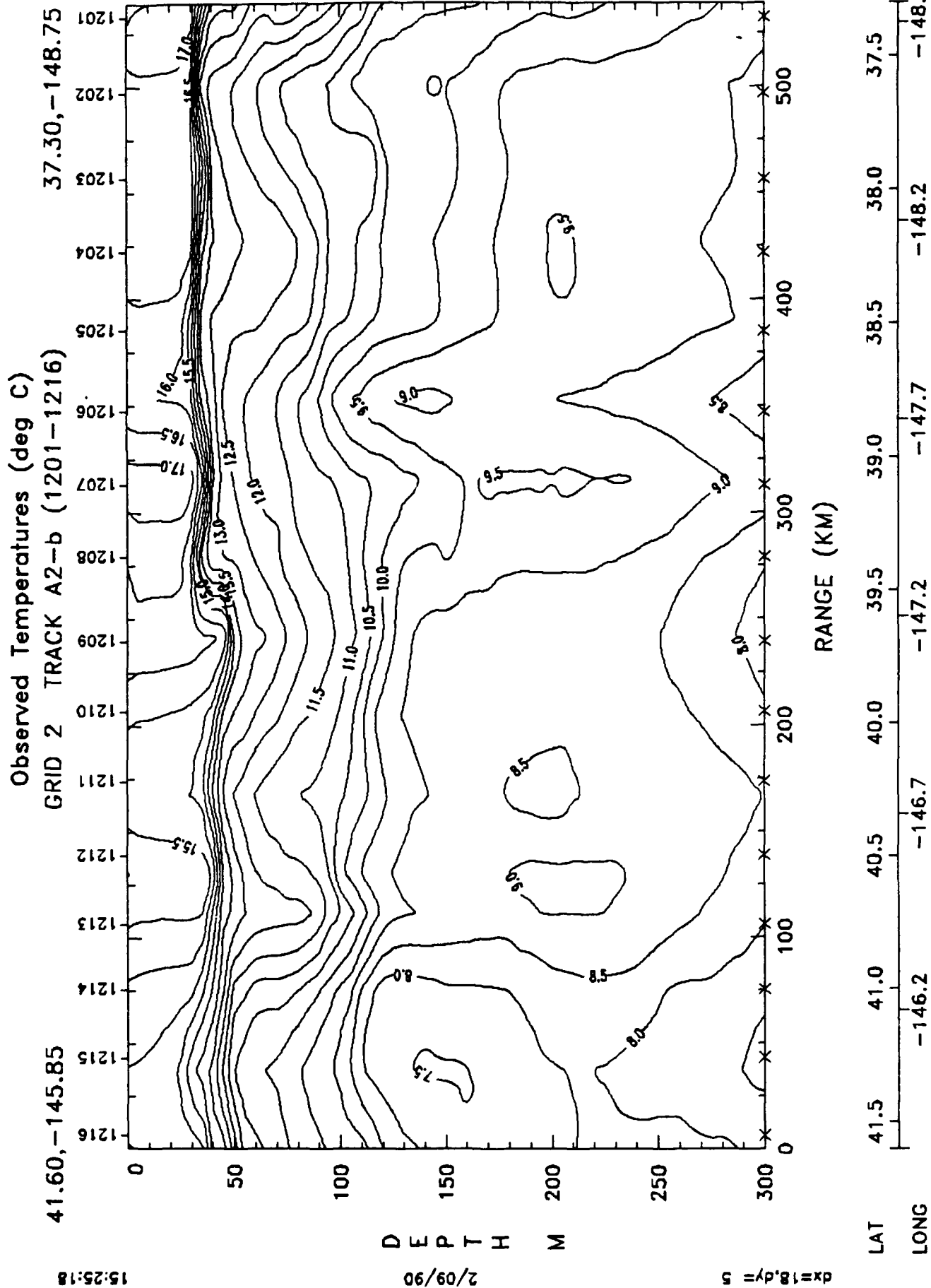
dx=19.0y=5



LAT 41.0 40.5 40.0 39.5 39.0 38.5 38.0 37.5 37.0

LONG -146.0 -147.0 -147.5 -148.0

NOARL Code 331

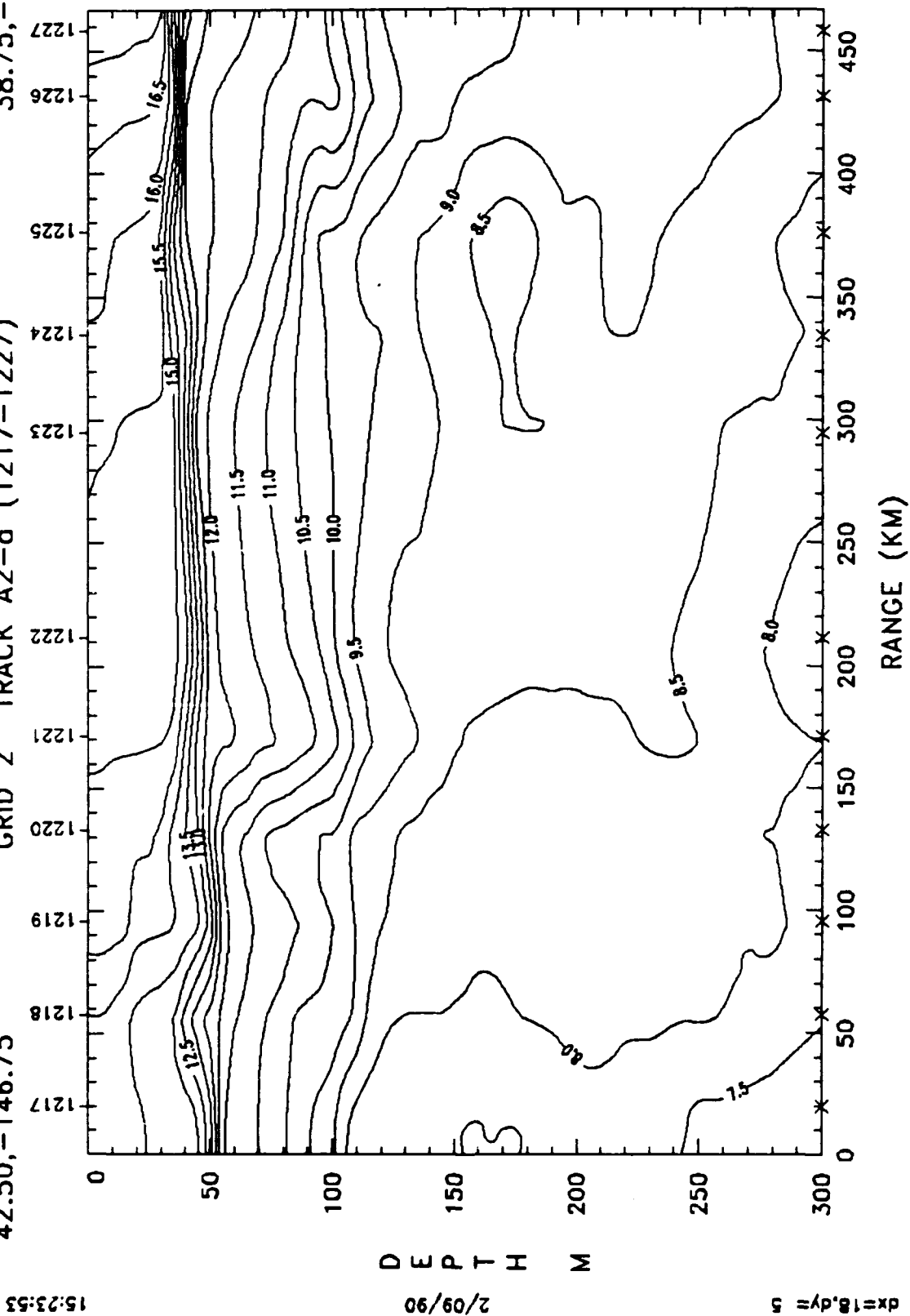


Observed Temperatures (deg C)

GRID 2 TRACK A2-a (1217-1227)

42.50,-146.75

38.75,-149.25



LAT 42.5 42.0 41.5 41.0 40.5 40.0 39.5 39.0

LONG -147.0 -147.5 -148.0 -148.5 -149.0

Observed Temperatures (deg C)
 GRID 2 TRACK D2-a (1501-1508)

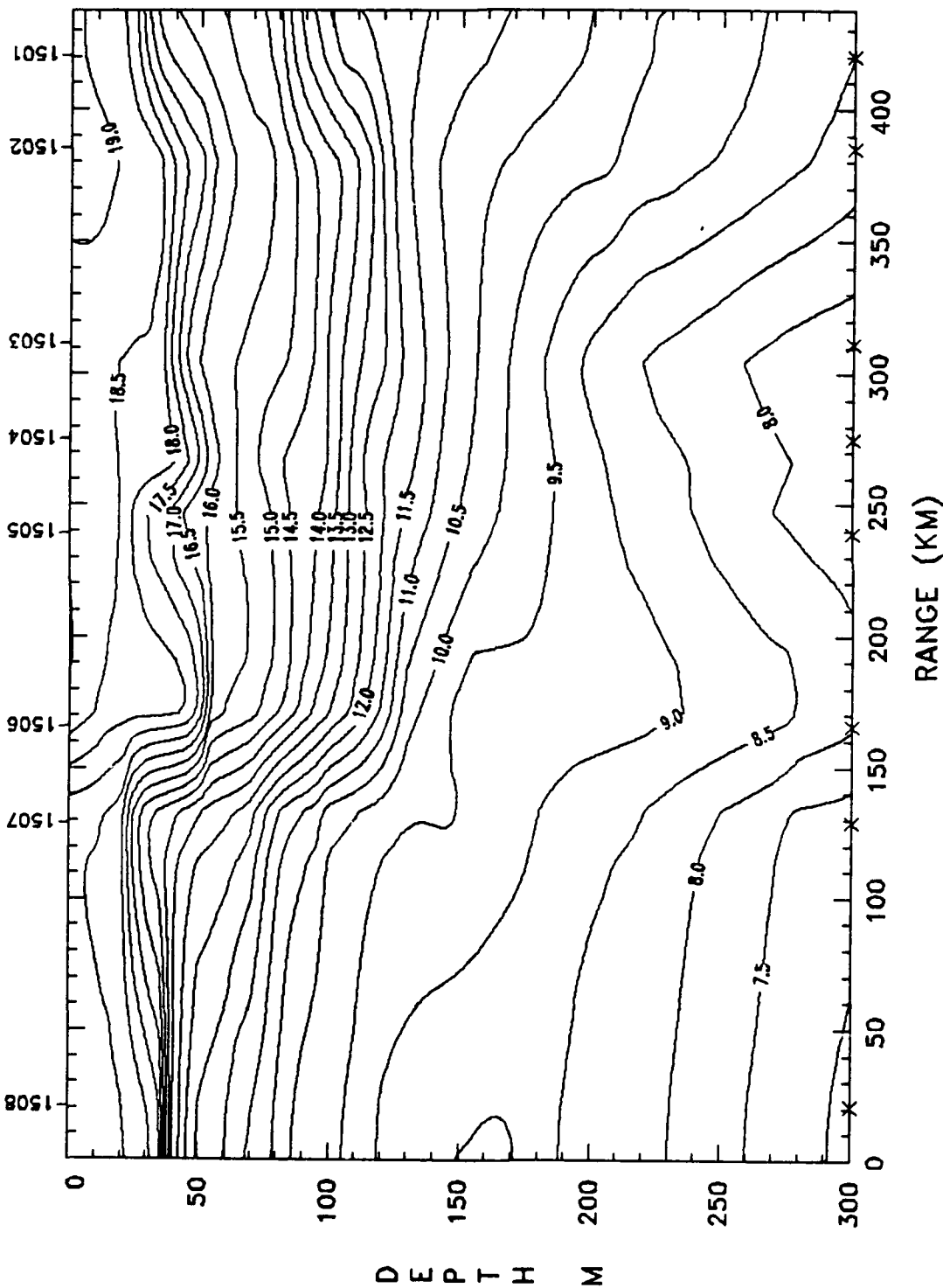
38.50,-142.00

35.00,-144.25

15:36:14

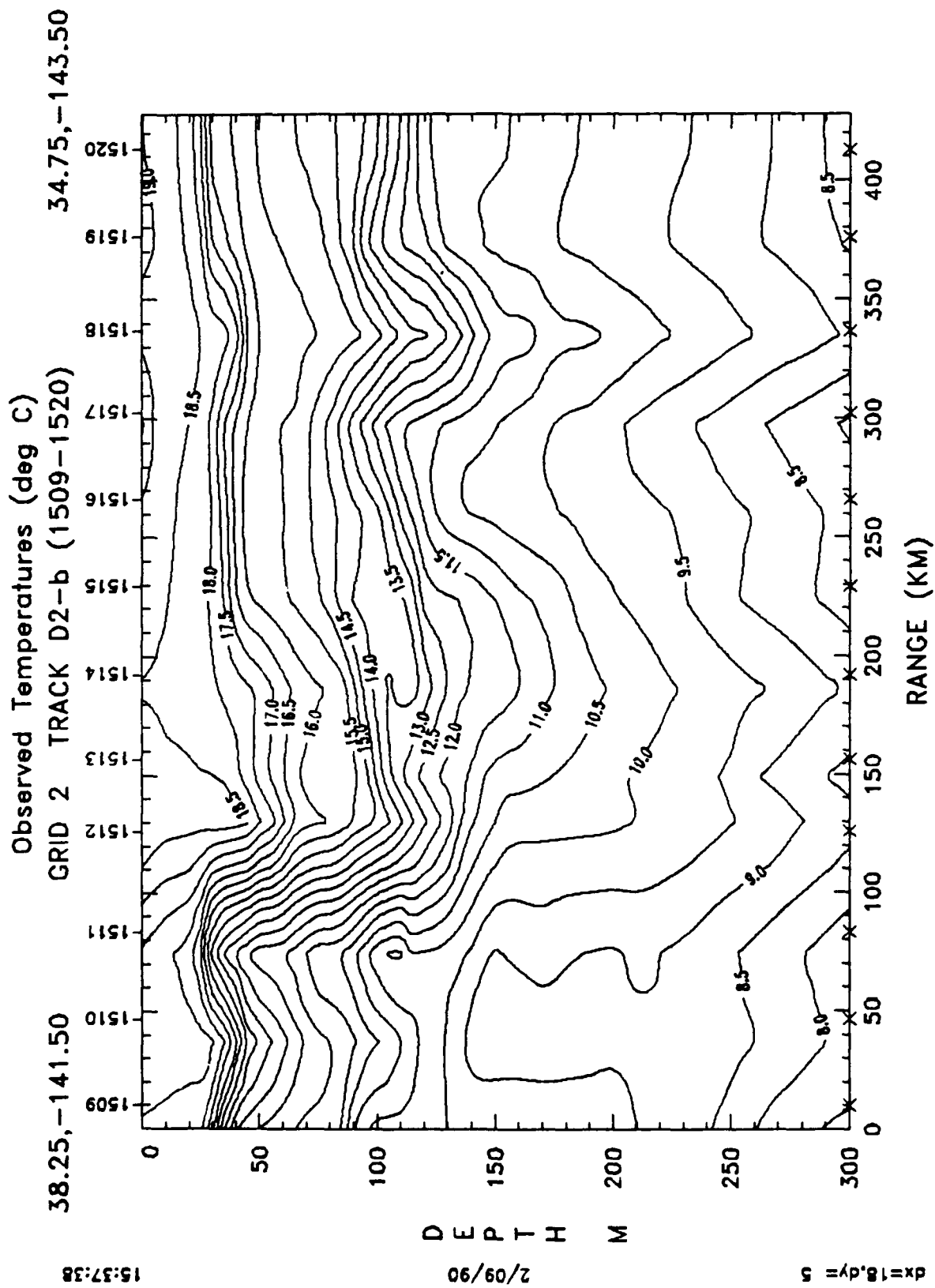
2/09/90

dx=19.0, dy=5



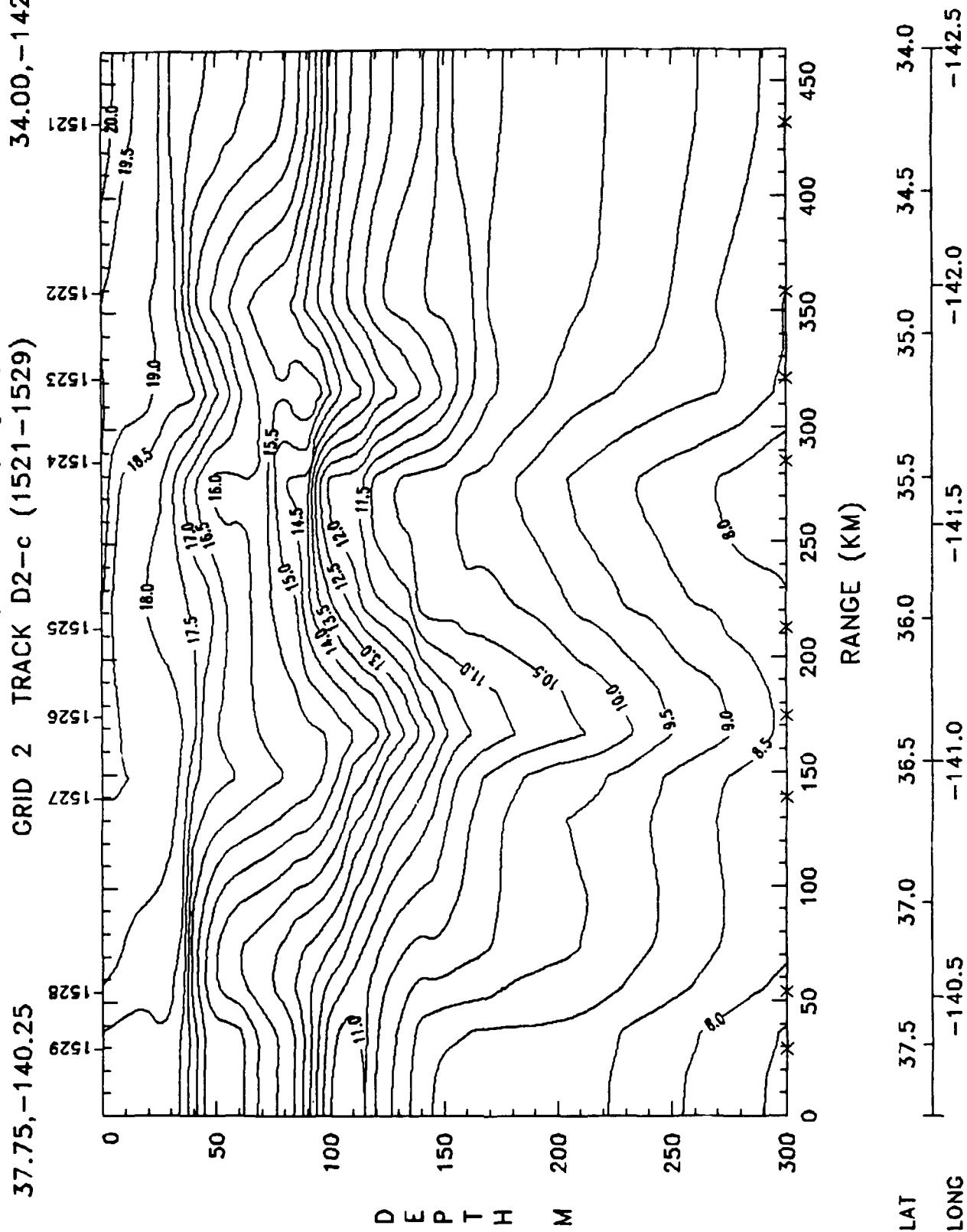
LAT 38.5 38.0 37.5 37.0 36.5 36.0 35.5 35.0
 LONG -142.0 -142.5 -143.0 -143.5 -144.0

NOARL Code 331



LAT 38.0 37.5 37.0 36.5 36.0 35.5 35.0
LONG -141.5 -142.0 -142.5 -143.0 -143.5
NOARL Code 331

Observed Temperatures (deg C)
 GRID 2 TRACK D2-c (1521-1529) 34.00, -142.50



LAT 37.5 37.0 36.5 36.0 35.5 35.0 34.5 34.0
 LONG -140.5 -141.0 -141.5 -142.0 -142.5

NOARL Code 331

15:39:03

2/09/90

dx=18,dy=5

Observed Temperatures (deg C)
 GRID 2 TRACK D2-c (1521-1529)

37.75, -140.25

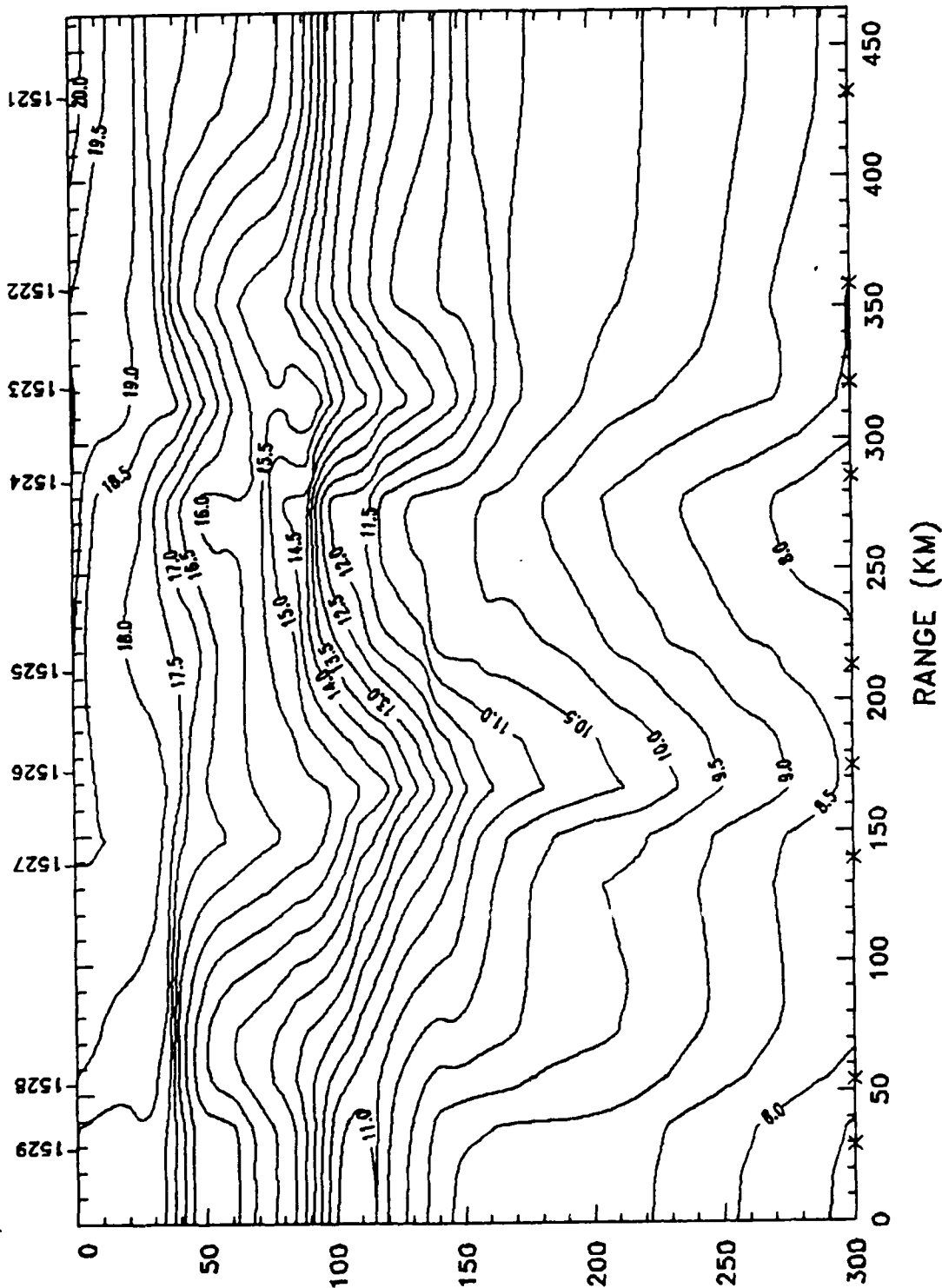
34.00, -142.50

15:39:03

DEPTH M

2/09/90

dx=18, dy=5



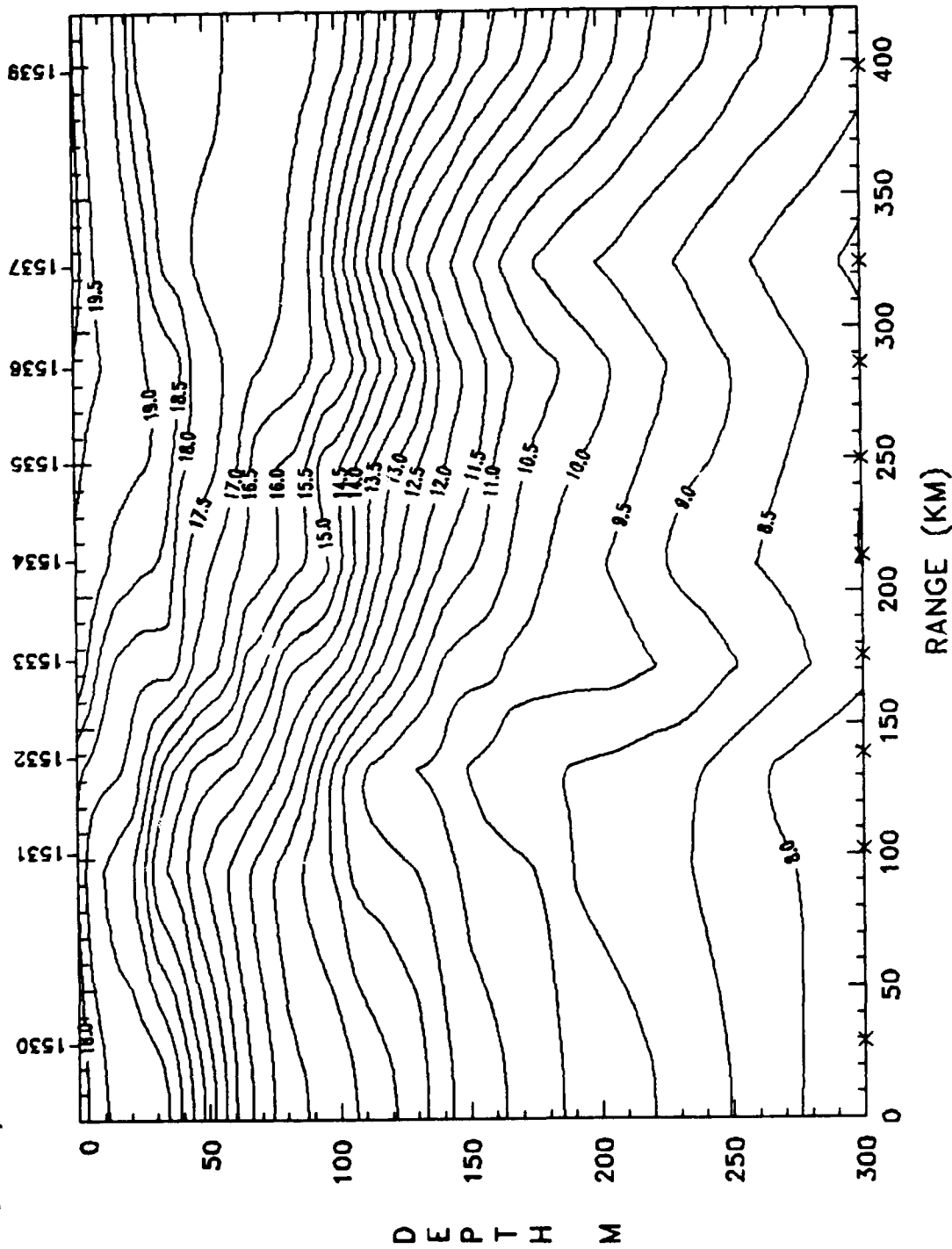
LAT 37.5 37.0 36.5 36.0 35.5 35.0 34.5 34.0
 LONG -140.5 -141.0 -141.5 -142.0 -142.5

NOARL Code 331

Observed Temperatures (deg C)
 GRID 2 TRACK D2-d (1530-1539) 33.75,-141.00

37.25,-139.25

15:40:27



LAT 37.0 36.5 36.0 35.5 35.0 34.5 34.0
 LONG -139.5 -140.0 -140.5 -141.0

NOARL Code 331

DEPTH M

2/09/90

dx=19.0, dy=5

Appendix I.

NEPAC Grid 2 (6 - 7 July 1989)

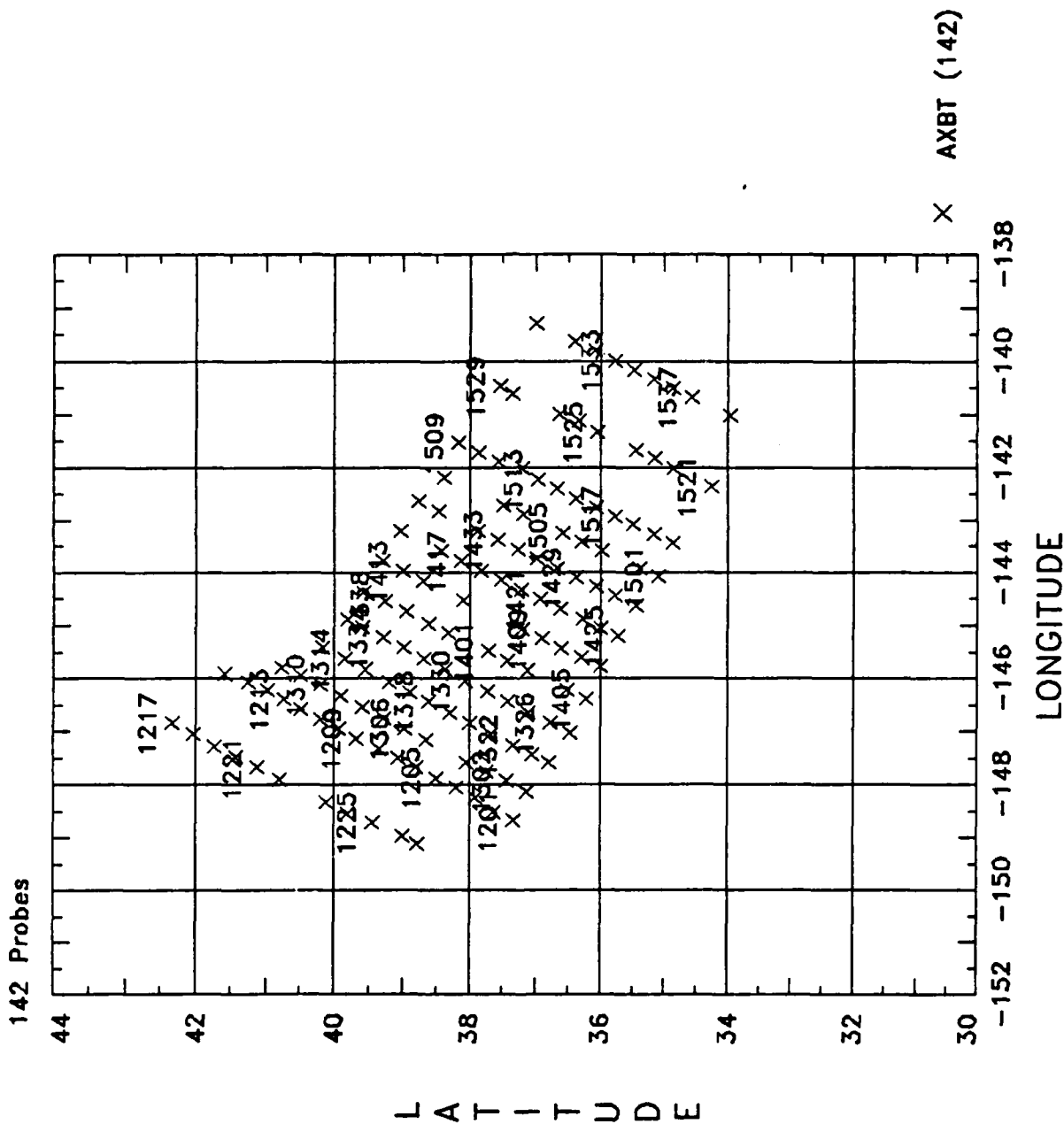
Temperature Contours along Selected Vertical Transects

Surface to 5500 m

8:55:51

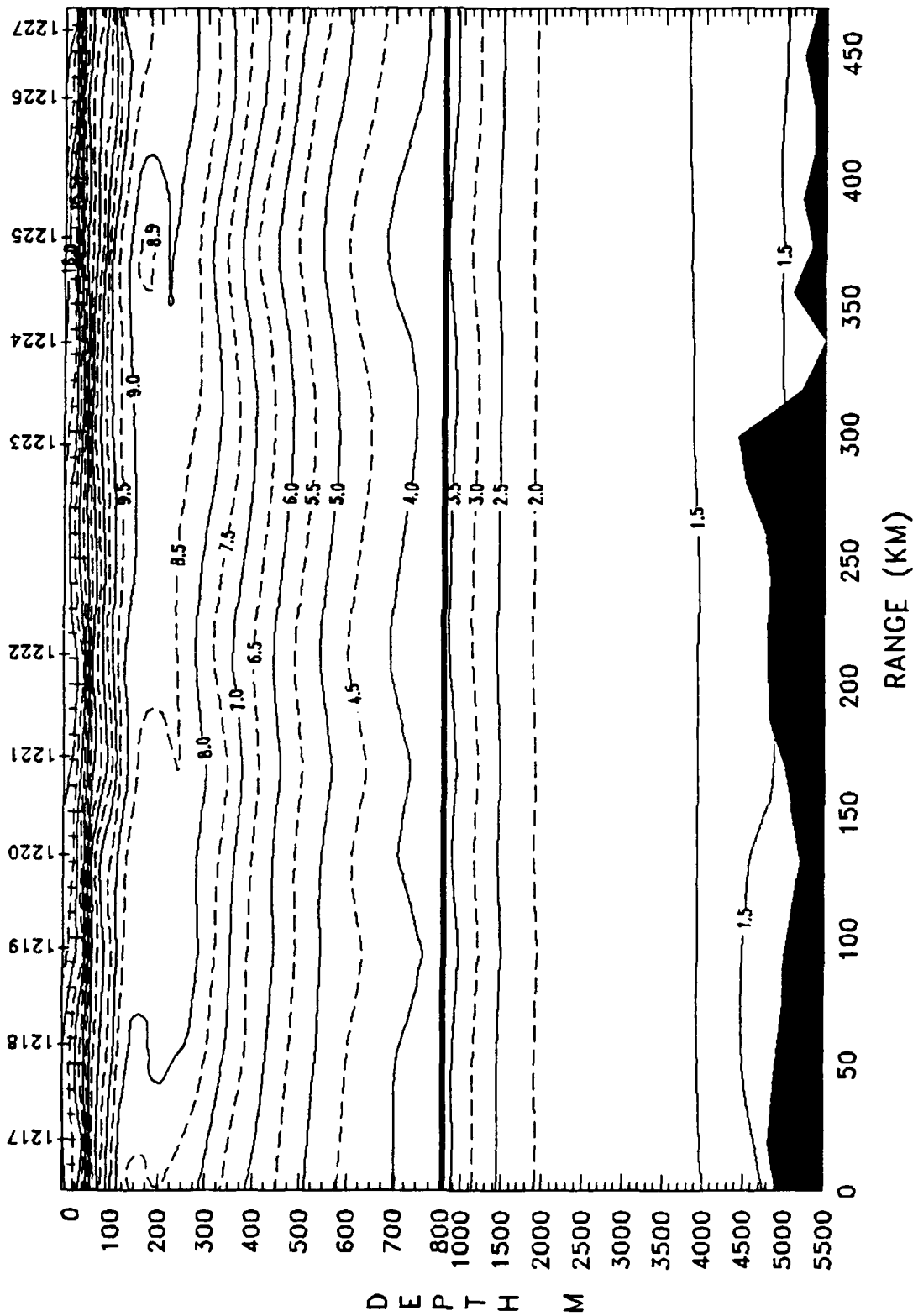
5/09/90

NEPAC Grid 2 (6-7 July 1989)



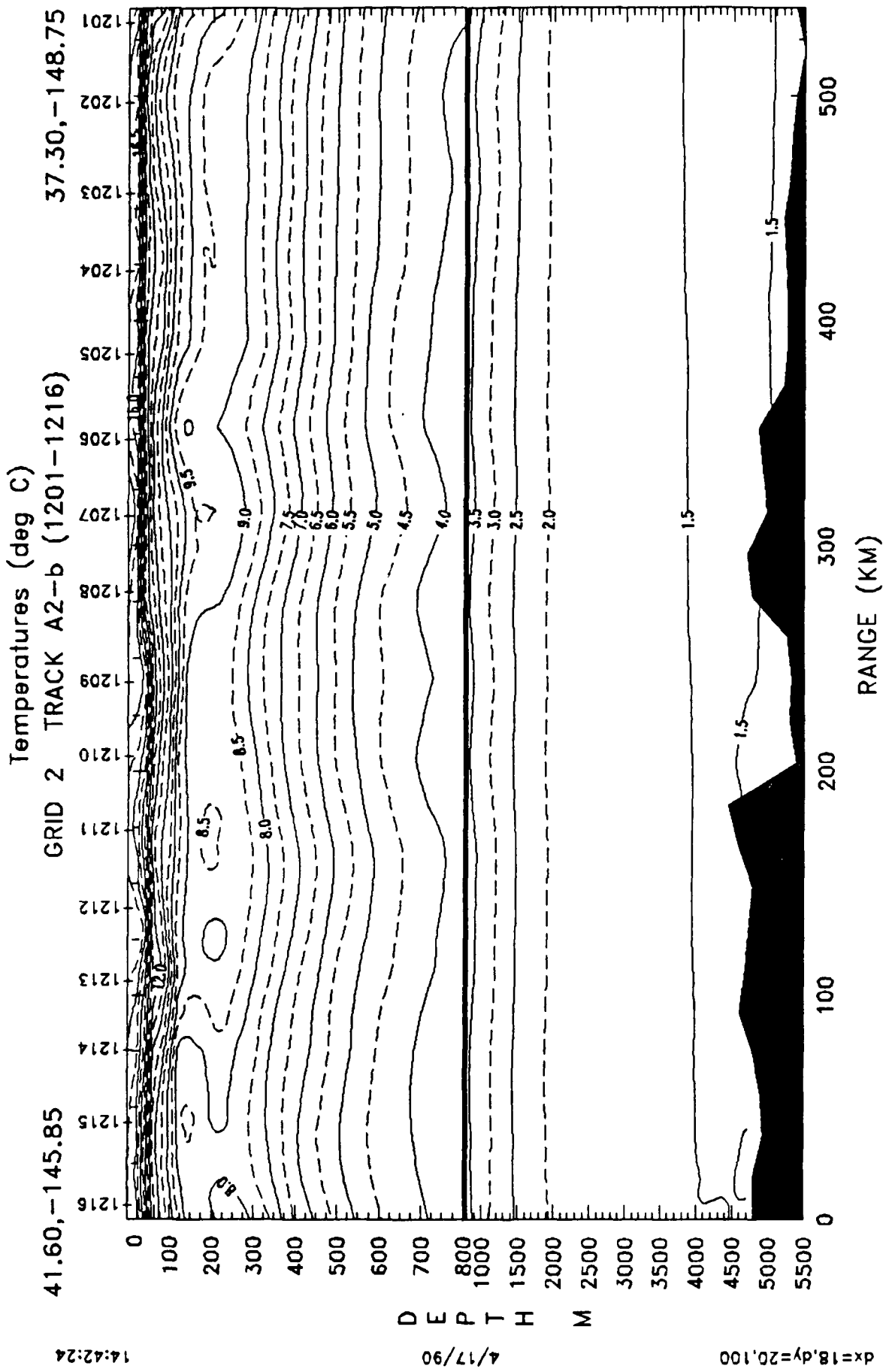
$$dx = 18, dy = 20, dz = 100$$

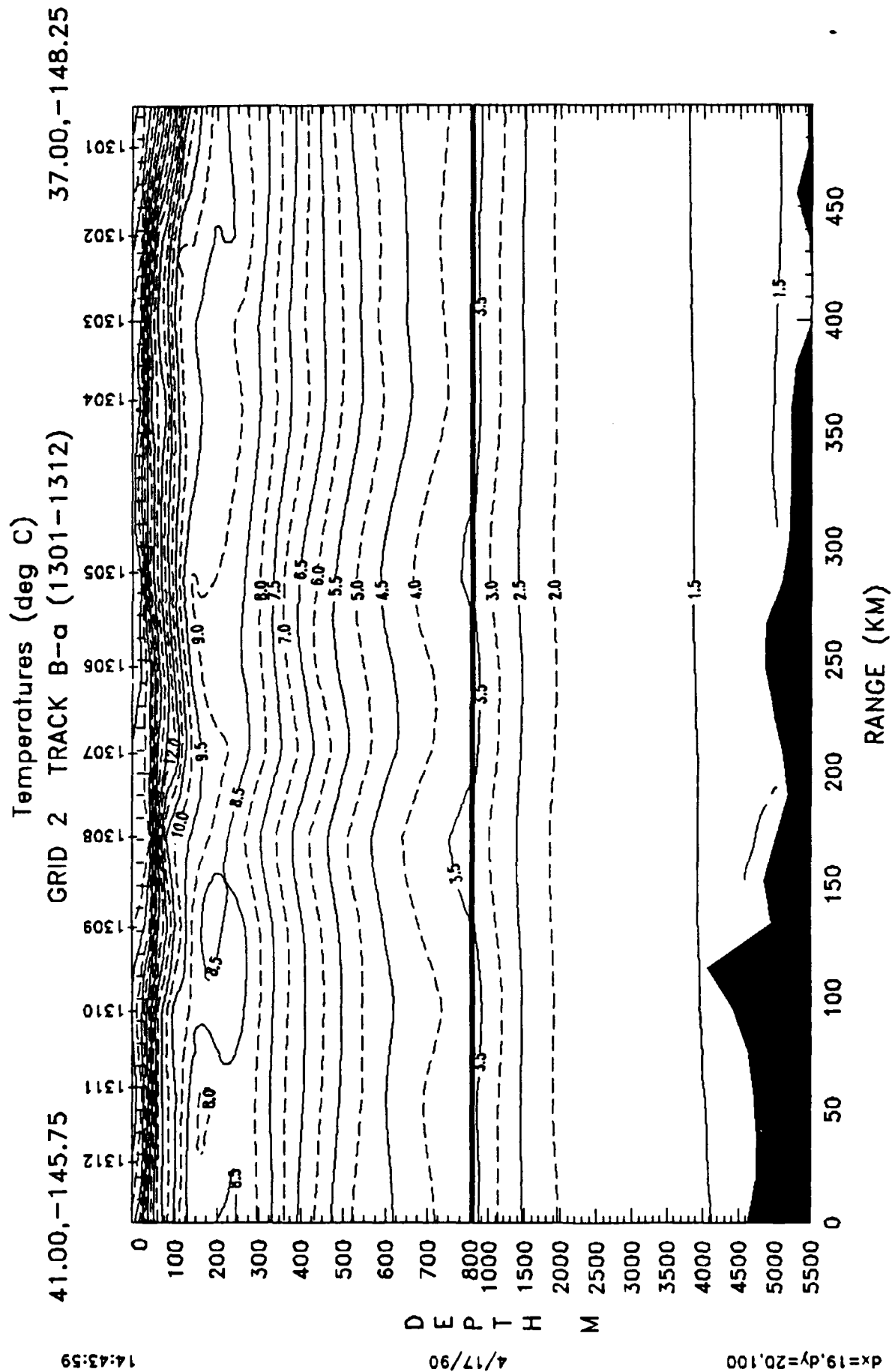
38.75,-149.25



LAT	42.5	42.3	42.0	41.8	41.5	41.3	41.0	40.8	40.5	40.3	40.0	39.8	39.5	39.3	39.0	38.8
LONG	-146.8	-147.0	-147.3	-147.5	-147.8	-148.0	-148.3	-148.5	-148.8	-149.0	-149.3					

NOARL Code 331

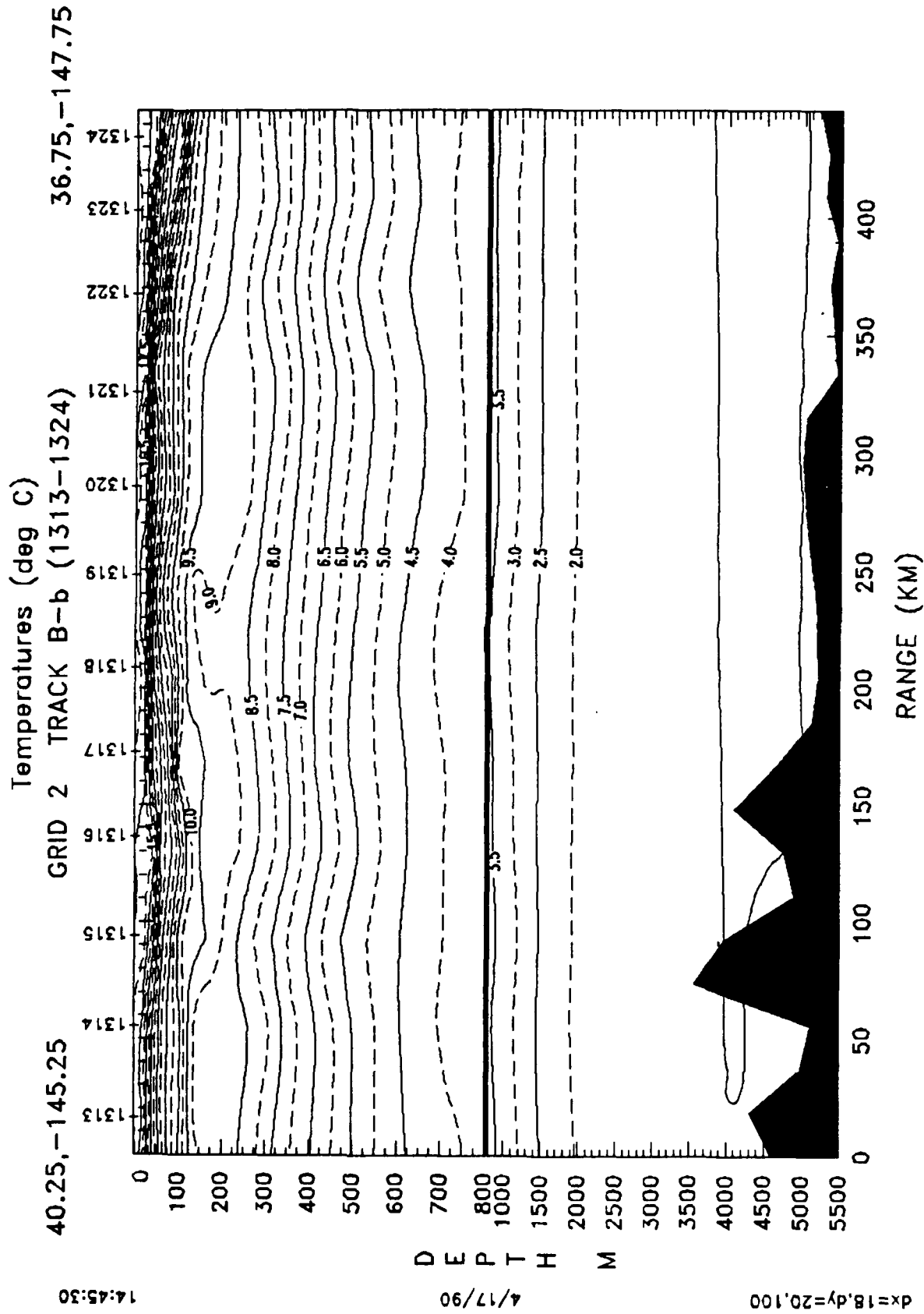




LAT 41.0 40.5 40.0 39.5 39.0 38.5 38.0 37.5 37.0

LONG -145.8 -146.0 -146.3 -146.5 -146.8 -147.0 -147.3 -147.5 -147.8 -148.0 -148.3

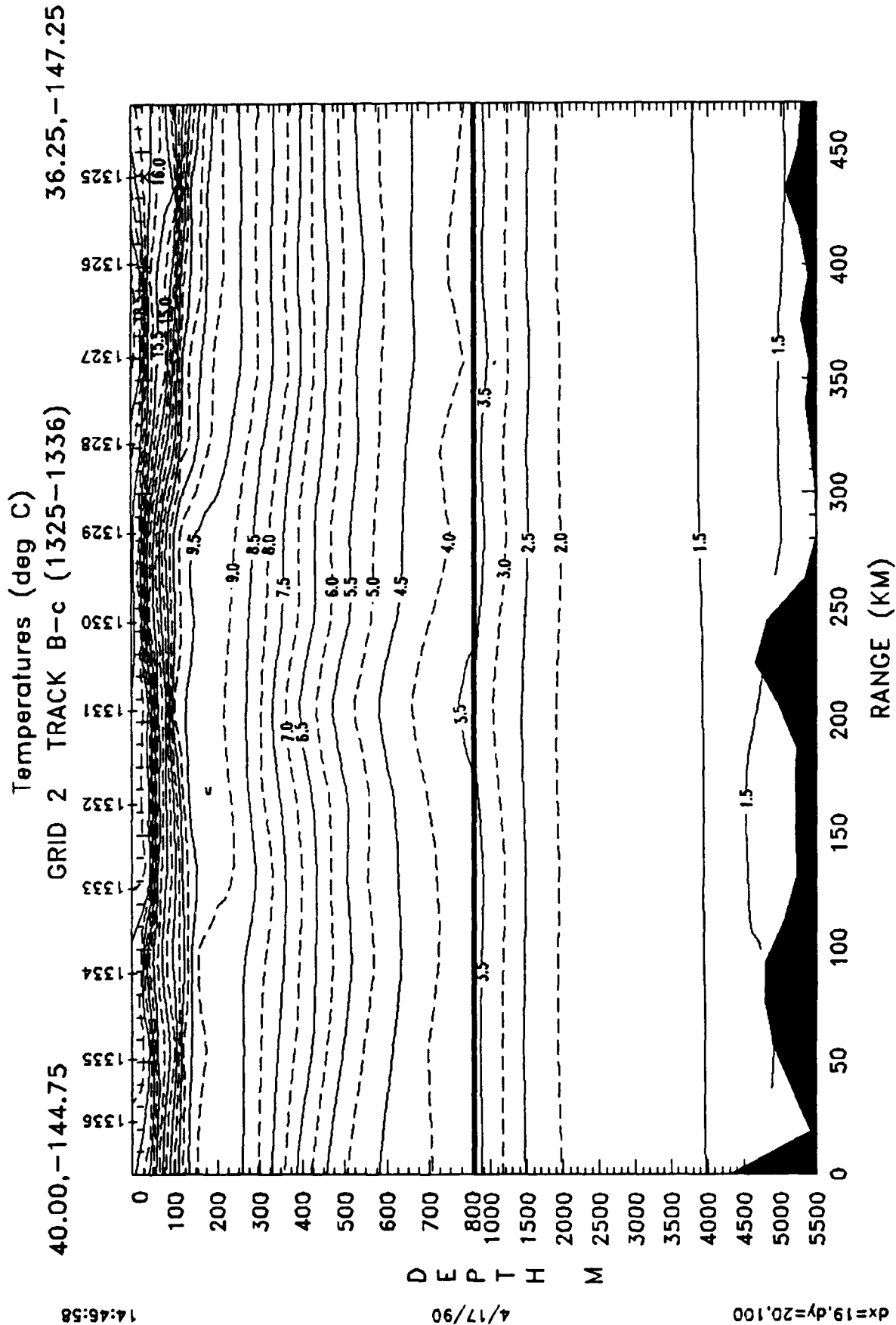
NOARL Code 331



LAT 40.3 39.8 39.5 39.3 39.0 38.8 38.5 38.3 38.0 37.8 37.5 37.3 37.0 36.8

LONG -145.3 -145.5 -145.8 -146.0 -146.3 -146.5 -146.8 -147.0 -147.3 -147.5 -147.8

NOARL Code 331



LAT 40.0 39.8 39.5 39.3 39.0 38.8 38.5 38.3 38.0 37.8 37.5 37.3 37.0 36.8 36.5 36.3

LONG -144.8 -145.0 -145.3 -145.5 -145.8 -146.0 -146.3 -146.5 -146.8 -147.0 -147.3

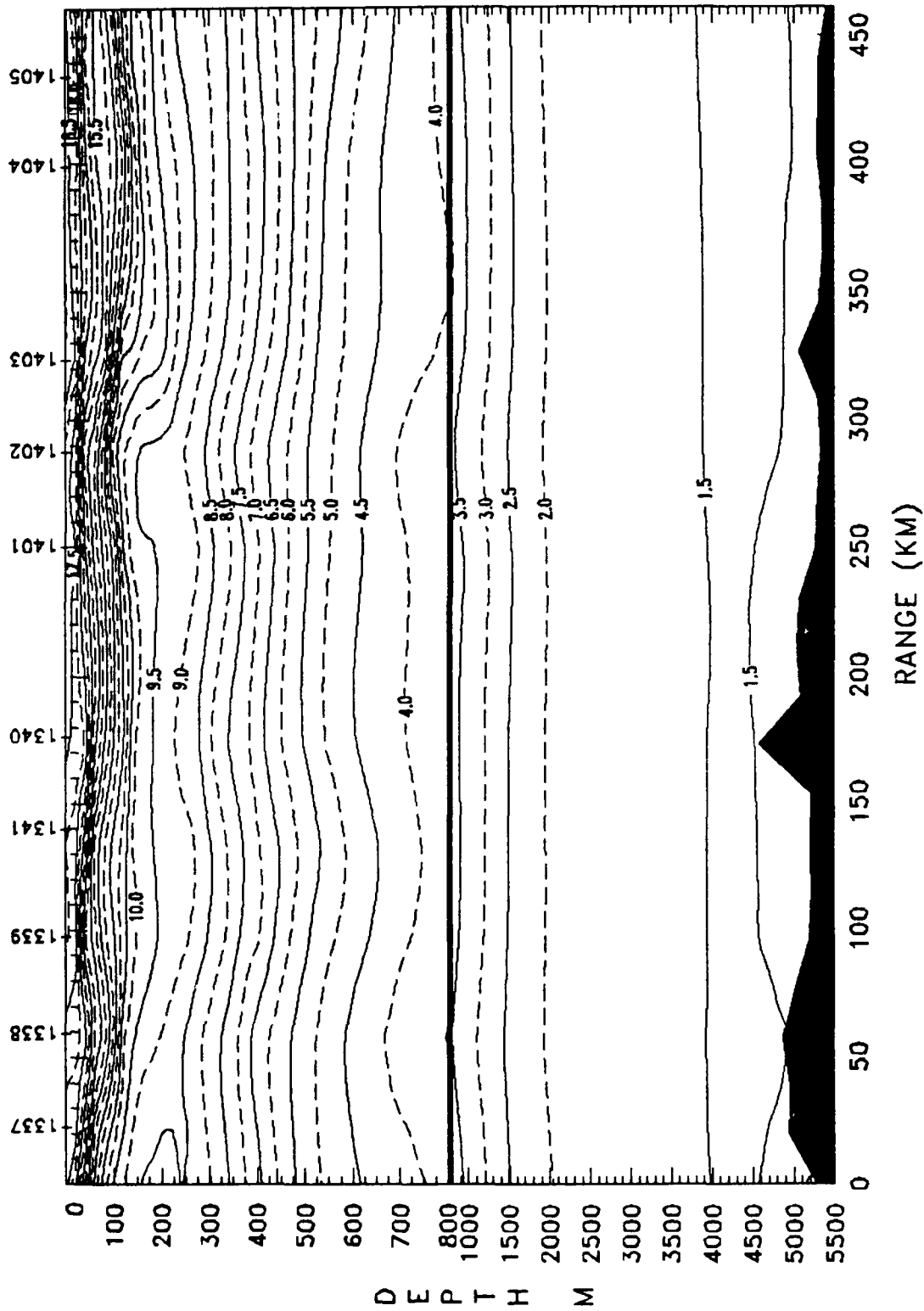
NOARL Code 331

Temperatures (deg C) GRID 2 TRACK B-d (1337-1405) 39.75,-144.25 36.00,-146.50

14:48:32

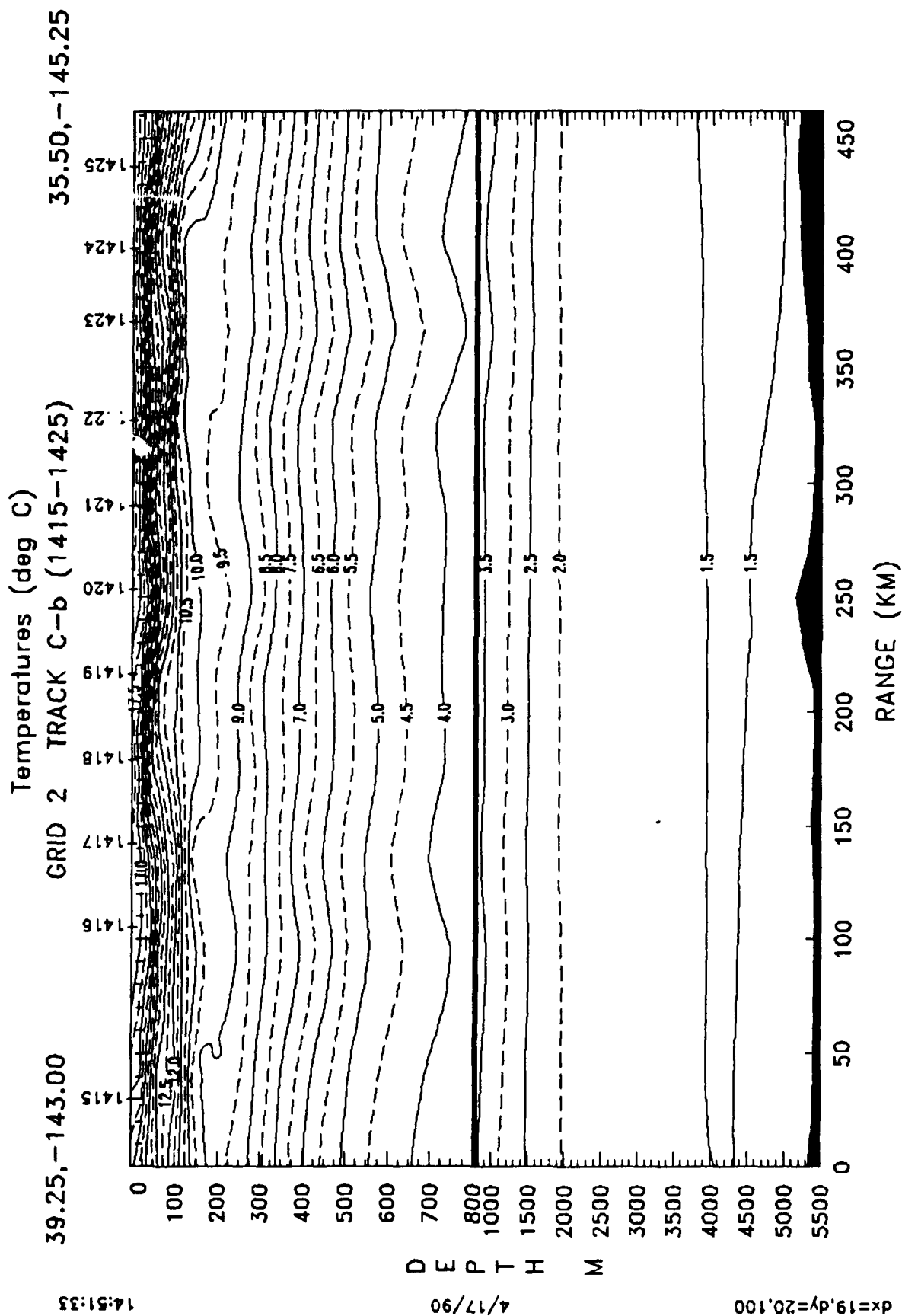
4/17/90

dx=19,dy=20,100



LAT 39.8 39.5 39.3 39.0 38.8 38.5 38.3 38.0 37.8 37.5 37.3 37.0 36.8 36.5 36.3 36.0
 LONG -144.3 -144.5 -144.8 -145.0 -145.3 -145.5 -145.8 -146.0 -146.3 -146.5

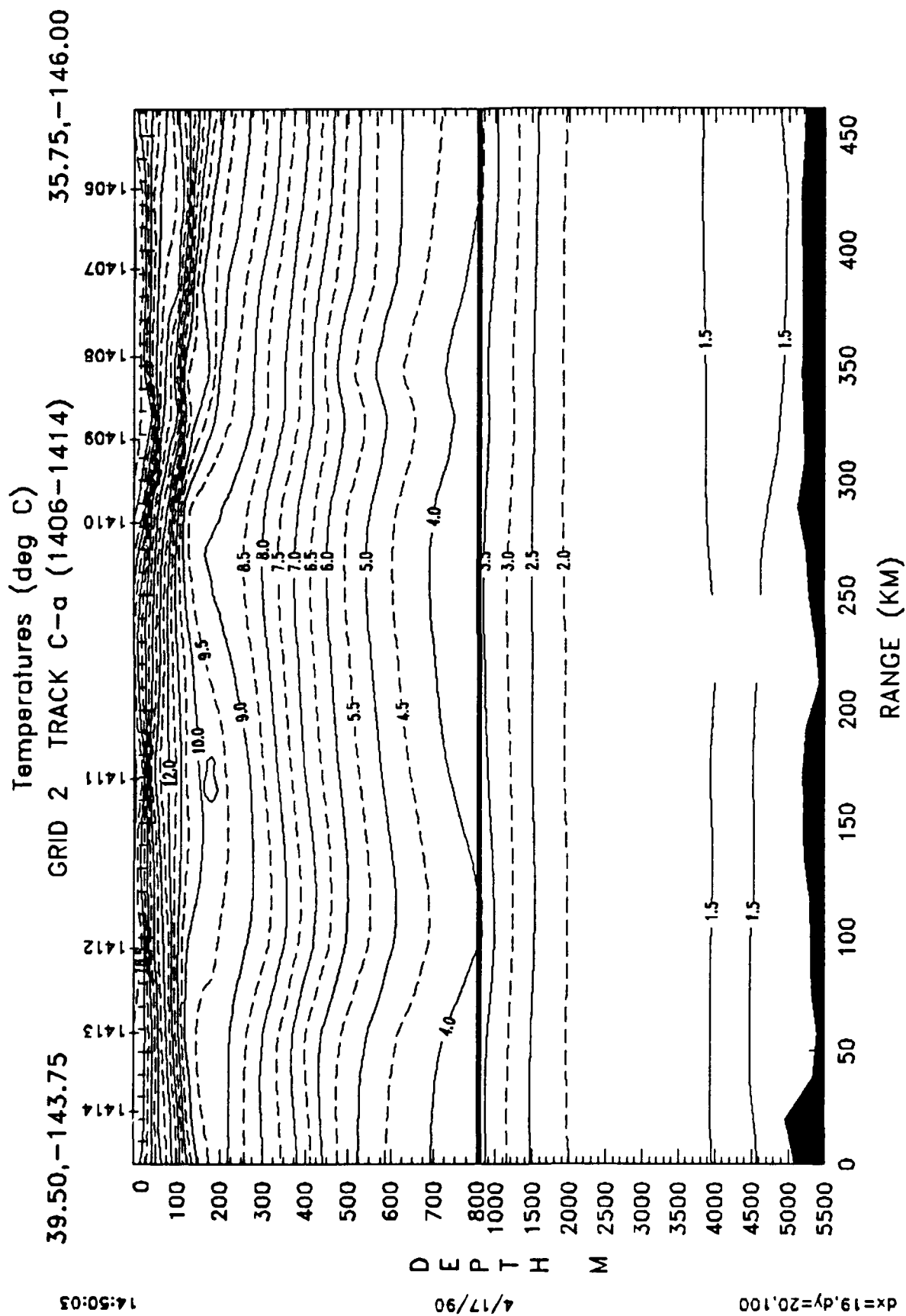
NOARL Code 331



LAT 39.3 39.0 38.8 38.5 38.3 38.0 37.8 37.5 37.3 37.0 36.8 36.5 36.3 36.0 35.8 35.5

LONG -143.0 -143.3 -143.8 -144.0 -144.3 -144.5 -144.8 -145.0 -145.3

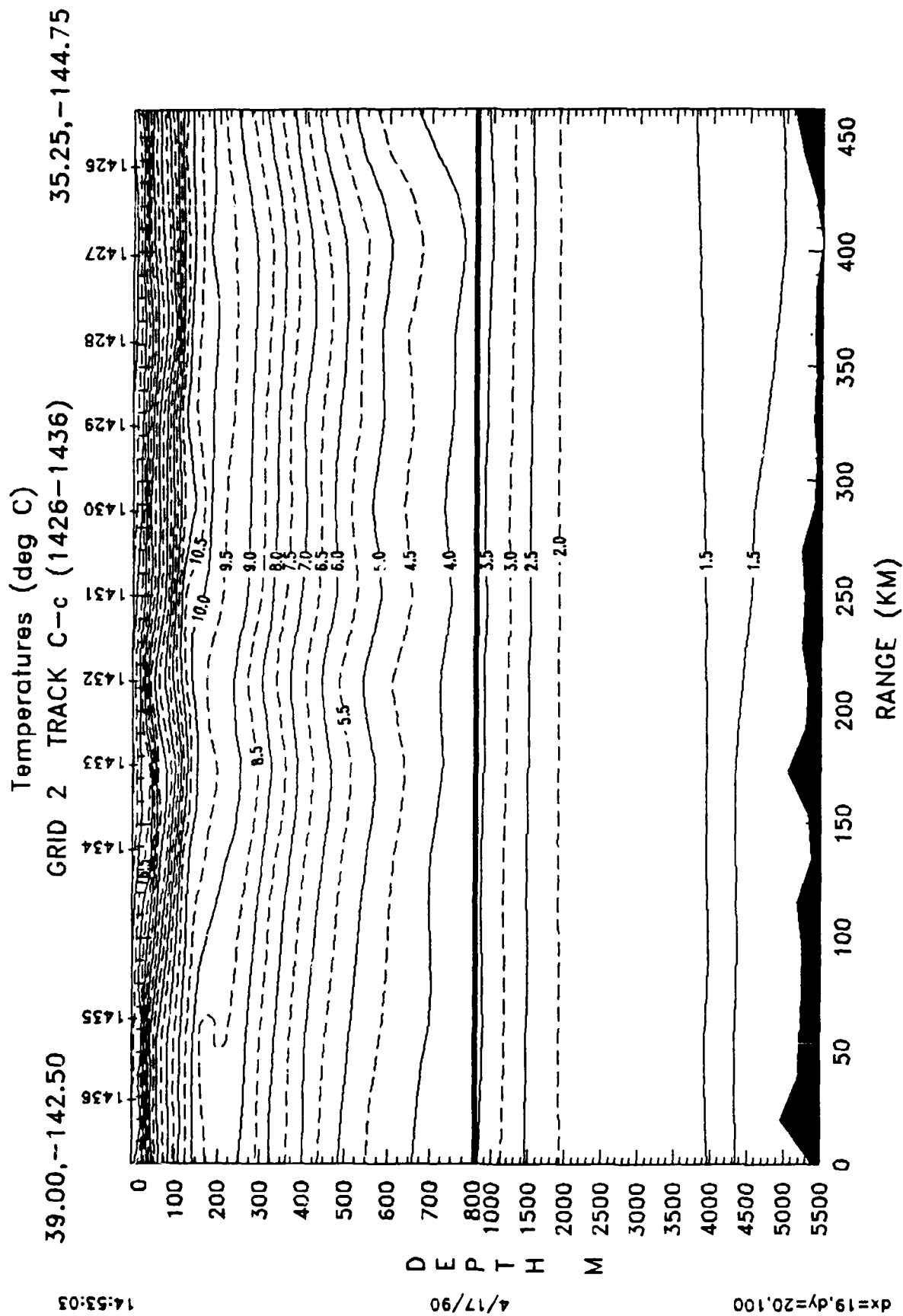
NOARL Code 331



LAT 39.5 39.3 39.0 38.8 38.5 38.3 38.0 37.8 37.5 37.3 37.0 36.8 36.5 36.3 36.0 35.8

LONG -143.8 -144.0 -144.3 -144.5 -144.8 -145.0 -145.3 -145.5 -145.8 -146.0

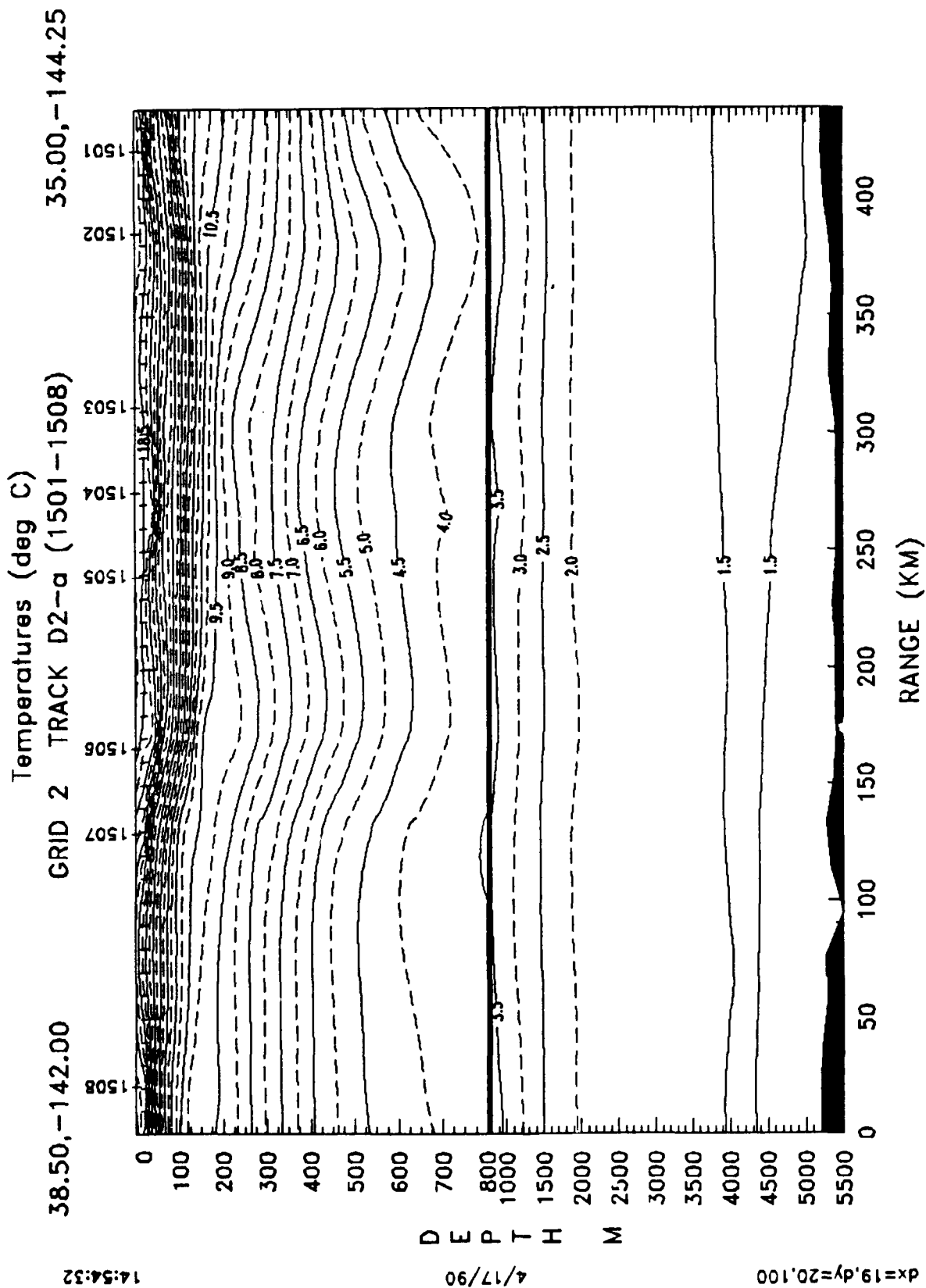
NOARL Code 331



LAT 39.0 38.8 38.5 38.3 38.0 37.8 37.5 37.3 37.0 36.8 36.5 36.3 36.0 35.8 35.5 35.3

LONG -142.5 -142.8 -143.0 -143.3 -143.5 -143.8 -144.0 -144.3 -144.5 -144.8

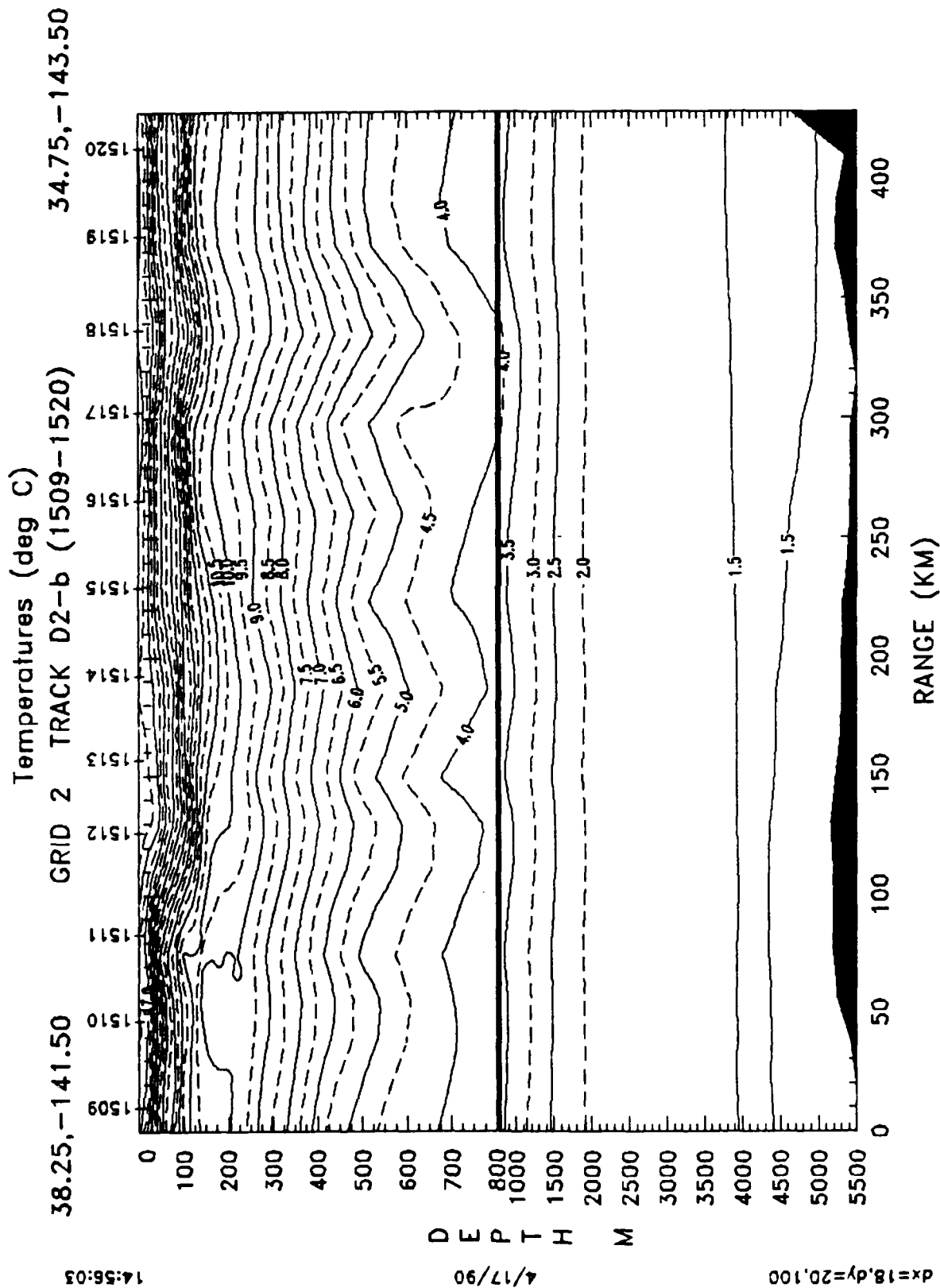
NOARL Code 331



LAT 38.5 38.3 38.0 37.8 37.5 37.3 37.0 36.8 36.5 36.3 36.0 35.8 35.5 35.3 35.0

LONG -142.0 -142.3 -142.5 -142.8 -143.0 -143.3 -143.5 -143.8 -144.0 -144.3

NOARL Code 331



LAT 38.3 38.0 37.8 37.5 37.3 37.0 36.8 36.5 36.3 36.0 35.8 35.5 35.3 35.0 34.8

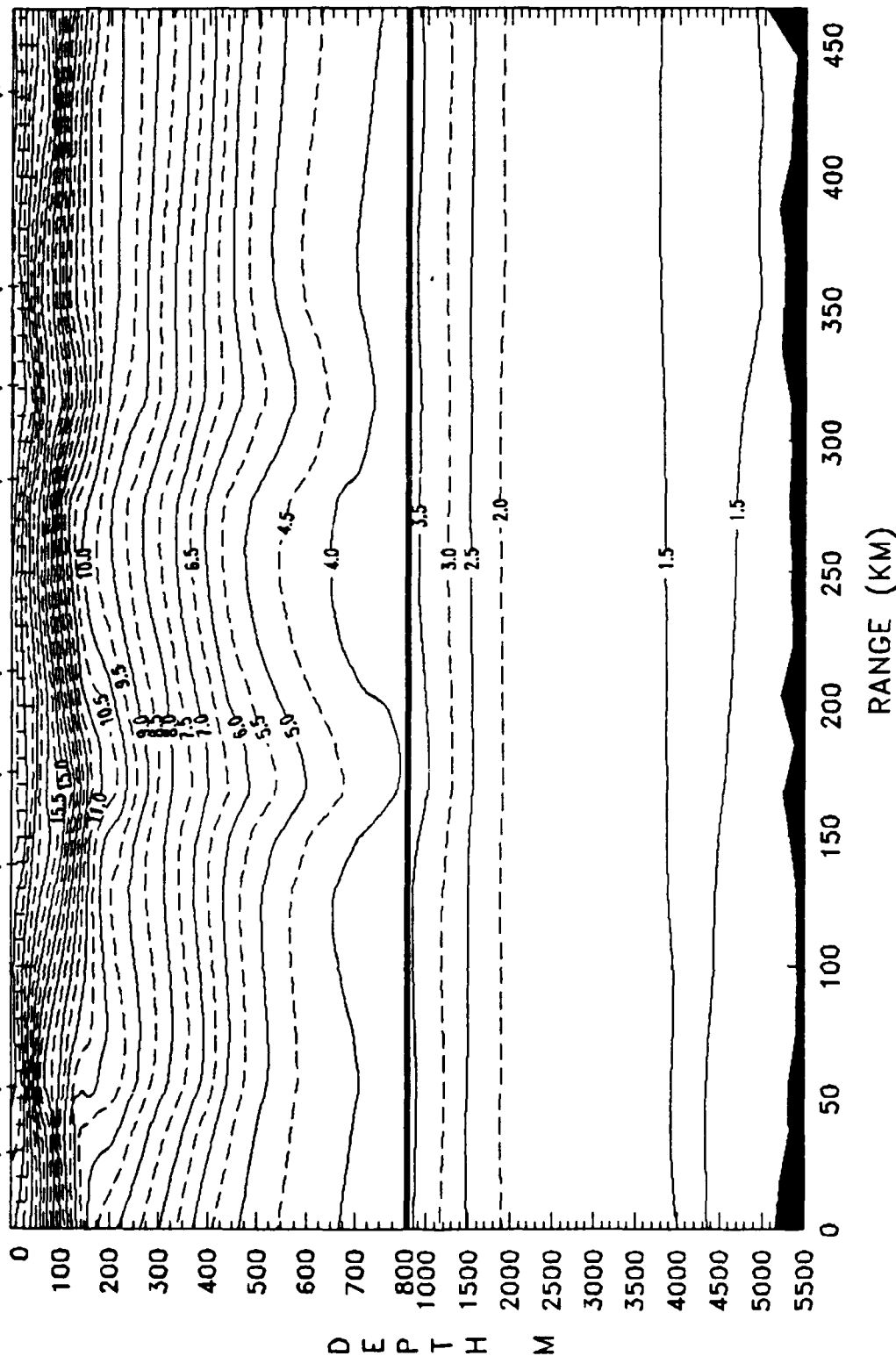
LONG -141.5 -141.8 -142.0 -142.3 -142.5 -142.8 -143.0 -143.3 -143.5

NOARL Code 331

Temperatures (deg C) GRID 2 TRACK D2-c (1521-1529) 34.00,-142.50

37.75,-140.25

14:57:33



LAT 37.8 37.5 37.3 37.0 36.8 36.5 36.3 36.0 35.8 35.5 35.3 35.0 34.8 34.5 34.3 34.0
 LONG -140.3 -140.5 -140.8 -141.0 -141.3 -141.5 -141.8 -142.0 -142.3 -142.5

NOARL Code 331

DEPTH M

4/17/90

dx=18,dy=20,100

$$dx = 19, dy = 20, dz = 10$$

33.75,-141.00

NOARL Code 331

Appendix J.

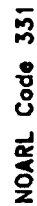
NEPAC Grid 2 (6 - 7 July 1989)

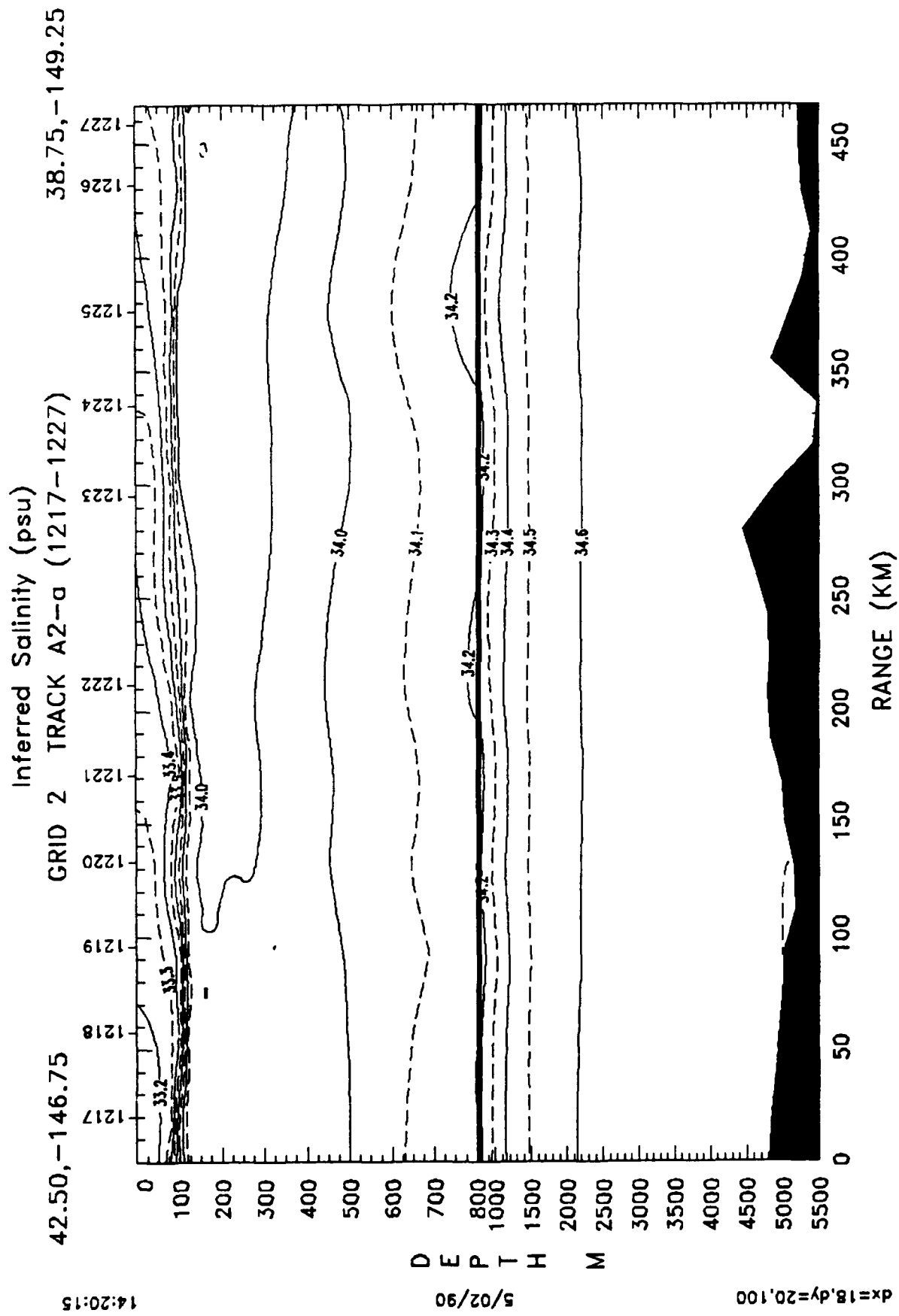
Inferred Salinity Contours along Selected Vertical Transects

Surface to 5500 m

8:55:51

06/60/5





LAT 42.5 42.3 42.0 41.8 41.5 41.3 41.0 40.8 40.5 40.3 40.0 39.8 39.5 39.3 39.0 38.8

LONG -146.8 -147.0 -147.3 -147.5 -147.8 -148.0 -148.3 -148.5 -148.8 -149.0 -149.3

NOARL Code 331

Inferred Salinity (psu)

41.60, -145.85 1216 1215 1214 1213 1212 1211 1210 1209 1208 1207 1206 1205 1204 1203 1202 1201

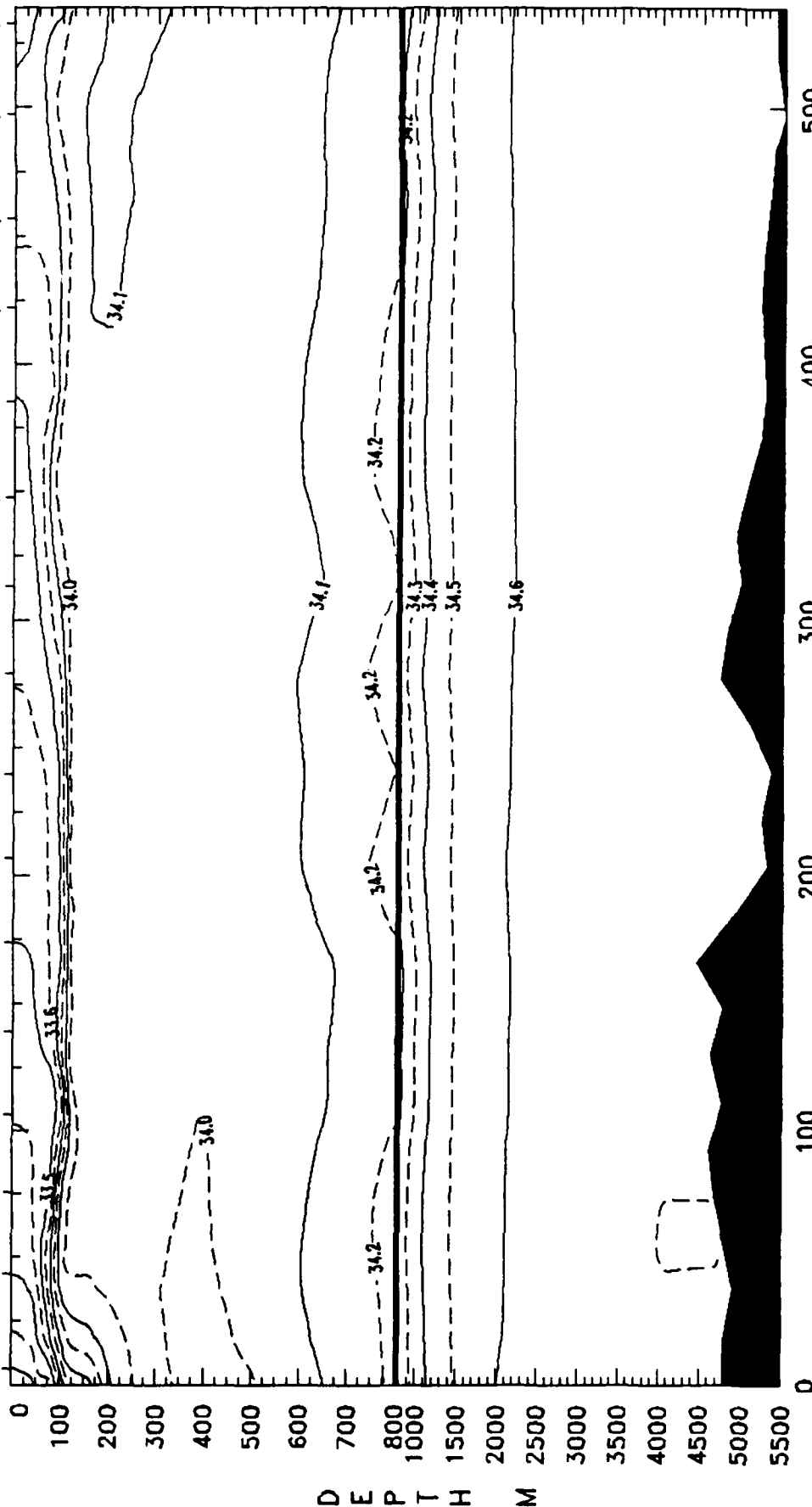
GRID 2 TRACK A2-b (1201-1216)

37.30, -148.75

14:30:46

5/02/90

dx=18,dy=20,100



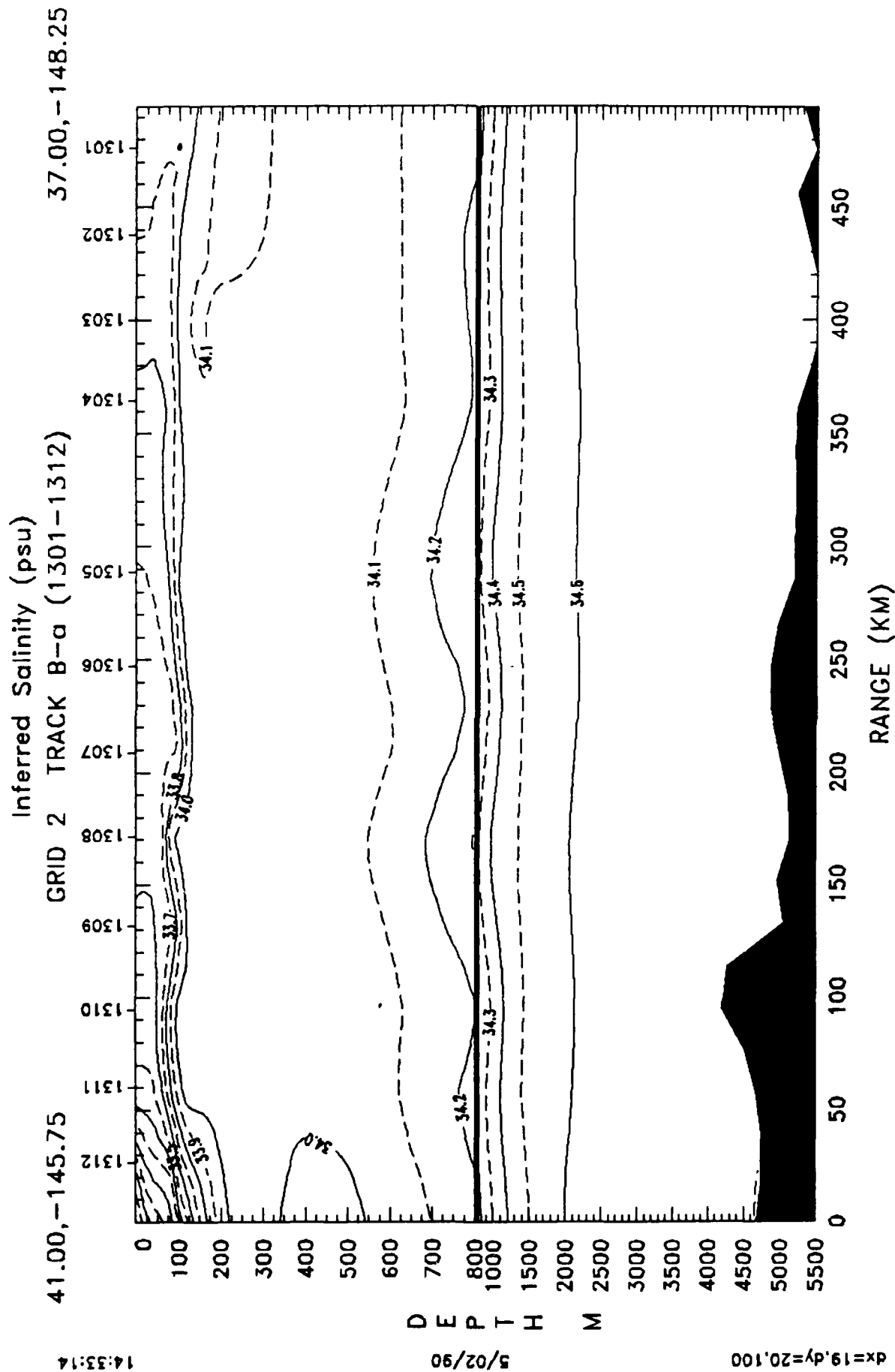
RANGE (KM)

LAT

LONG

41.5 41.0 40.5 40.0 39.5 39.0 38.5 38.0 37.5

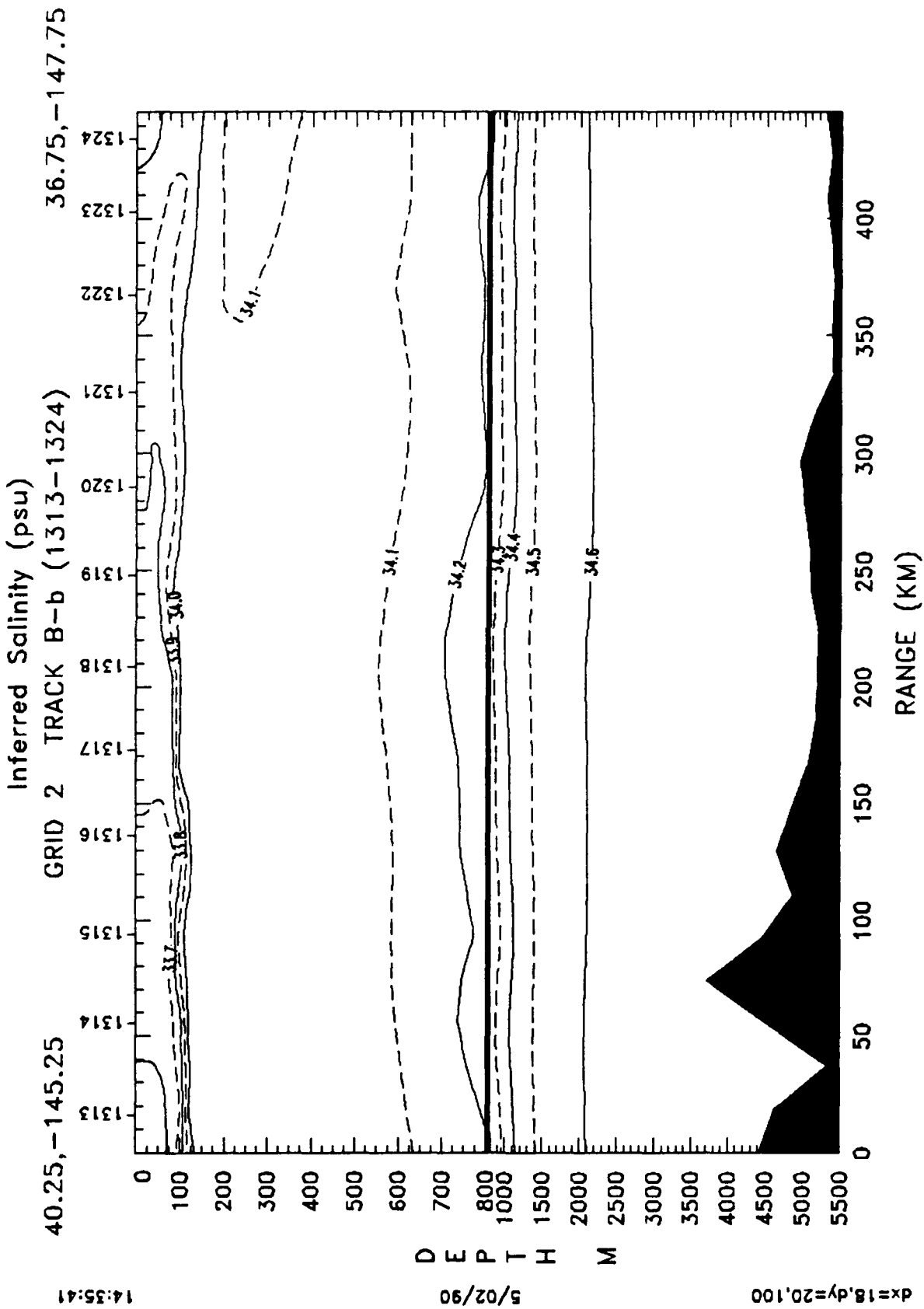
NOARL Code 331



LAT 41.0 40.5 40.0 39.5 39.0 38.5 38.0 37.5 37.0

LONG -145.8 -146.0 -146.3 -146.5 -146.8 -147.0 -147.3 -147.5 -147.8 -148.0 -148.3

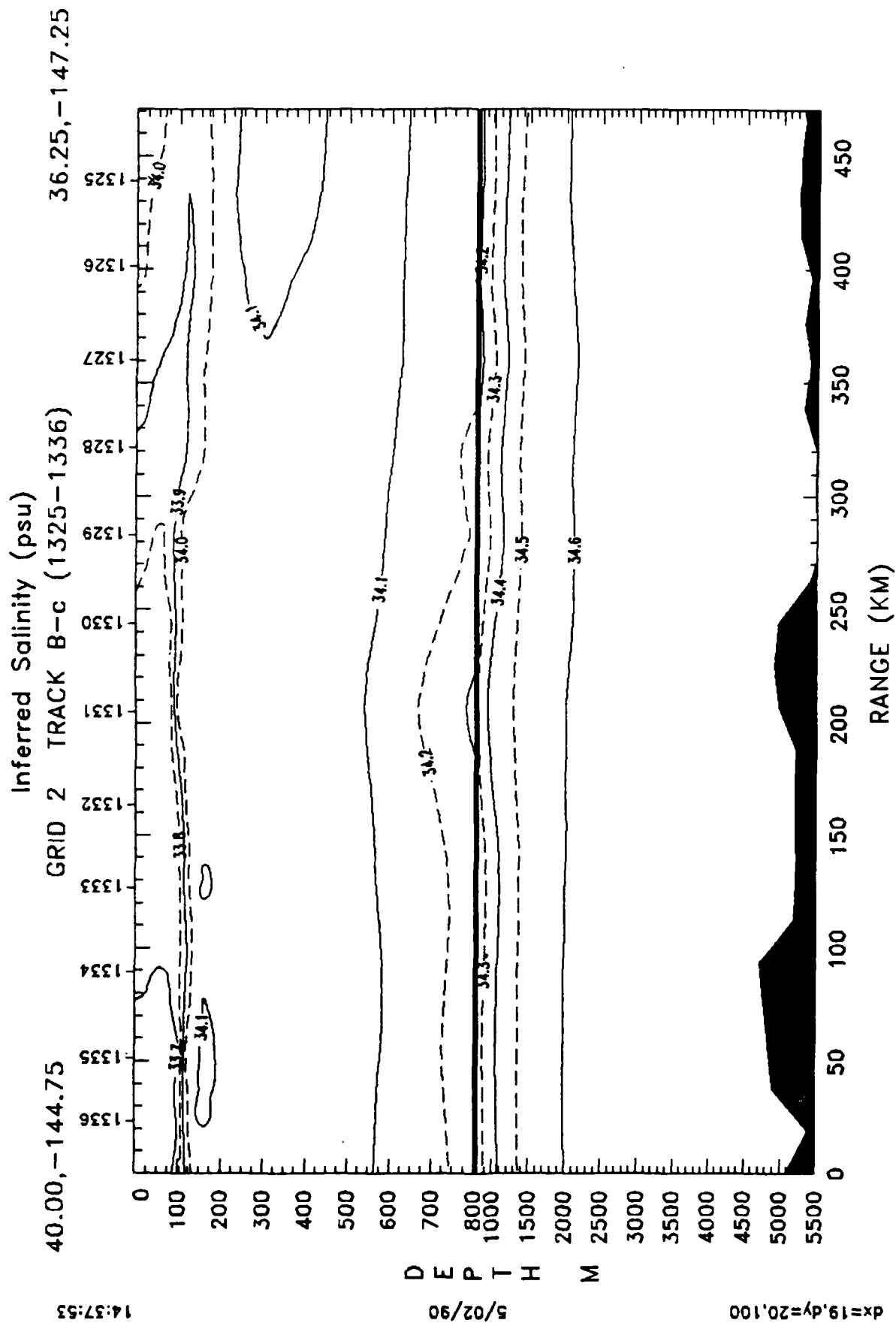
NOARL Code 331



LAT 40.3 40.0 39.8 39.5 39.3 39.0 38.8 38.5 38.3 38.0 37.8 37.5 37.3 37.0 36.8

LONG -145.3 -145.5 -145.8 -146.0 -146.3 -146.5 -146.8 -147.0 -147.3 -147.5 -147.8

NOARL Code 331



LAT 40.0 39.8 39.5 39.3 39.0 38.8 38.5 38.3 38.0 37.8 37.5 37.3 37.0 36.8 36.5 36.3

LONG -144.8 -145.0 -145.3 -145.5 -145.8 -146.0 -146.3 -146.5 -146.8 -147.0 -147.3

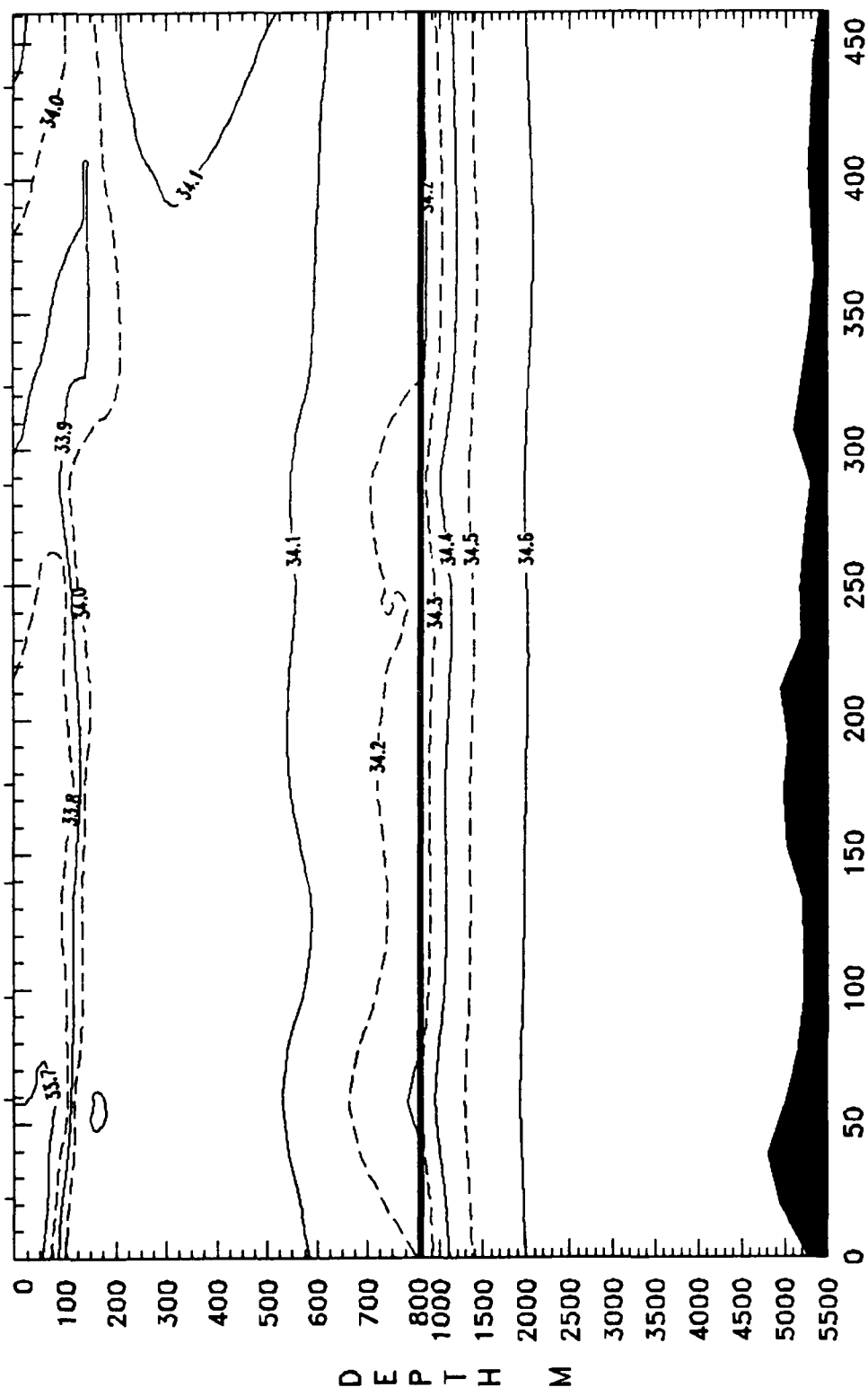
NOARL Code 331

Inferred Salinity (psu)
 GRID 2 TRACK B-d (1337-1405)
 39.75,-144.25 36.00,-146.50

14:40:12

5/02/90

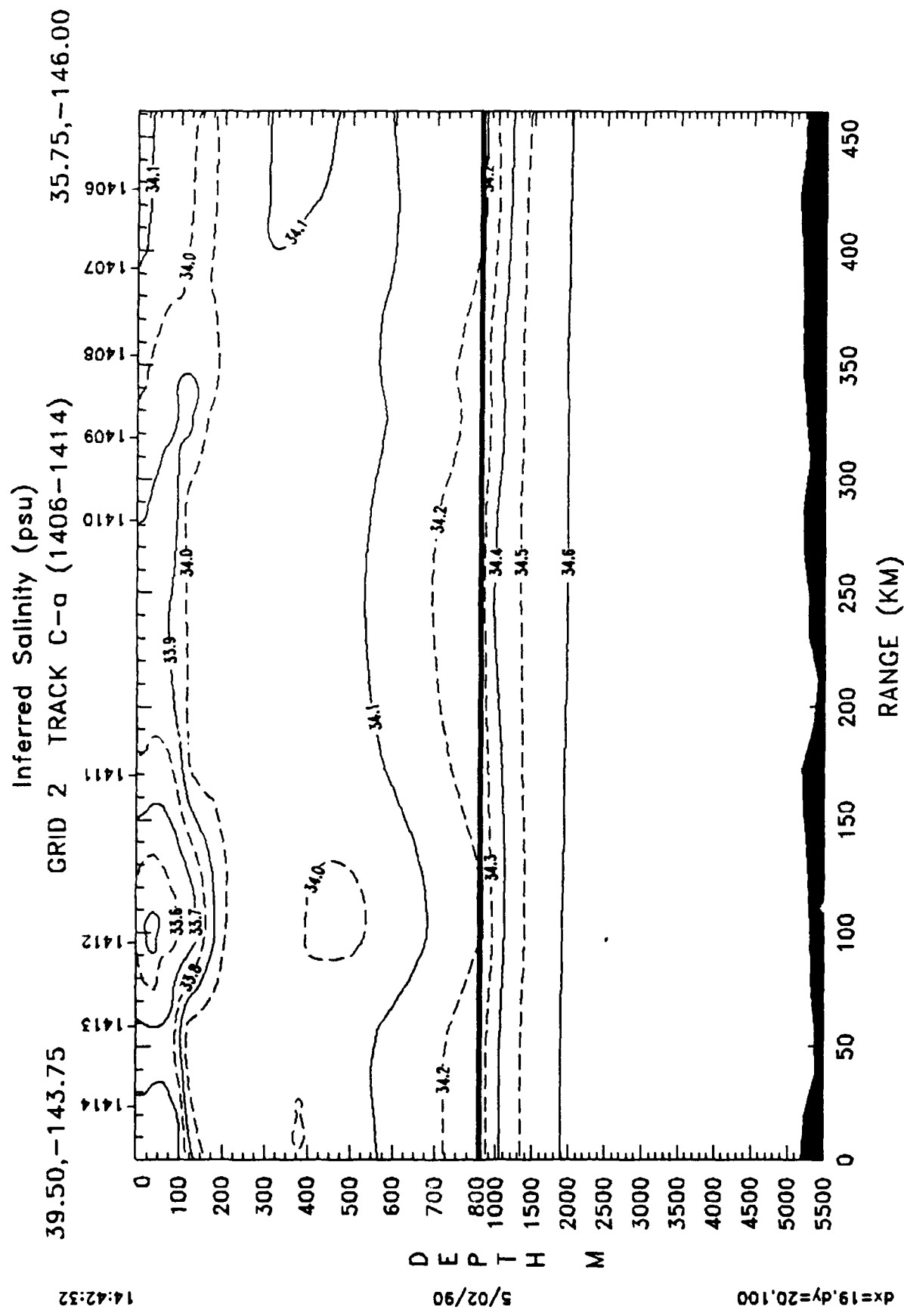
dx=19,dy=20,100



RANGE (KM)

LAT 39.8 39.5 39.3 39.0 38.8 38.5 38.3 38.0 37.8 37.5 37.3 37.0 36.8 36.5 36.3 36.0
 LONG -144.3 -144.5 -144.8 -145.0 -145.3 -145.5 -145.8 -146.0 -146.3 -146.5

NOARL Code 331



LAT 39.5 39.3 39.0 38.8 38.5 38.3 38.0 37.8 37.5 37.3 37.0 36.8 36.5 36.3 36.0 35.8

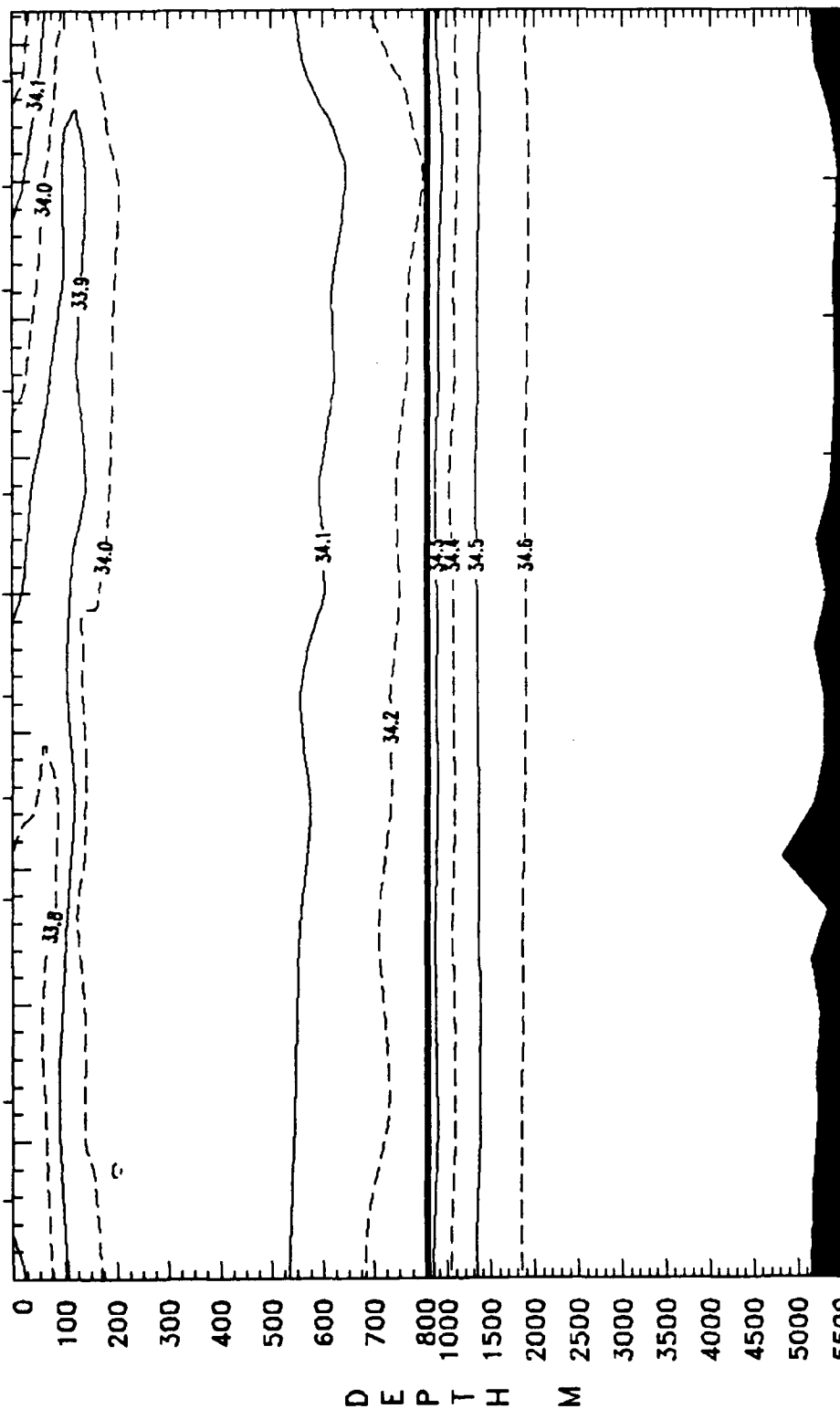
LONG -143.8 -144.0 -144.3 -144.5 -144.8 -145.0 -145.3 -145.5 -145.8 -146.0

NOARL Code 331

Inferred Salinity (psu) GRID 2 TRACK C-c (1426-1436)

39.00,-142.50 35.25,-144.75

14:46:52



RANGE (KM)

LAT 39.0 38.8 38.5 38.3 38.0 37.8 37.5 37.3 37.0 36.8 36.5 36.3 36.0 35.8 35.5 35.3
 LONG -142.5 -142.8 -143.0 -143.3 -143.5 -143.8 -144.0 -144.3 -144.5 -144.8

NOARL Code 331

D E P T H

5/02/90

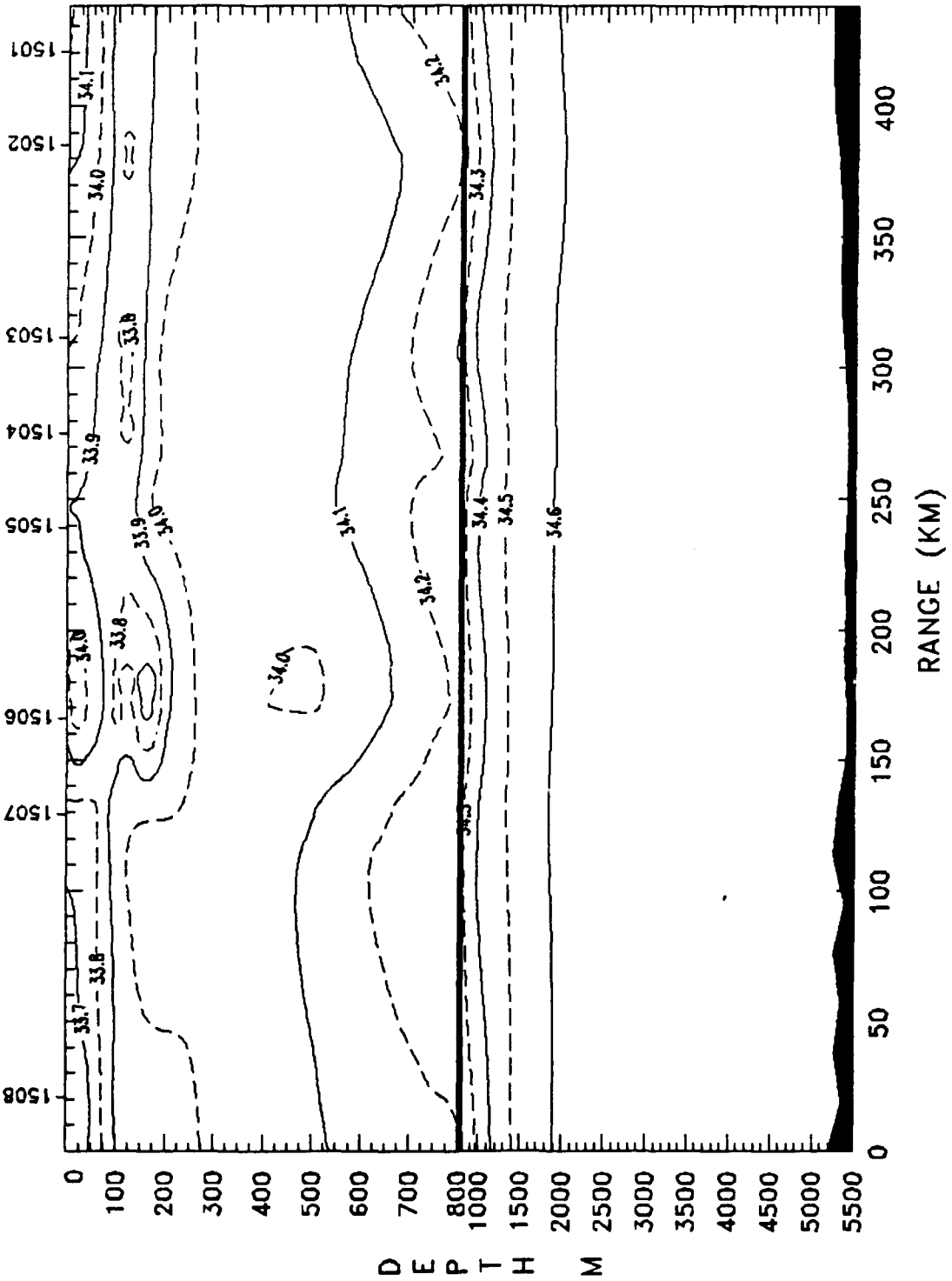
dx=19,dy=20,100

Inferred Salinity (psu)
 GRID 2 TRACK D2-a (1501-1508) 35.00, -144.25
 38.50, -142.00

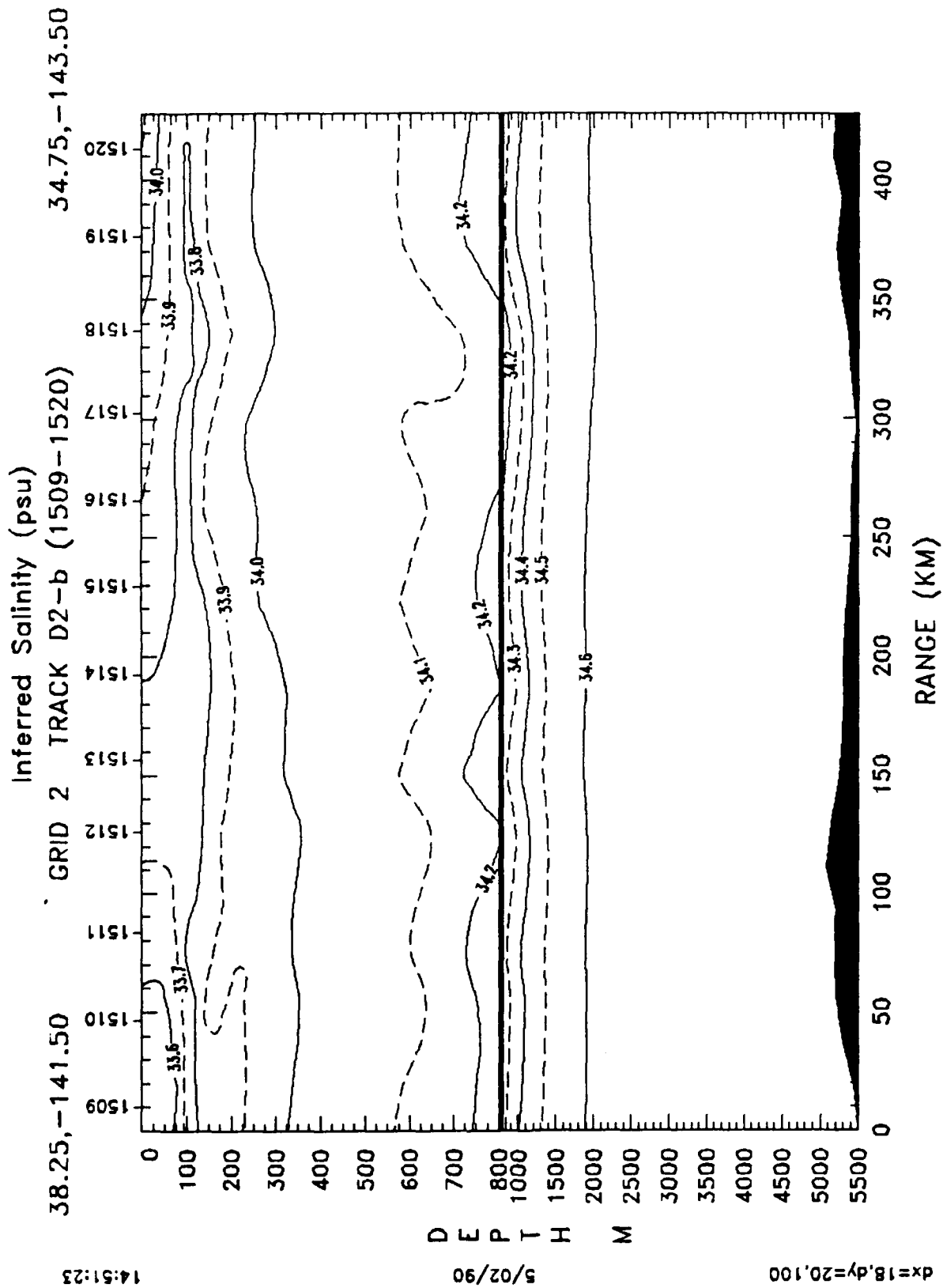
14:49:06

5/02/90

dx=19,dy=20,100



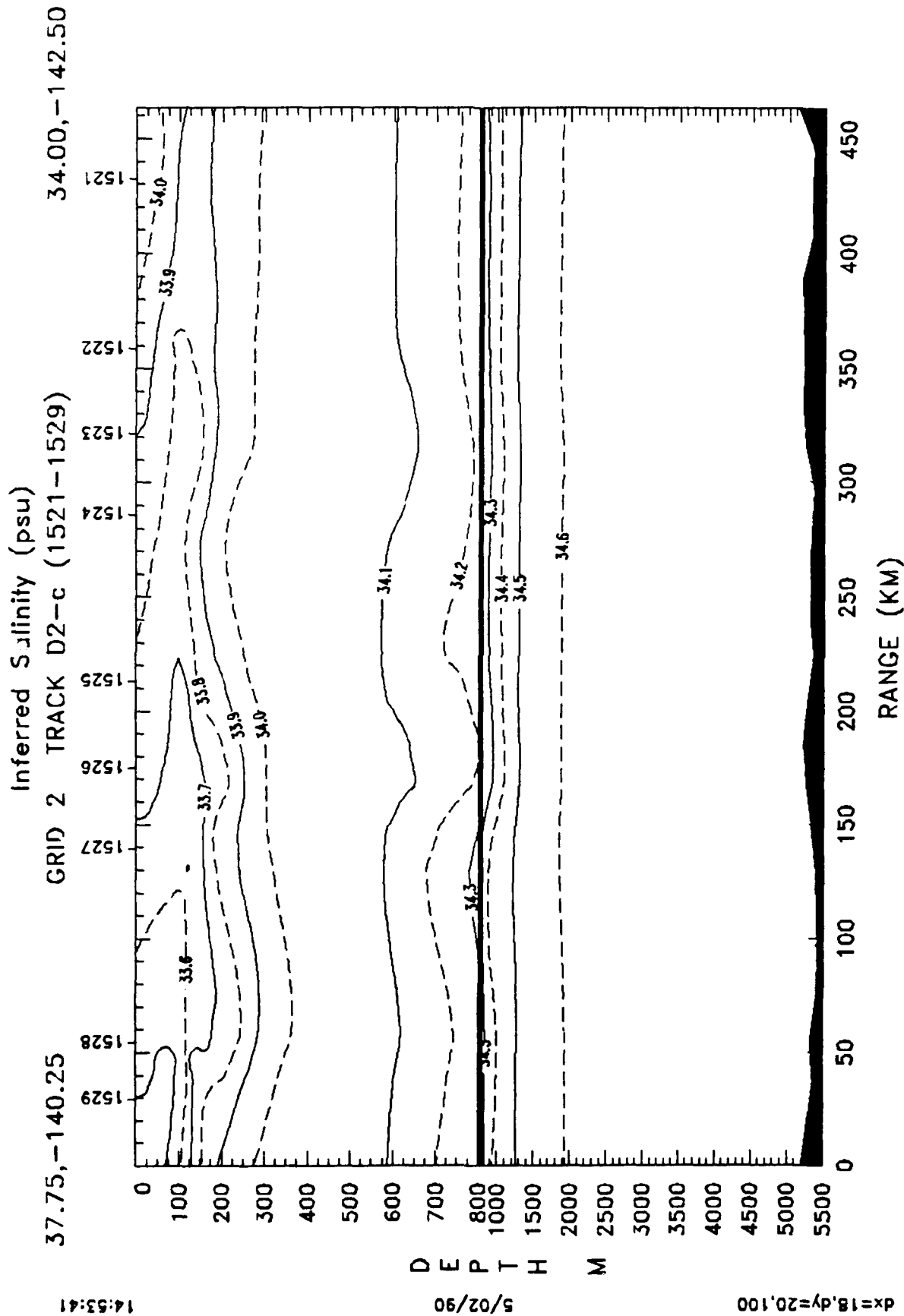
LAT 38.5 38.3 38.0 37.8 37.5 37.3 37.0 36.8 36.5 36.3 36.0 35.8 35.5 35.3 35.0
 LONG -142.0 -142.3 -142.5 -142.8 -143.0 -143.3 -143.5 -143.8 -144.0 -144.3
 NOARL Code 331



LAT 38.3 38.0 37.8 37.5 37.3 37.0 36.8 36.5 36.3 36.0 35.8 35.5 35.3 35.0 34.8

LONG -141.5 -141.8 -142.0 -142.3 -142.5 -142.8 -143.0 -143.3 -143.5

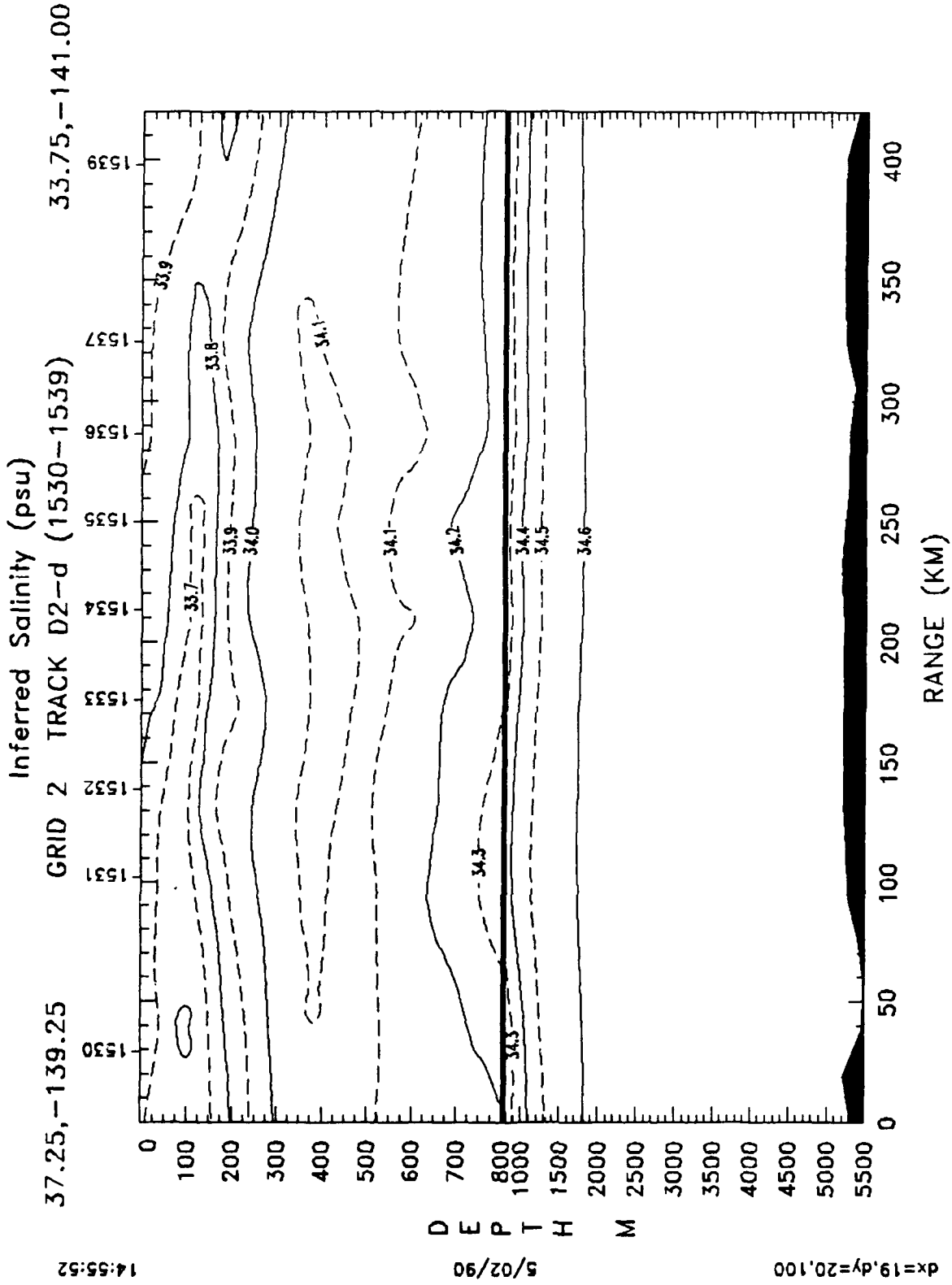
NOARL Code 331



LAT 37.8 37.5 37.3 37.0 36.8 36.5 36.3 36.0 35.8 35.5 35.3 35.0 34.8 34.5 34.3 34.0

LONG -140.3 -140.5 -140.8 -141.0 -141.3 -141.5 -141.8 -142.0 -142.3 -142.5

NOARL Code 331



LAT 37.3 37.0 36.8 36.5 36.3 36.0 35.8 35.5 35.3 35.0 34.8 34.5 34.3 34.0 33.8

LONG -139.3 -139.5 -139.8 -140.0 -140.3 -140.5 -140.8 -141.0

NOARL Code 331

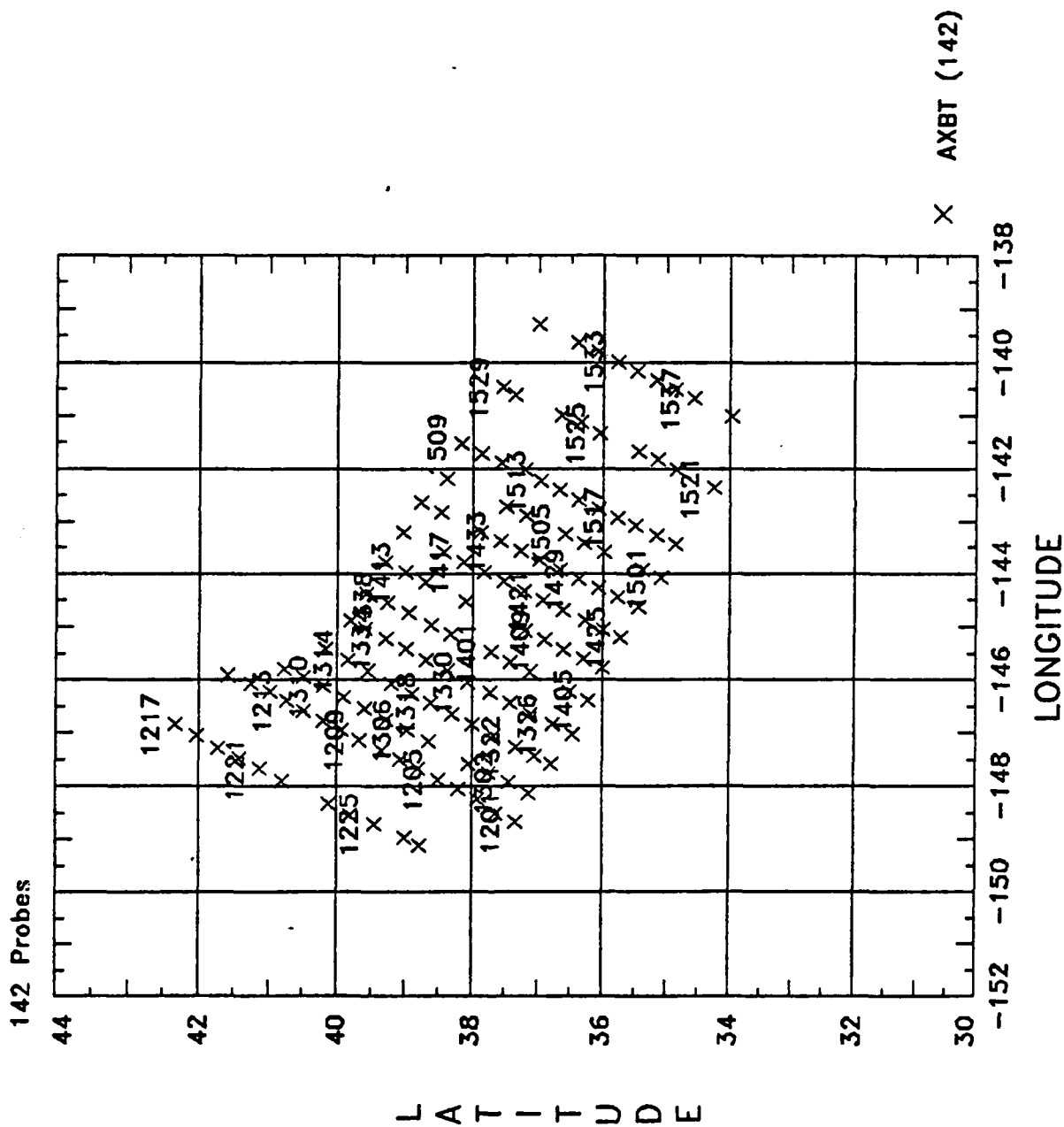
Appendix K

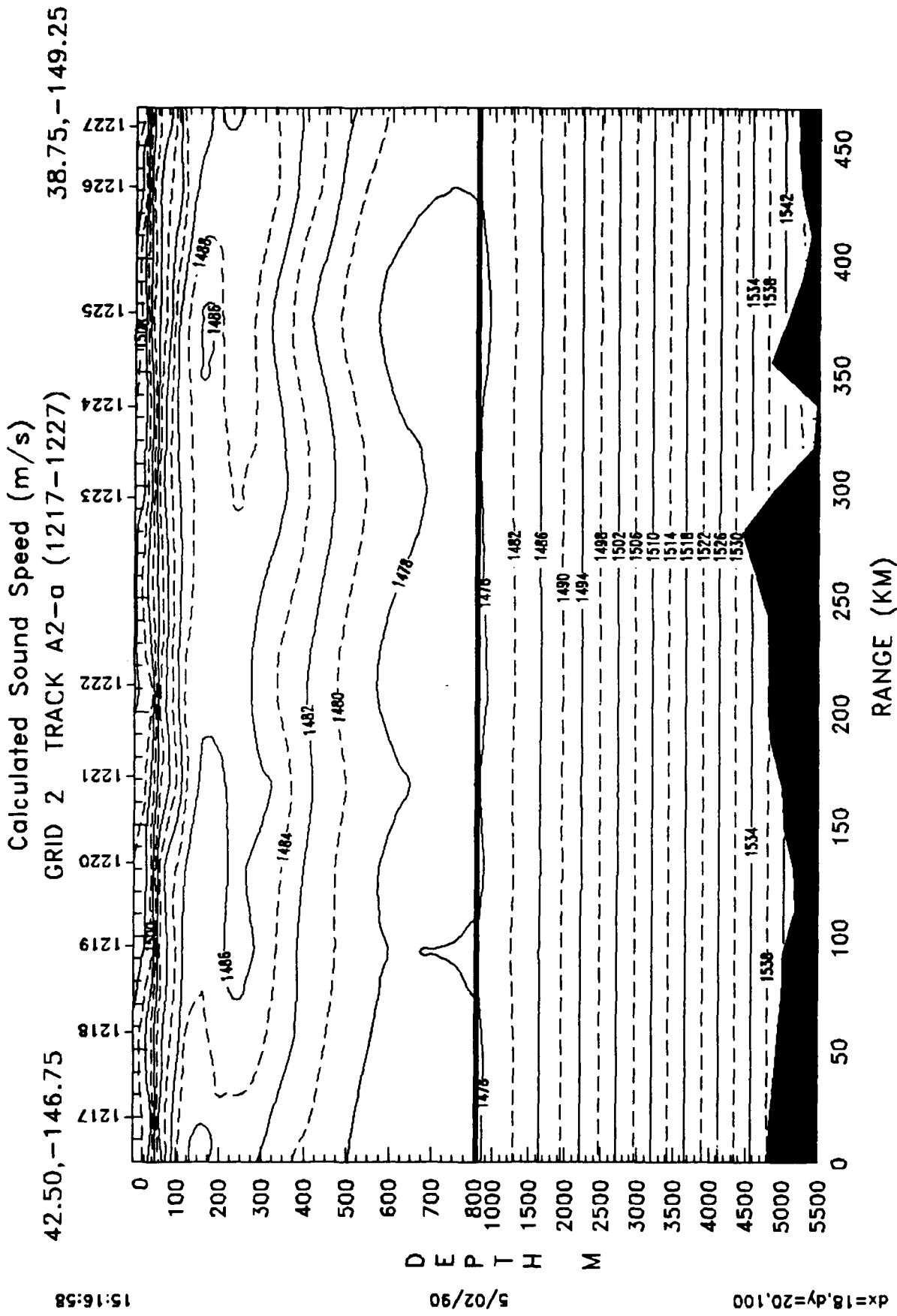
NEPAC Grid 2 (6 - 7 July 1989)

Calculated Sound Speed Contours along Selected Vertical Transects

Surface to 5500 m

NEPAC Grid 2 (6-7 July 1989)



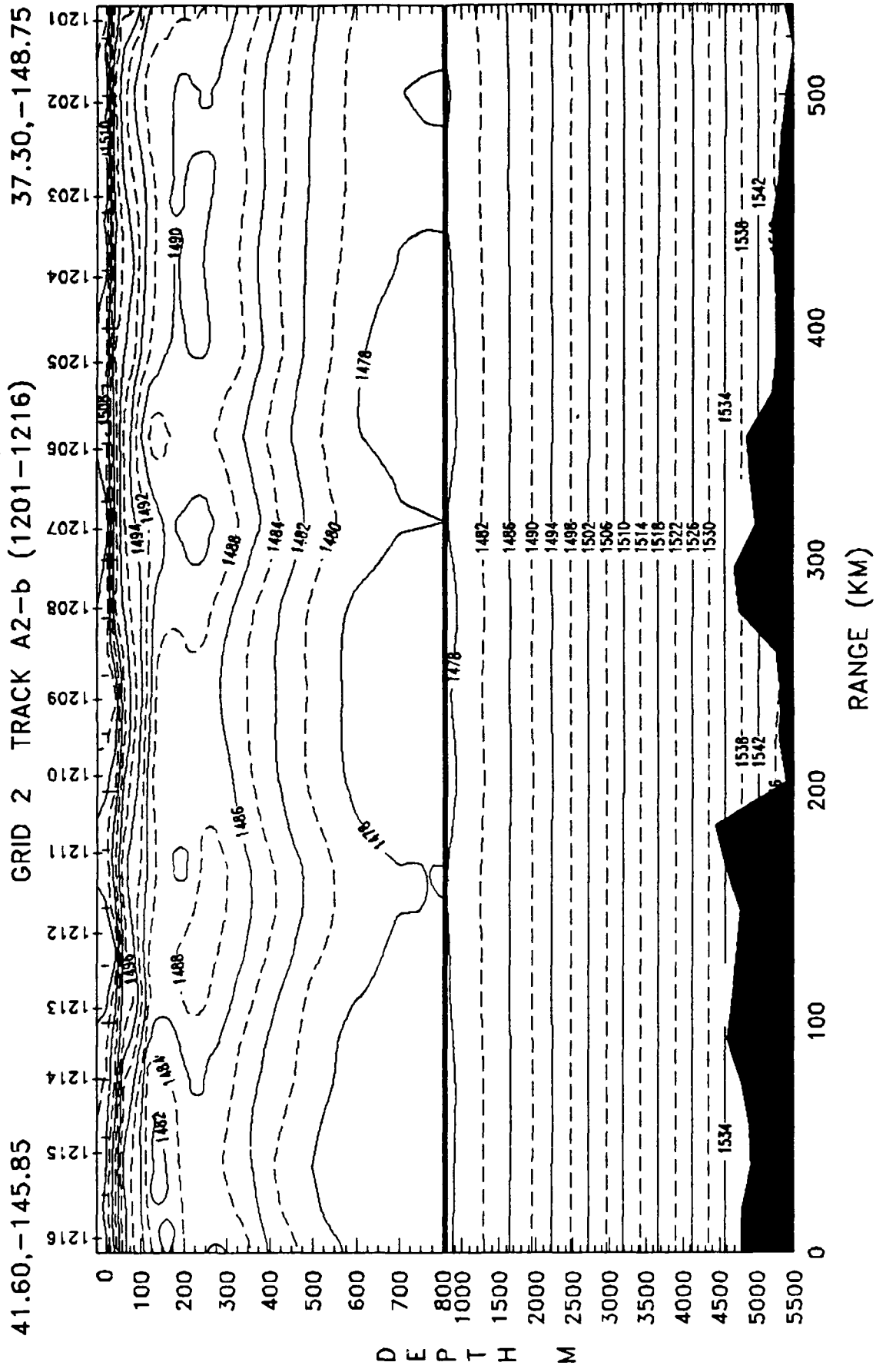


LAT 42.5 42.3 42.0 41.8 41.5 41.3 41.0 40.8 40.5 40.3 40.0 39.8 39.5 39.3 39.0 38.8

LONG -146.8 -147.0 -147.3 -147.5 -147.8 -148.0 -148.3 -148.5 -148.8 -149.0 -149.3

NOARL Code 331

Calculated Sound Speed (m/s)
 GRID 2 TRACK A2-b (1201-1216)



LAT 41.5 41.0 40.5 40.0 39.5 39.0 38.5 38.0 37.5
 LONG -146.0 -146.2 -146.5 -146.7 -147.0 -147.2 -147.5 -147.7 -148.0 -148.2 -148.5 -148.7
 NOARL Code 331

14:00:53

4/17/90

dx=18,dy=20,100

Calculated Sound Speed (m/s) GRID 2 TRACK B-a (1301-1312)

41.00,-145.75

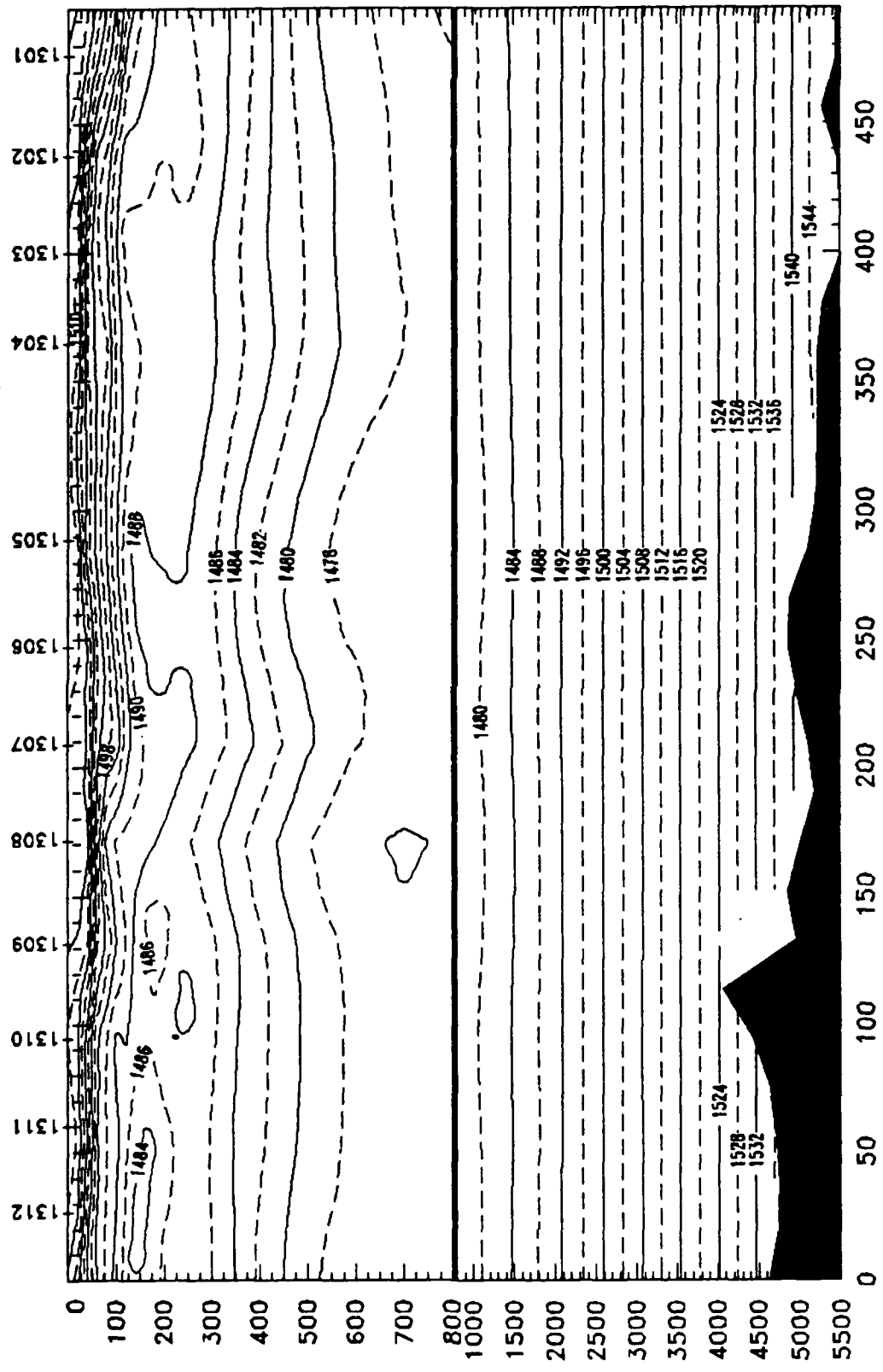
37.00,-148.25

14:02:30

DEPTH M

4/17/90

dx=19,dy=20,100

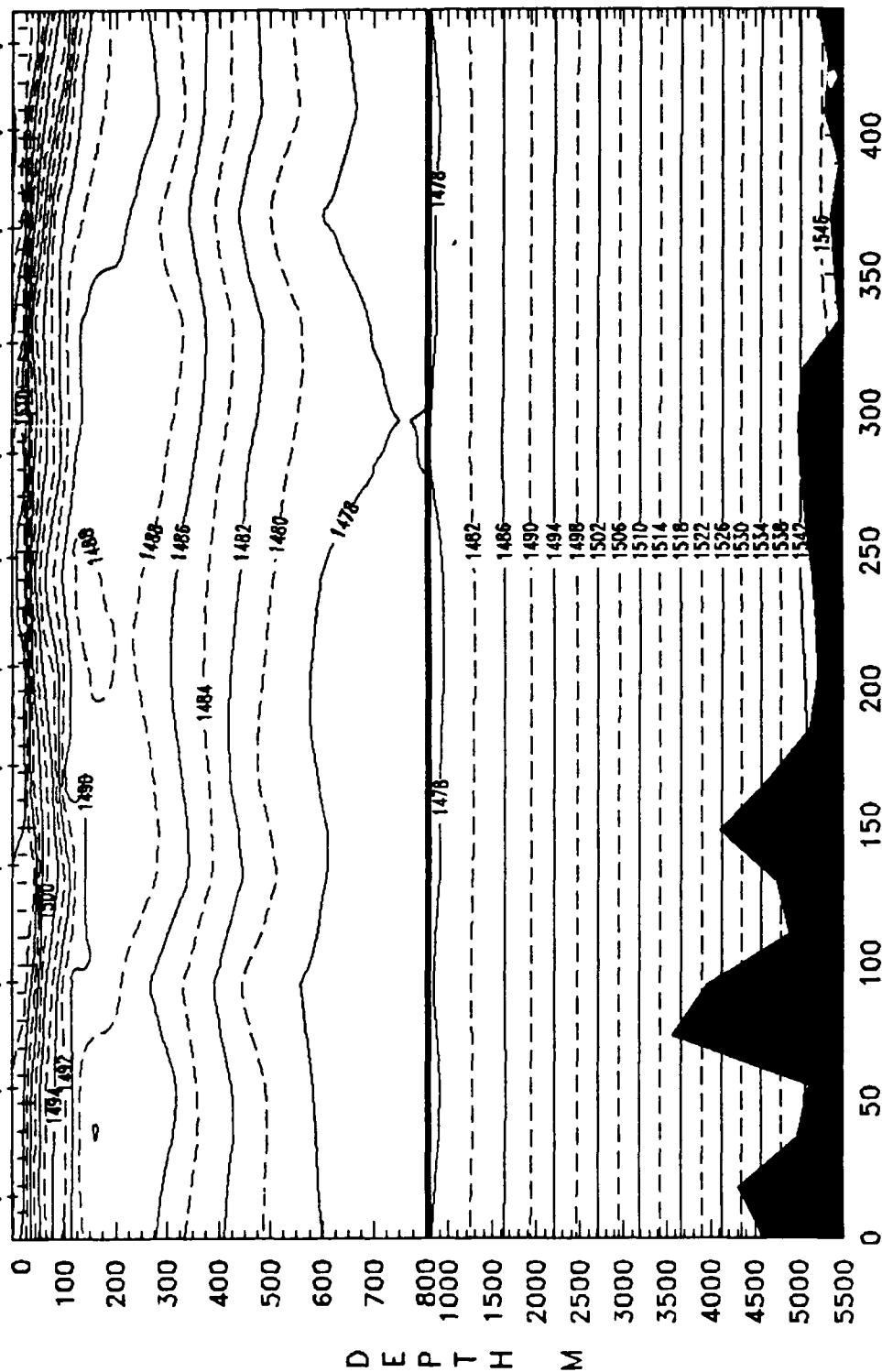


RANGE (KM)

LAT 41.0 40.5 40.0 39.5 39.0 38.5 38.0 37.5 37.0
LONG -145.8 -146.0 -146.3 -146.5 -146.8 -147.0 -147.3 -147.5 -147.8 -148.0 -148.3

40.25,-145.25
 Calculated Sound Speed (m/s)
 GRID 2 TRACK B-b (1313-1324)
 36.75,-147.75

14:04:05



RANGE (KM)

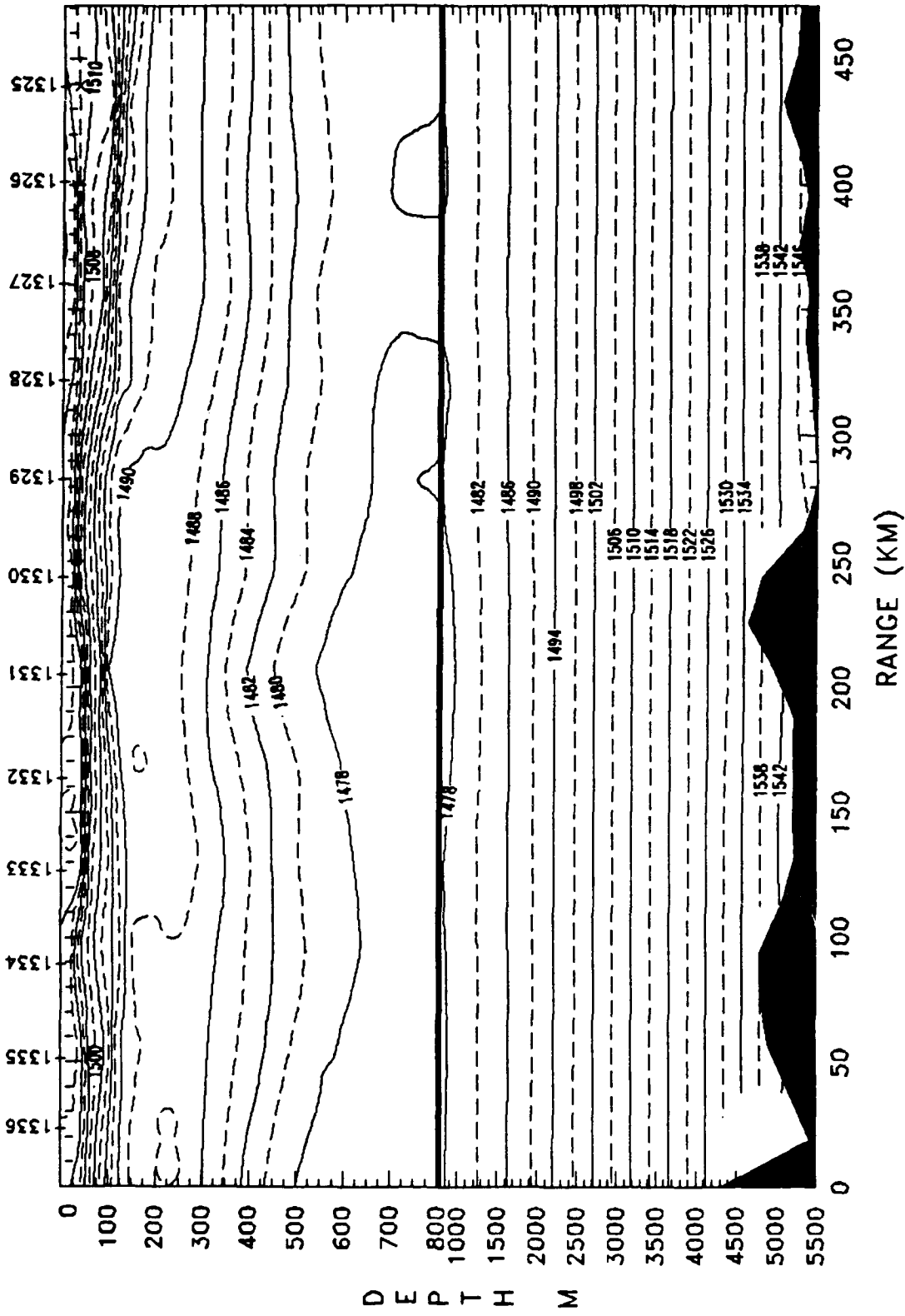
LAT 40.3 40.0 39.8 39.5 39.3 39.0 38.8 38.5 38.3 38.0 37.8 37.5 37.3 37.0 36.8
 LONG -145.3 -145.5 -145.8 -146.0 -146.3 -146.5 -146.8 -147.0 -147.3 -147.5 -147.8

NOARL Code 331

dx=18,dy=20,100

4/17/90

40.00, -144.75
 14:09:36
 Calculated Sound Speed (m/s)
 GRID 2 TRACK B-c (1325-1336)
 36.25, -147.25



LAT 40.0 39.8 39.5 39.3 39.0 38.8 38.5 38.3 38.0 37.8 37.5 37.3 37.0 36.8 36.5 36.3
 LONG -144.8 -145.0 -145.3 -145.5 -145.8 -146.0 -146.3 -146.5 -146.8 -147.0 -147.3

Calculated Sound Speed (m/s)
 GRID 2 TRACK B-d (1337-1405)

39.75, -144.25

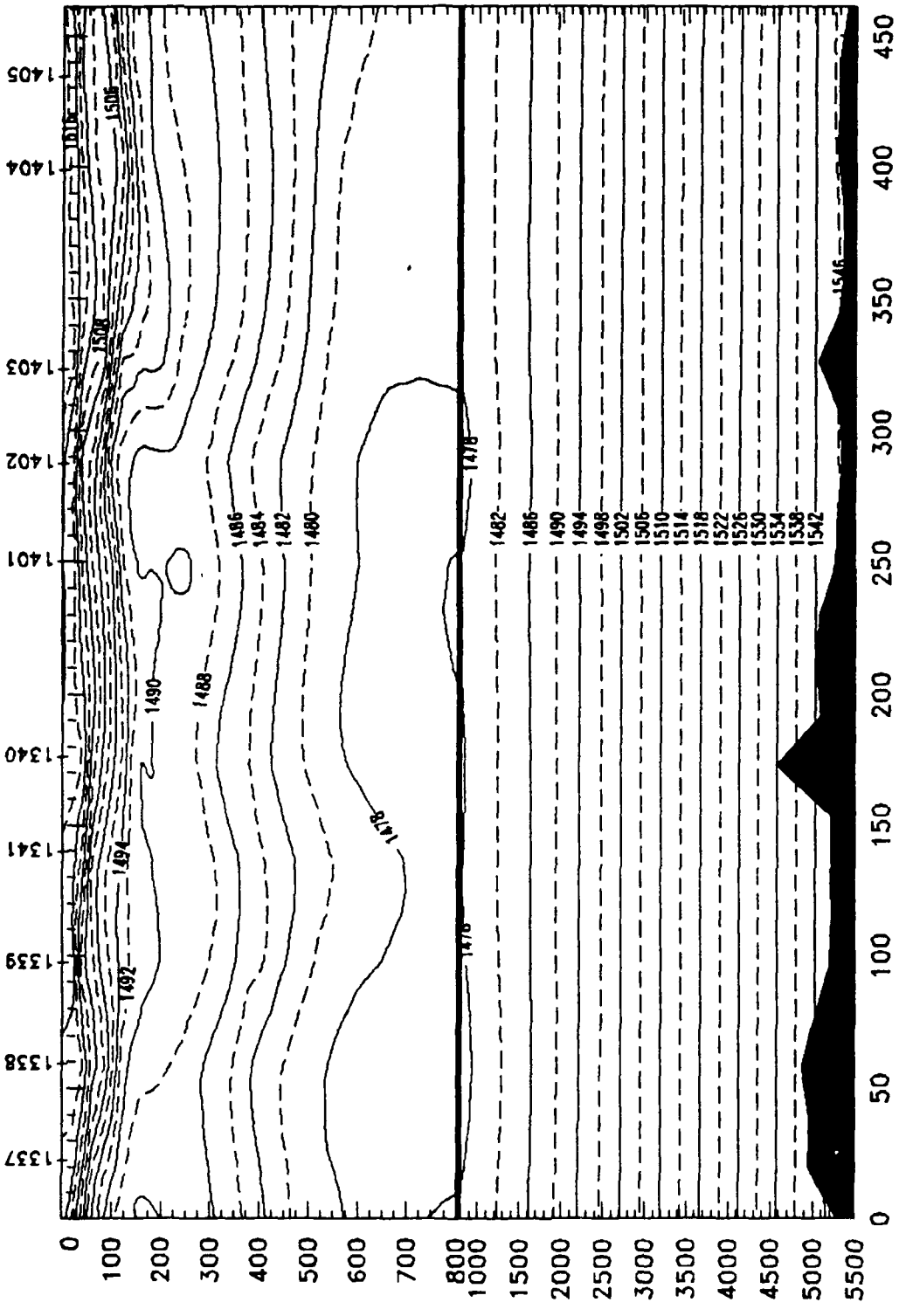
36.00, -146.50

14:07:11

DEPTH M

4/17/90

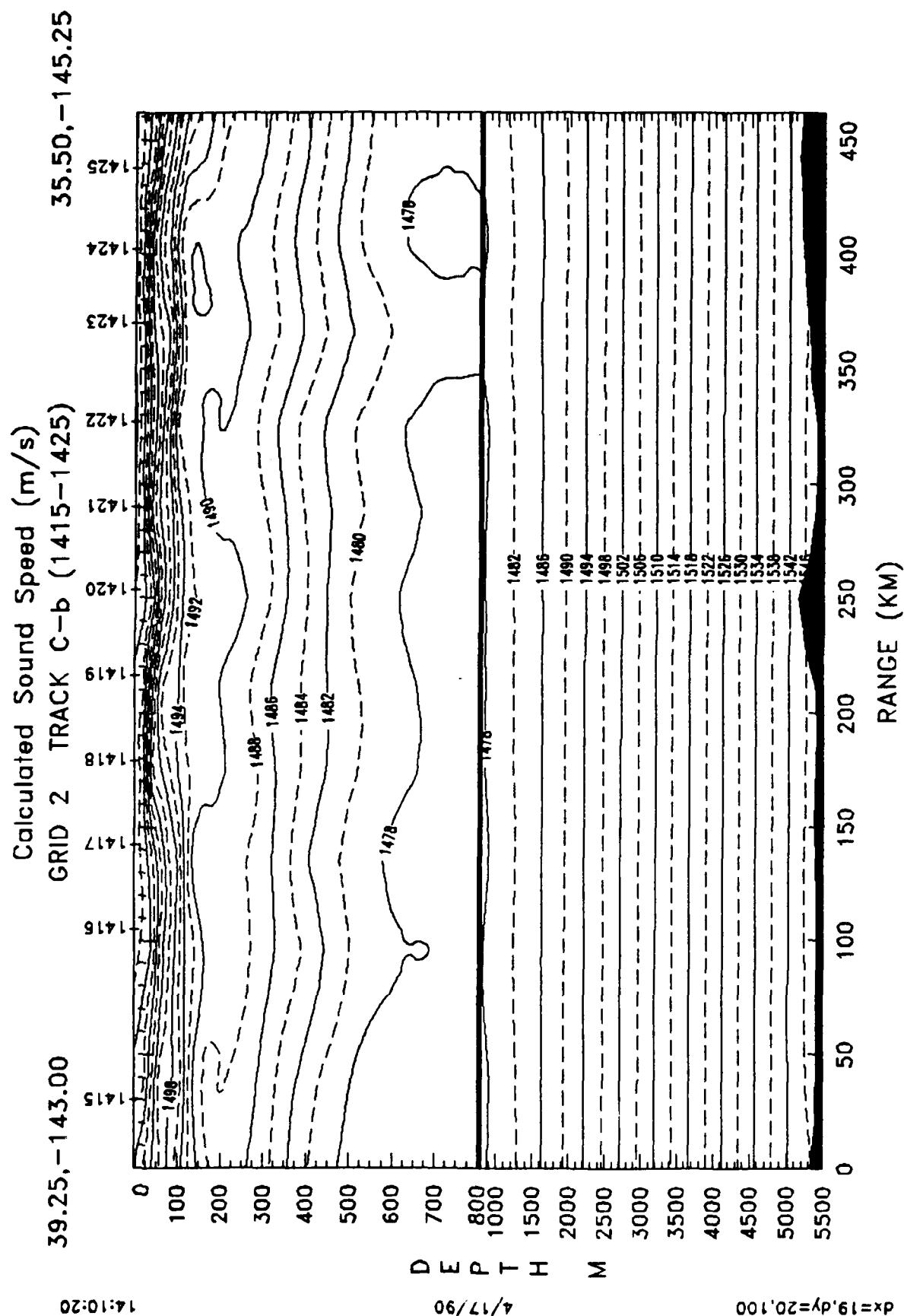
dx=19, dy=20, 100



RANGE (KM)

LAT 39.8 39.5 39.3 39.0 38.8 38.5 38.3 38.0 37.8 37.5 37.3 37.0 36.8 36.5 36.3 36.0
 LONG -144.3 -144.5 -144.8 -145.0 -145.3 -145.5 -145.8 -146.0 -146.3 -146.5

NOARL Code 331

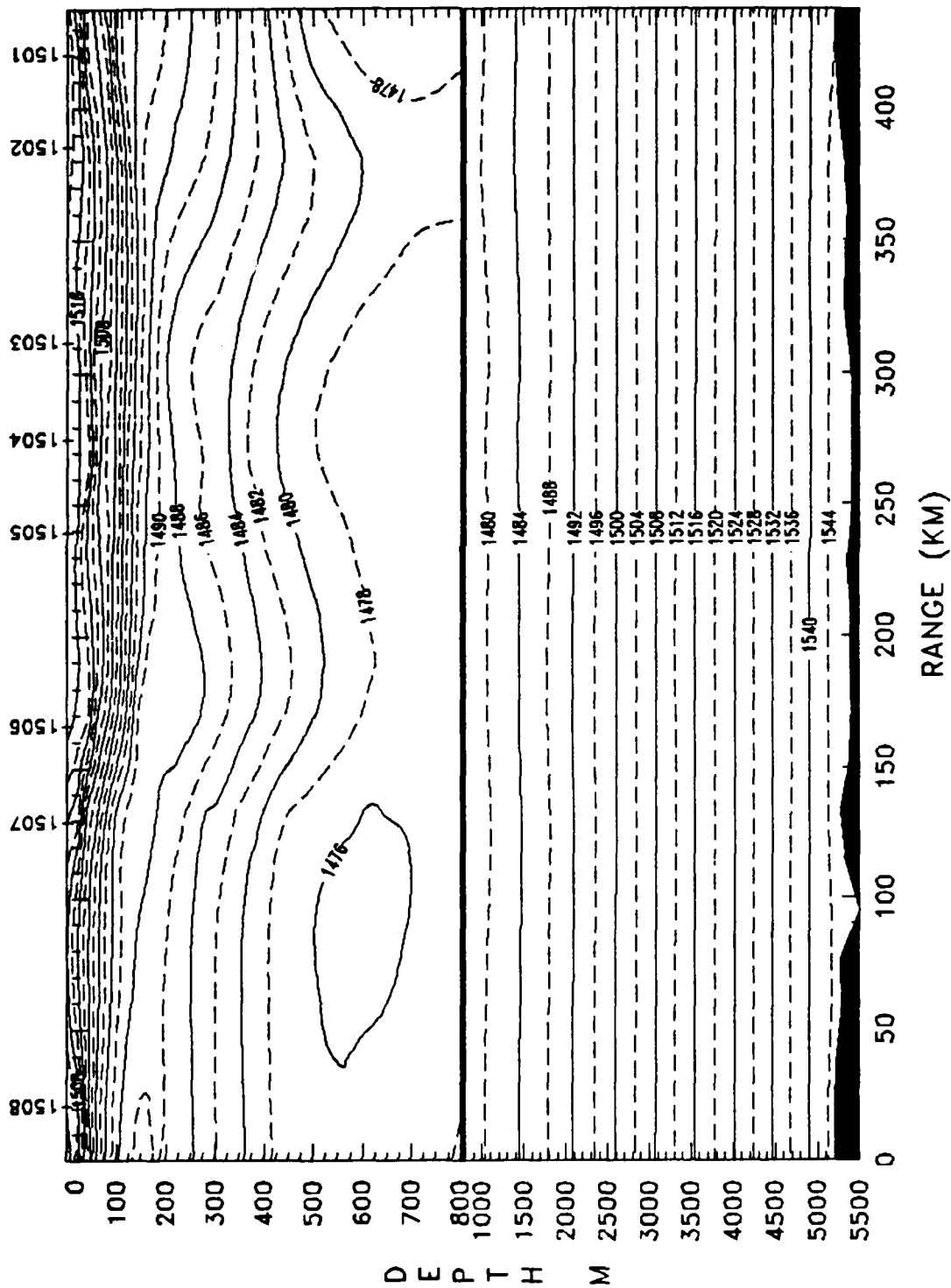


LAT 39.3 39.0 38.8 38.5 38.3 38.0 37.8 37.5 37.3 37.0 36.8 36.5 36.3 36.0 35.8 35.5

LONG -143.0 -143.3 -143.5 -143.8 -144.0 -144.3 -144.5 -144.8 -145.0 -145.3

NOARL Code 331

14:13:27



LAT 38.5 38.3 38.0 37.8 37.5 37.3 37.0 36.8 36.5 36.3 36.0 35.8 35.5 35.3 35.0

LONG -142.0 -142.3 -142.5 -142.8 -143.0 -143.3 -143.5 -143.8 -144.0 -144.3

NOARL Code 331

$$dx=19, dy=20, 100$$

4/17/90

38.25, -141.50 34.75, -143.50

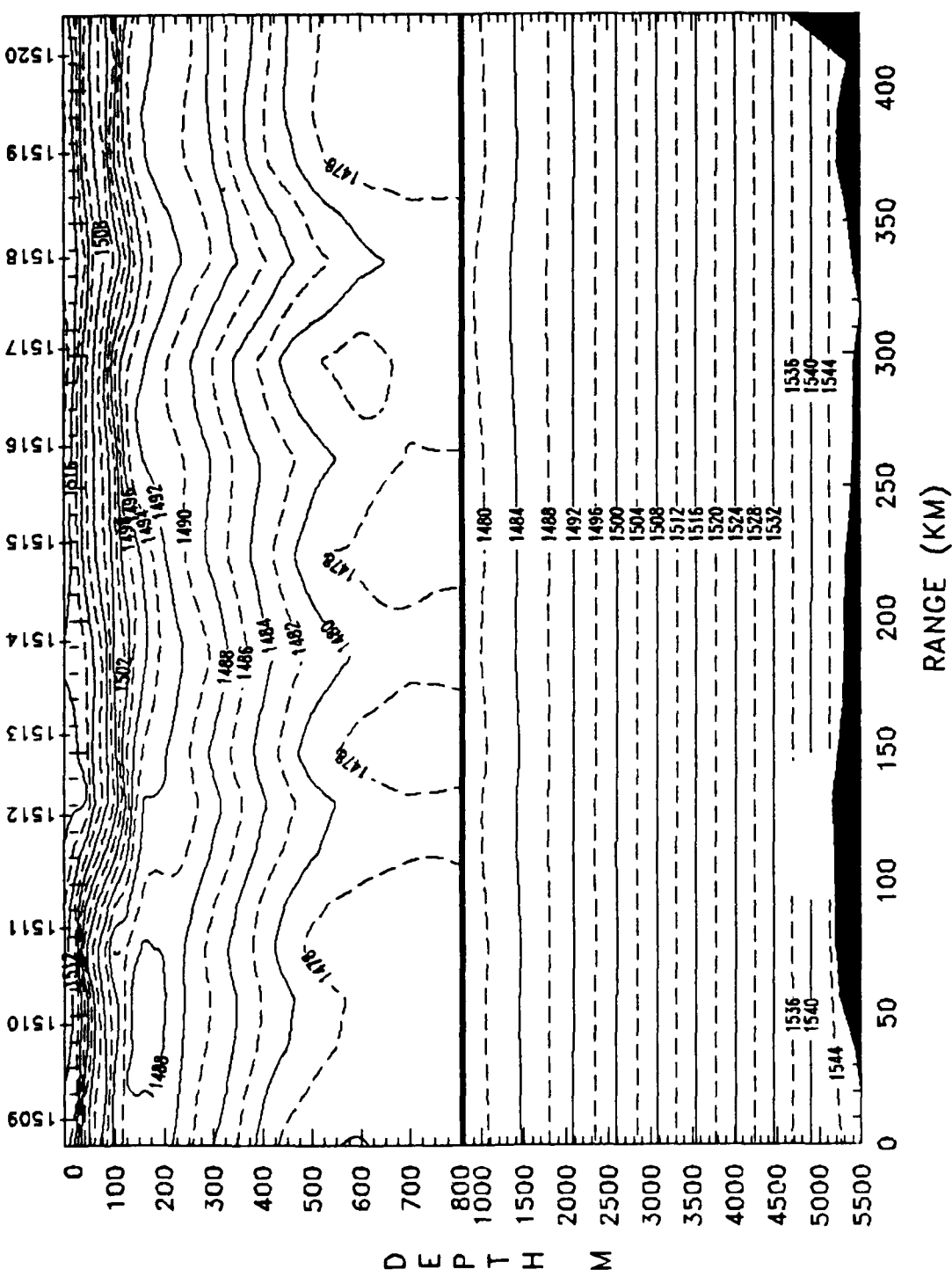
Calculated Sound Speed (m/s)

GRID 2 TRACK D2-b (1509-1520)

14:15:00

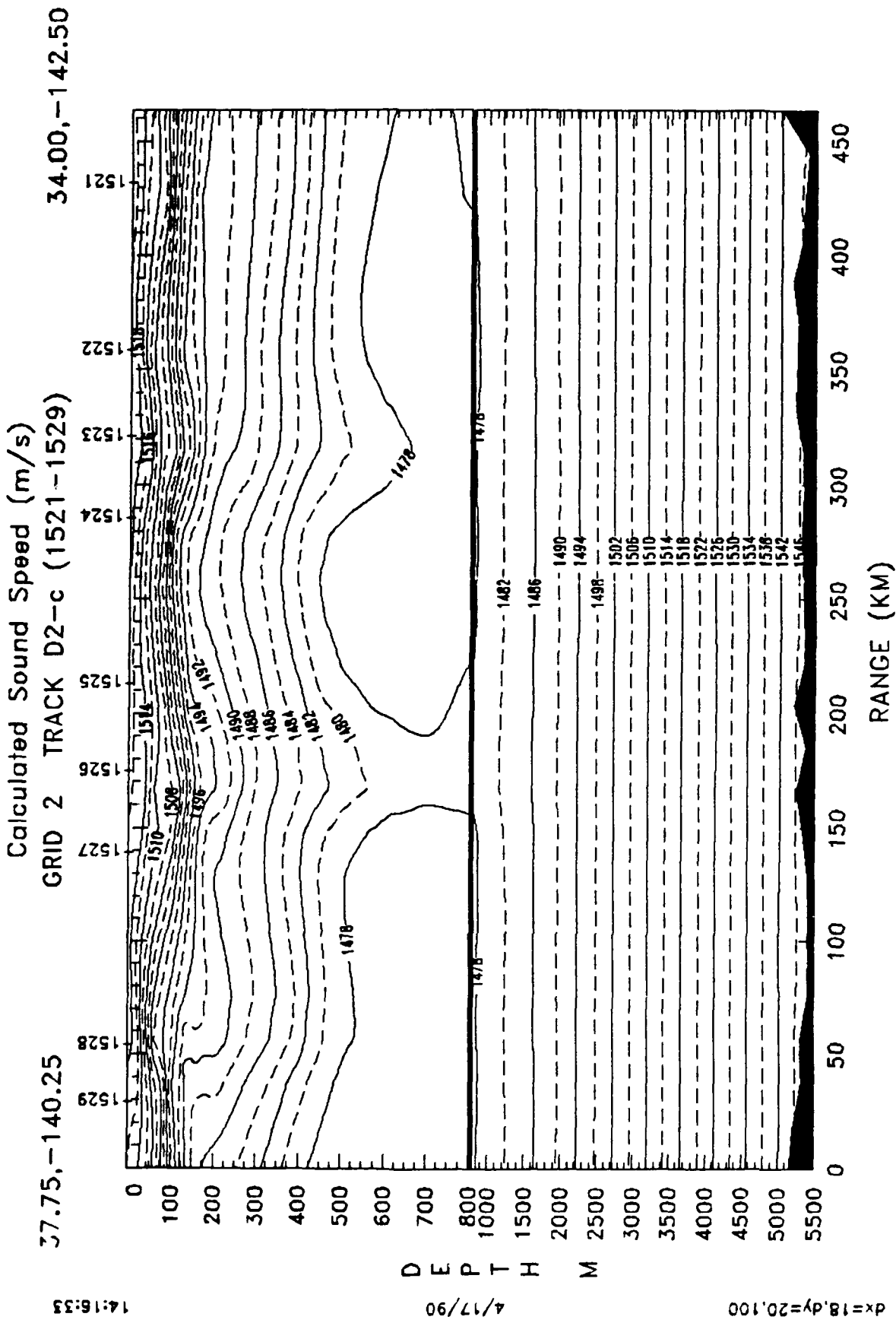
4/17/90

dx=18, dy=20, 100



LAT 38.3 38.0 37.8 37.5 37.3 37.0 36.8 36.5 36.3 36.0 35.8 35.5 35.3 35.0 34.8

LONG -141.5 -141.8 -142.0 -142.3 -142.5 -142.8 -143.0 -143.3 -143.5



LAT 37.8 37.5 37.3 37.0 36.8 36.5 36.3 36.0 35.8 35.5 35.3 35.0 34.8 34.5 34.3 34.0

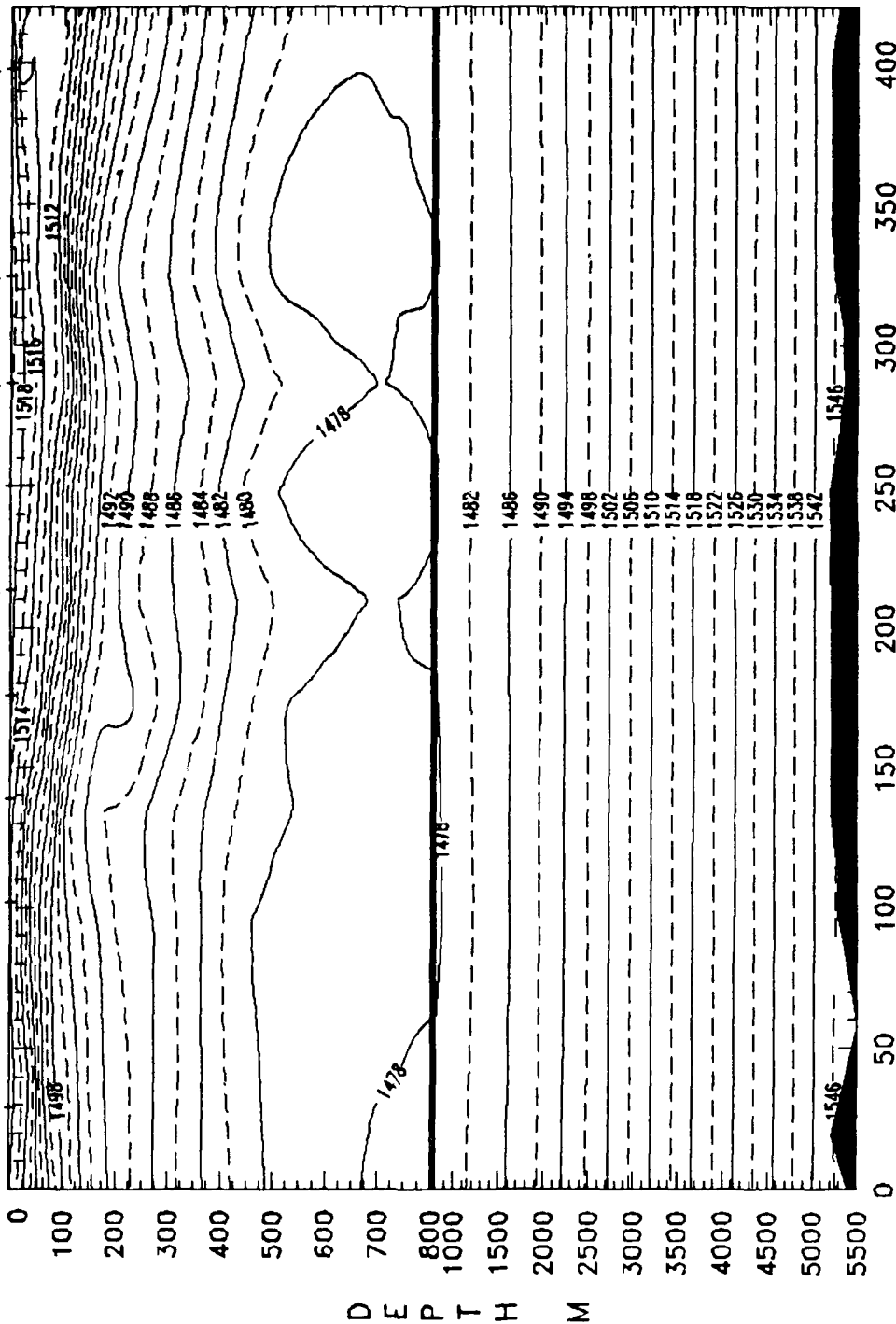
LONG -140.3 -140.5 -140.8 -141.0 -141.3 -141.5 -141.8 -142.0 -142.3 -142.5

NOARL Code 331

Calculated Sound Speed (m/s)
 GRID 2 TRACK D2-d (1530-1539) 33.75,-141.00

37.25,-139.25

13:44:49



4/17/90

dx=19,dy=20,100

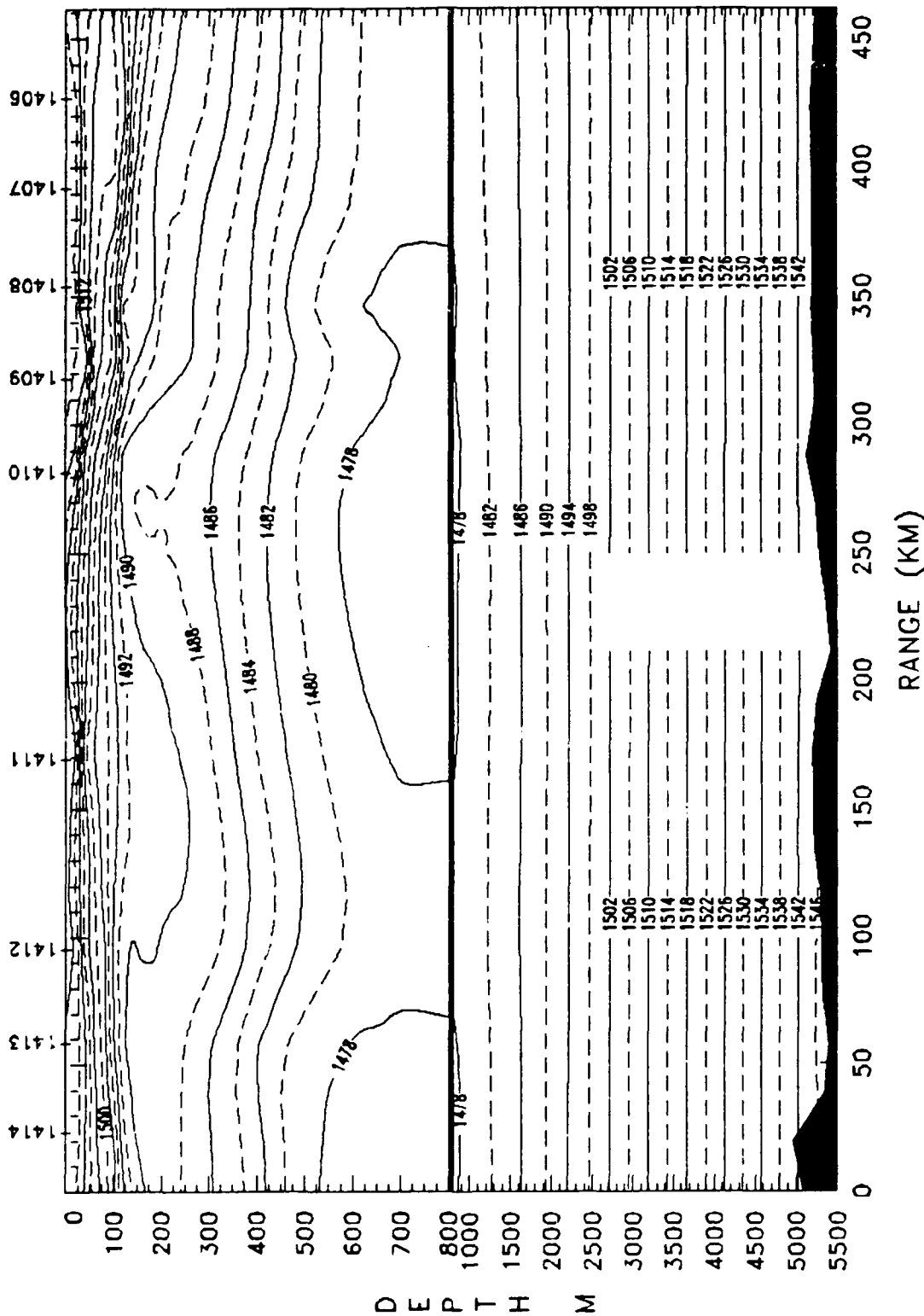
LAT 37.3 37.0 36.8 36.5 36.3 36.0 35.8 35.5 35.3 35.0 34.8 34.5 34.3 34.0 33.8
 LONG -139.3 -139.5 -139.8 -140.0 -140.3 -140.5 -140.8 -141.0

NOARL Code 331

Calculated Sound Speed (m/s)
 GRID 2 TRACK C-a (1406-1414)

39.50,-143.75

35.75,-146.00



LAT 39.5 39.3 39.0 38.8 38.5 38.3 38.0 37.8 37.5 37.3 37.0 36.8 36.5 36.3 36.0 35.8
 LONG -143.8 -144.0 -144.3 -144.5 -144.8 -145.0 -145.3 -145.5 -145.8 -146.0

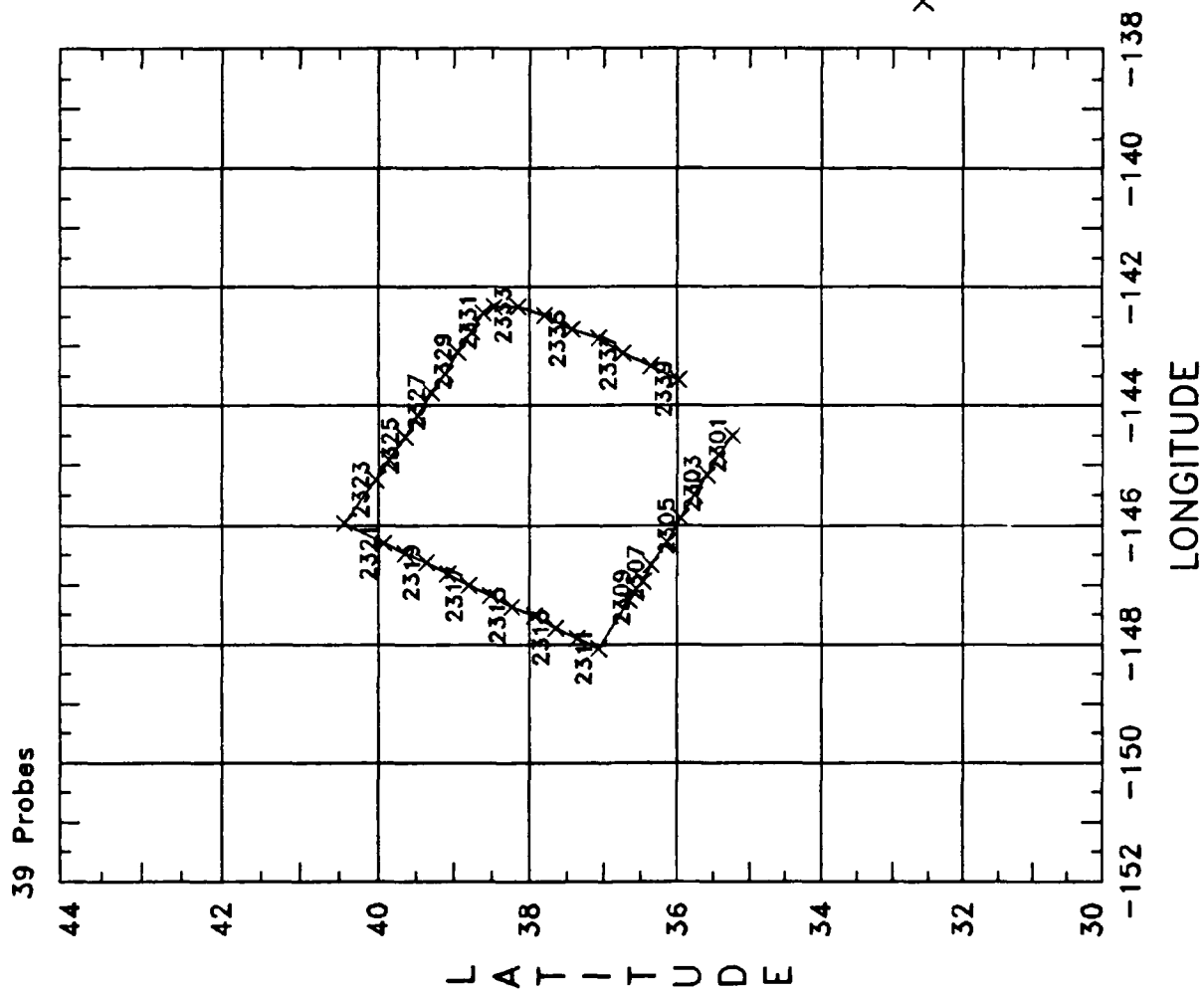
Appendix L

NEPAC Boundary Flight 2 (12 July 1989)

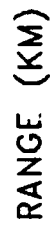
Vertical Temperature Contours along All 4 Sides

Surface to 300 m

NEPAC Boundary 2



40.50,-145.75	BNDRY #2	TRACK BN-a (2311-2322)	37.00,-148.25
---------------	----------	------------------------	---------------

$$s = \gamma p, g_1 = x p$$


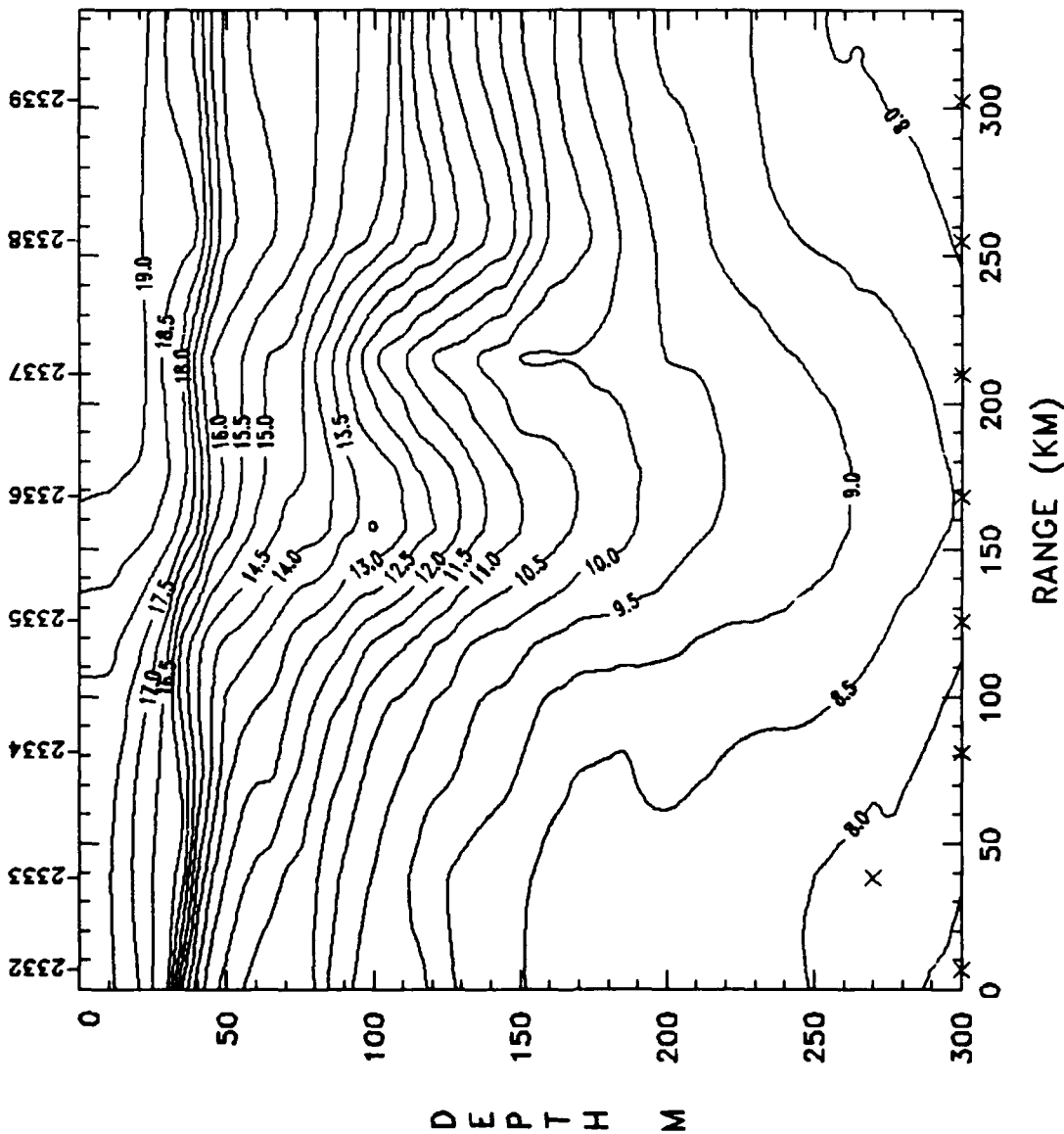
NOARL Code 331

Observed Temperatures (deg C) 38.50, -142.258NDRY #2 TRACK BN-b (2332-2339) 35.75, -143.75

16:10:15

2/09/90

dx=19,dy=5



LAT 38.5 38.0 37.5 37.0 36.5 36.0

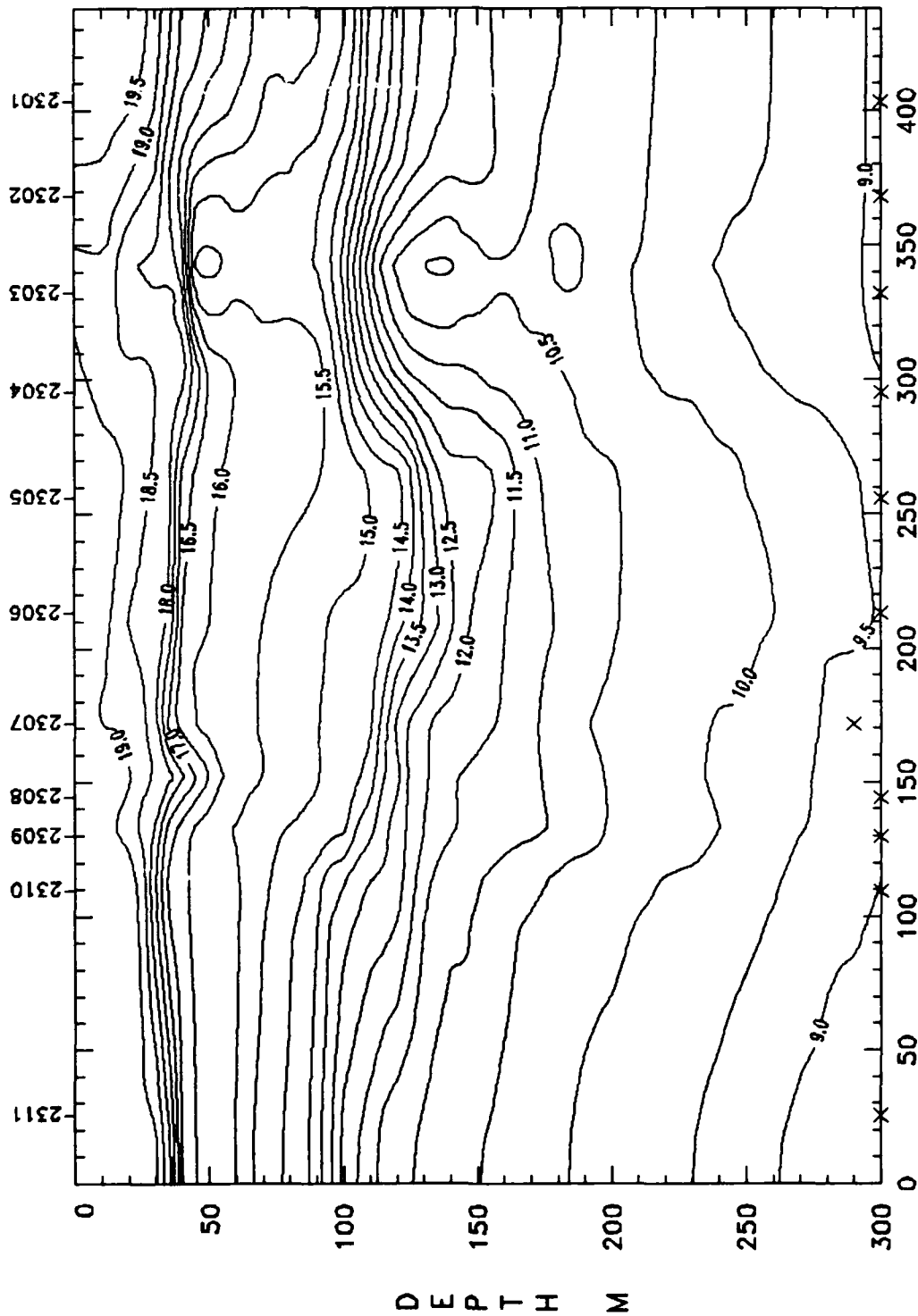
LONG -142.5 -143.0 -143.5

NOARL Code 331

Observed Temperatures (deg C)
 BNDRY #2 TRACK BN-c (2301-2311)

37.25, -148.25

35.00, -144.25



RANGE (KM)

LAT 37.0 36.5 36.0 35.5 35.0
 LONG -148.0 -147.5 -147.0 -146.5 -146.0 -145.5 -145.0 -144.5

NOARL Code 331

16:11:27

DEPTH M

2/09/90

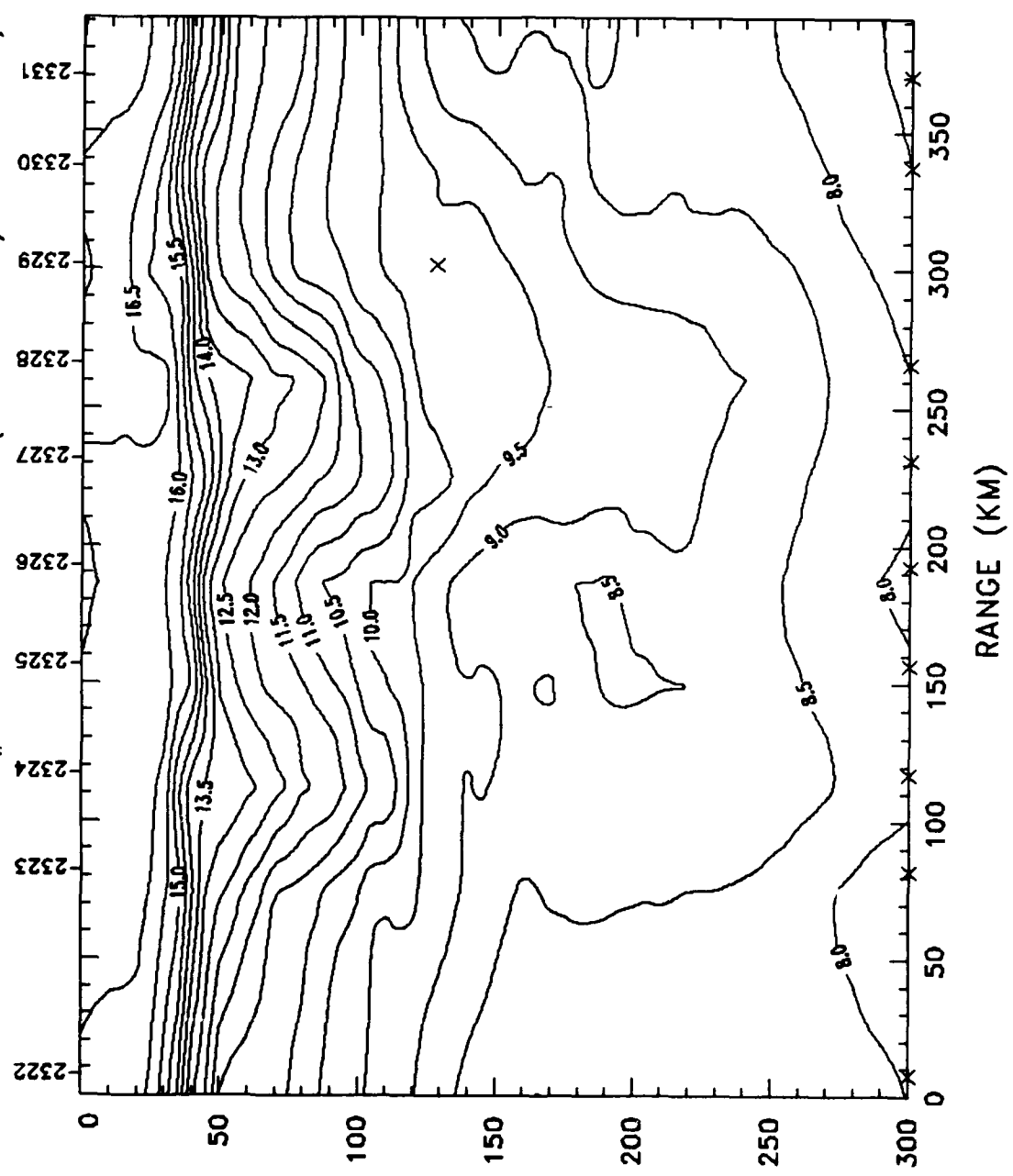
dx=19,dy=5

Observed Temperatures (deg C)
 40.50, -146.00 BNDRY #2 TRACK BN-d (2322-2331) 38.50, -142.25

16:12:45

2/09/90
 DEPTH M

dx=18,dy=5



LAT 40.5 39.5 39.0 38.5
 LONG -146.0 -145.5 -145.0 -144.5 -144.0 -143.5 -143.0 -142.5
 RANGE (KM)
 NOARL Code 331

Appendix M

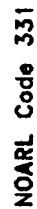
NEPAC Grid 3 (17 - 19 July 1989)

Temperature Contours along Selected Vertical Transects

Surface to 300 m

07:10:6

06/60/5

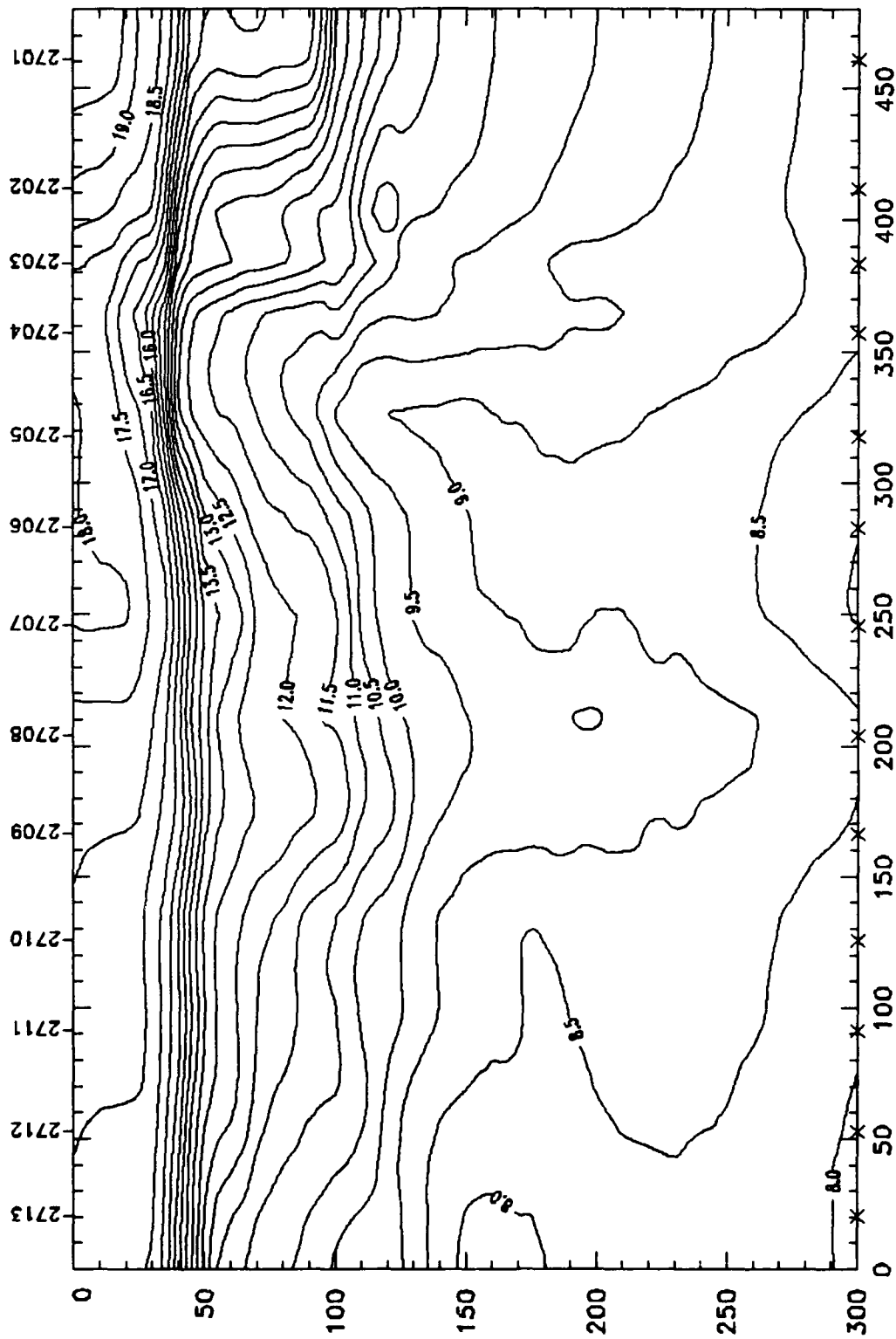


Observed Temperatures (deg C)
 GRID 3 TRACK B-a (2701-2713) 37.00,-148.25

40.75,-145.50

15:45:55

2/09/90
 DEPTH M



RANGE (KM)

LAT 40.5 40.0 39.5 39.0 38.5 38.0 37.5 37.0
 LONG -145.5 -146.0 -146.5 -147.0 -147.5 -148.0

NOARL Code 331

Observed Temperatures (deg C)
 GRID 3 TRACK B-b (2714-2725) 36.50,-147.75

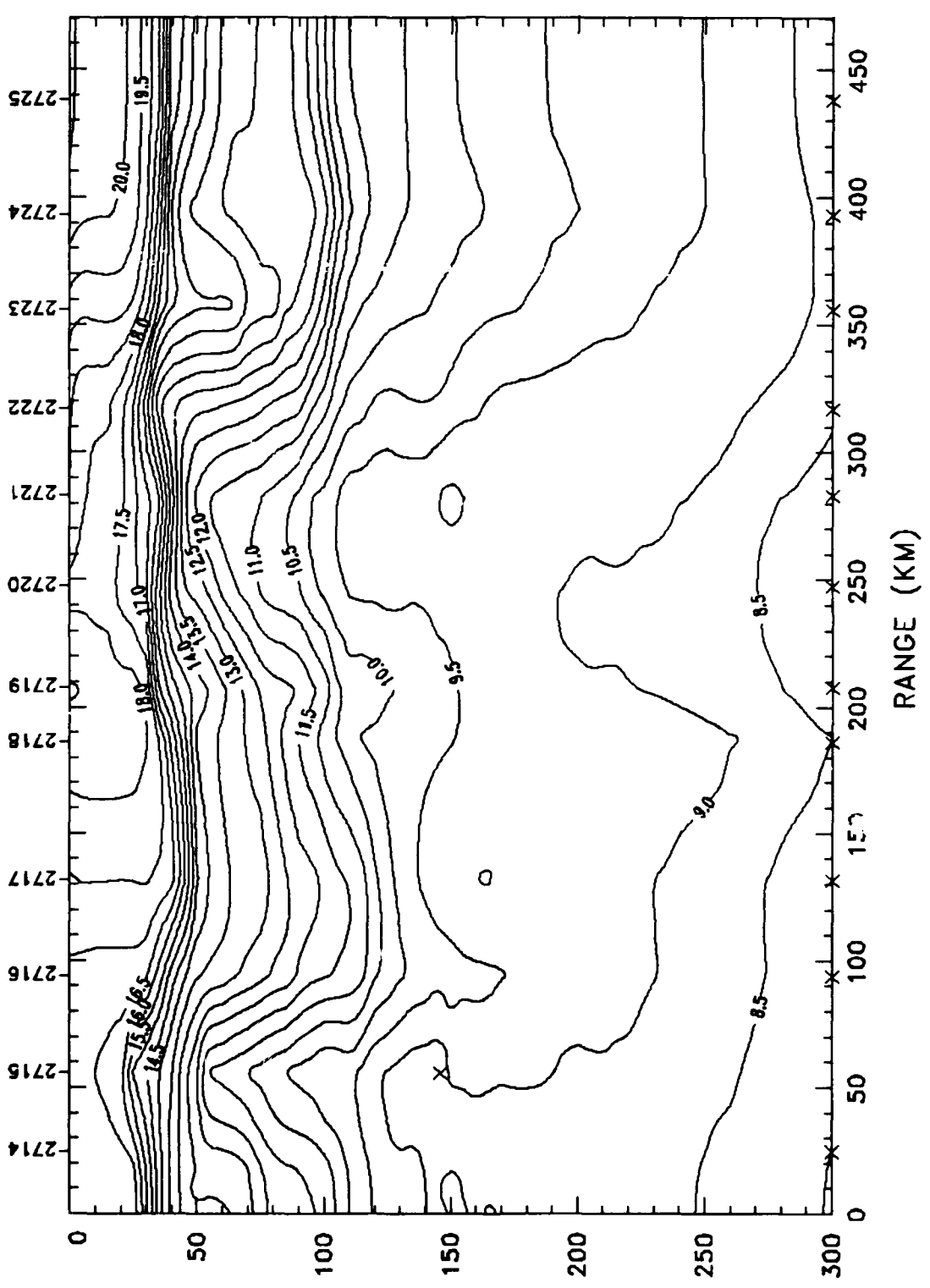
40.25,-145.25

15:47:20

D E P T H M

2/09/90

dx=19.4y=5



LAT 40.0 39.5 39.0 38.5 38.0 37.5 37.0 36.5
 LONG -145.5 -146.0 -146.5 -147.0 -147.5

NOARL Code 331

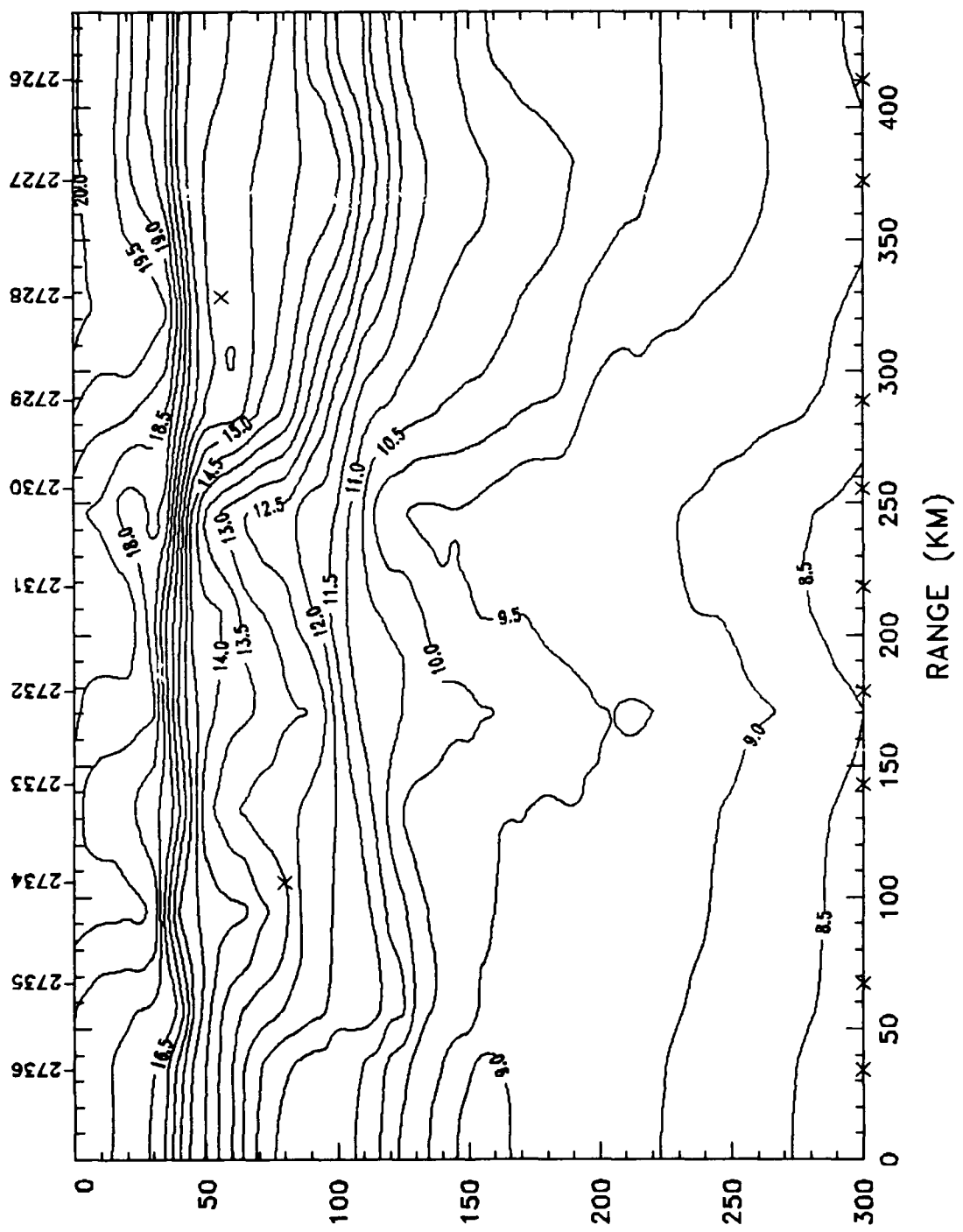
Observed Temperatures (deg C)
 GRID 3 TRACK B-c (2726-2736)

39.75, -145.00 36.25, -147.25

15:48:42

2/09/90

dx=19,dy=5



LAT 39.5 39.0 38.5 38.0 37.5 37.0 36.5
 LONG -145.0 -145.5 -146.0 -146.5 -147.0

NOARL Code 331

Observed Temperatures (deg C)
 GRID 3 TRACK B-d (2738-2806)

39.75, -144.25

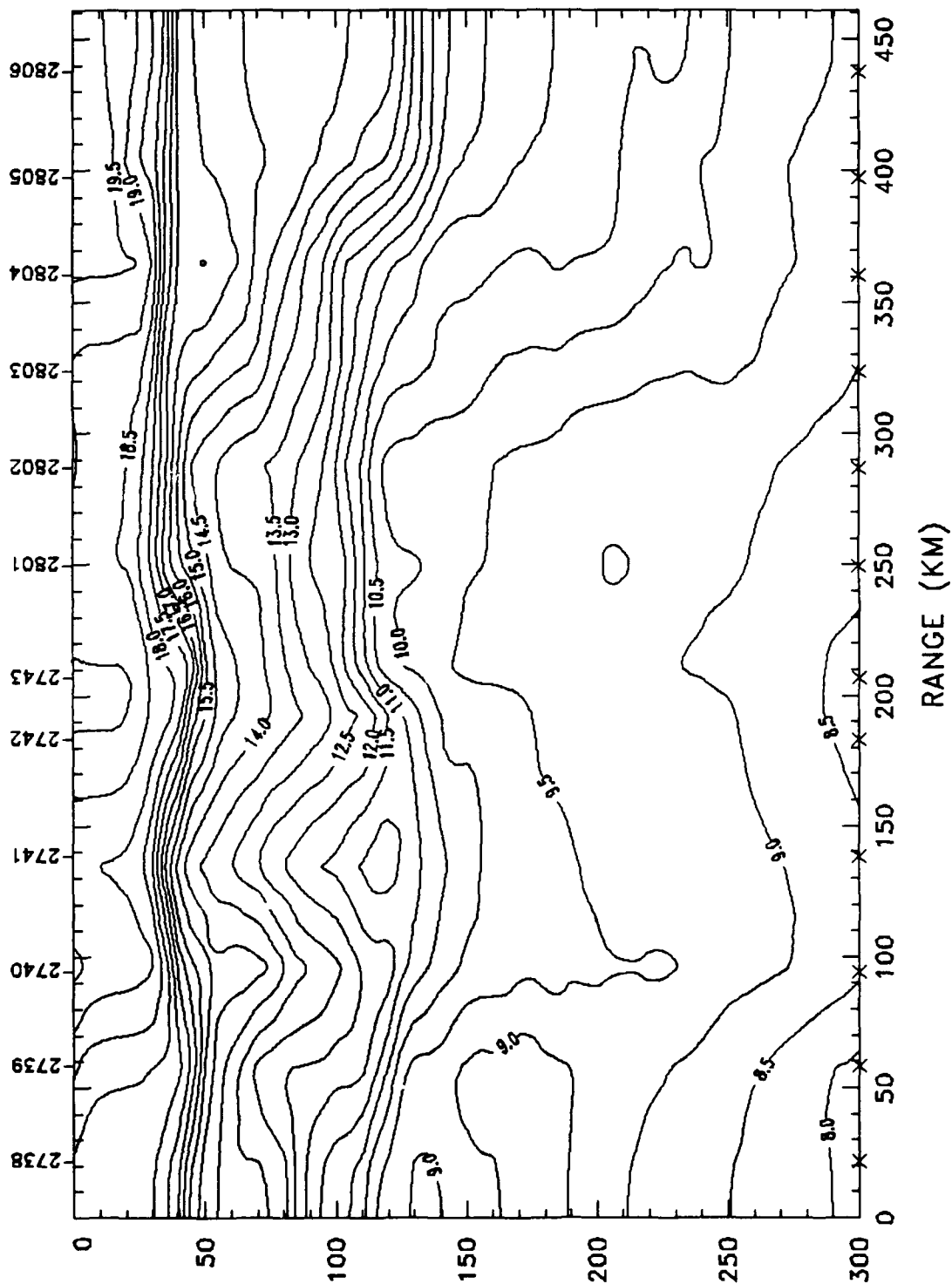
36.00, -146.50

15:50:04

DEPTH M

2/09/90

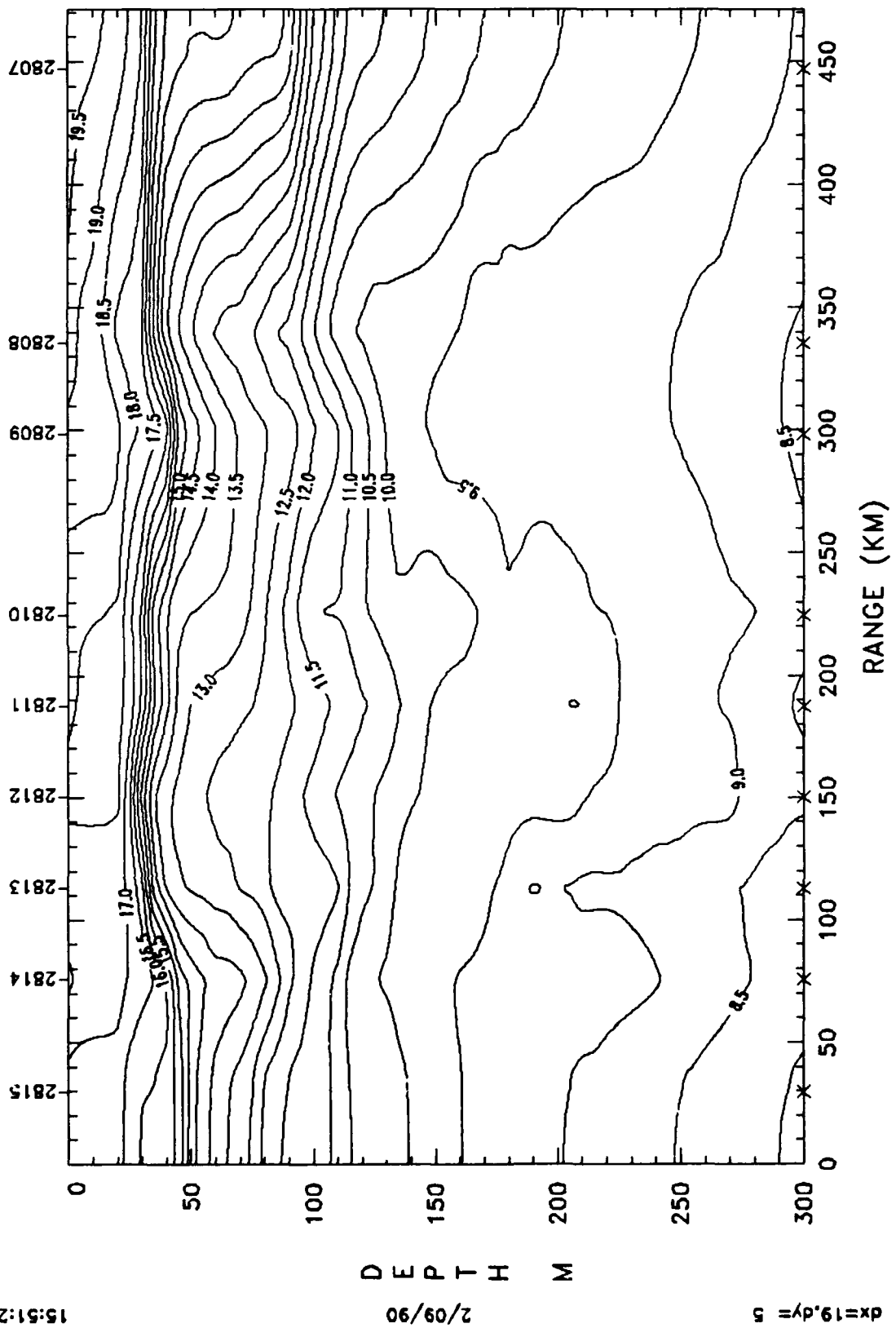
dx=19, dy=5



LAT 39.5 39.0 38.5 38.0 37.5 37.0 36.5 36.0
 LONG -144.5 -145.0 -145.5 -146.0 -146.5

NOARL Code 331

Observed Temperatures (deg C)
 GRID 3 TRACK C-a (2807-2815) 35.75,-146.00



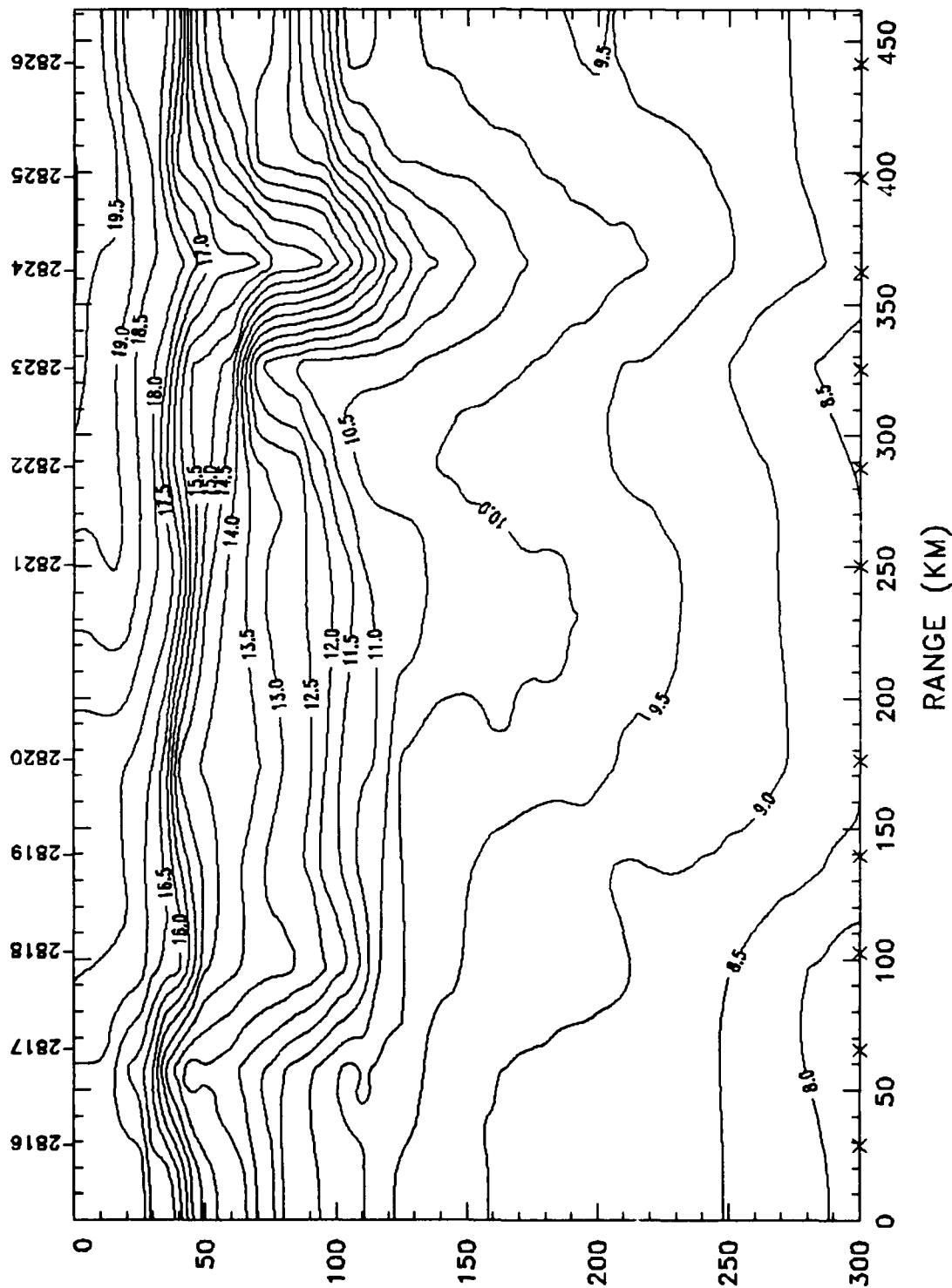
LAT 39.5 39.0 38.5 38.0 37.5 37.0 36.5 36.0
 LONG -143.5 -144.0 -144.5 -145.0 -145.5 -146.0

Observed Temperatures (deg C)
 GRID 3 TRACK C-b (2816-2826) 35.50,-145.25

39.25,-143.00

15:52:51

2/09/90
 DEPTH M



LAT 39.0 38.5 38.0 37.5 37.0 36.5 36.0 35.5
 LONG -143.0 -143.5 -144.0 -144.5 -145.0

NOARL Code 331

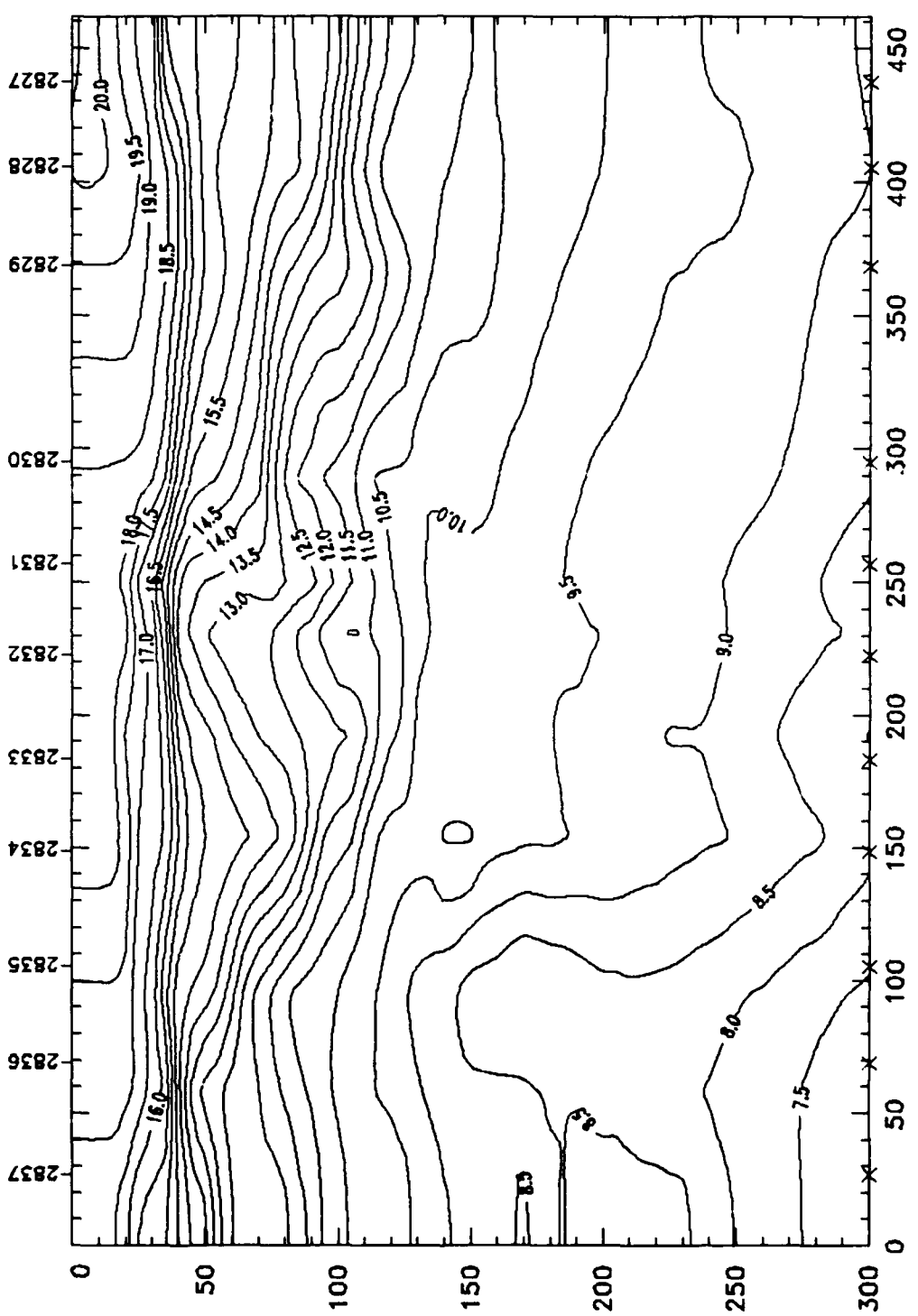
Observed Temperatures (deg C)
 GRID 3 TRACK C-c (2827-2837)

35.25, -144.75

39.00, -142.50

15:54:15

2/09/90
 DEPTH M



RANGE (KM)

LAT 39.0 38.5 38.0 37.5 37.0 36.5 36.0 35.5

LONG -142.5 -143.0 -143.5 -144.0 -144.5

NOARL Code 331

dx=19.0, dy=5

Observed Temperatures (deg C)
 GRID 3 TRACK D2-a (2901-2912)

38.50,-142.00

35.00,-144.25

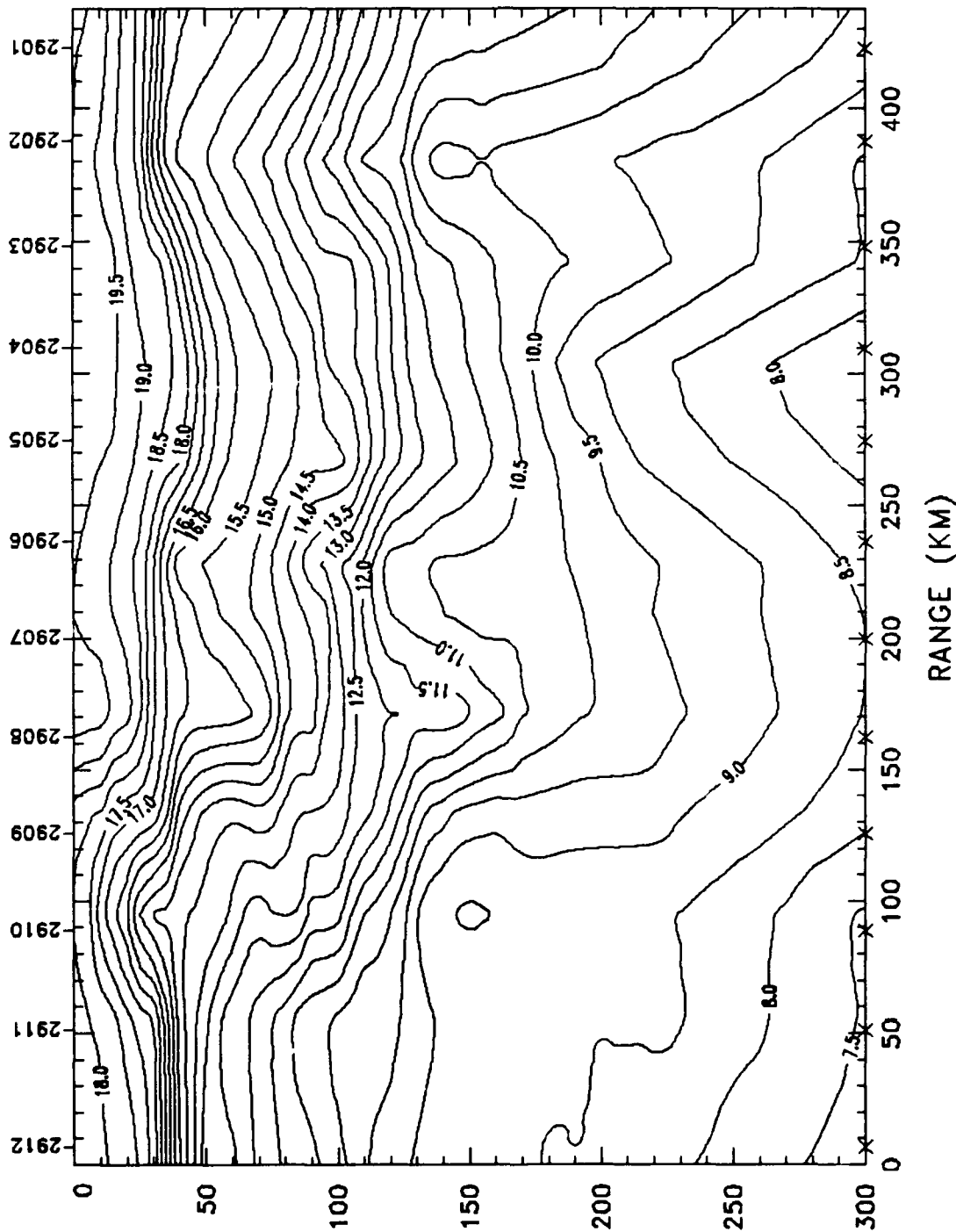
38.50,-142.00

15:55:42

DEPTH M

2/09/90

dx=19,dy=5



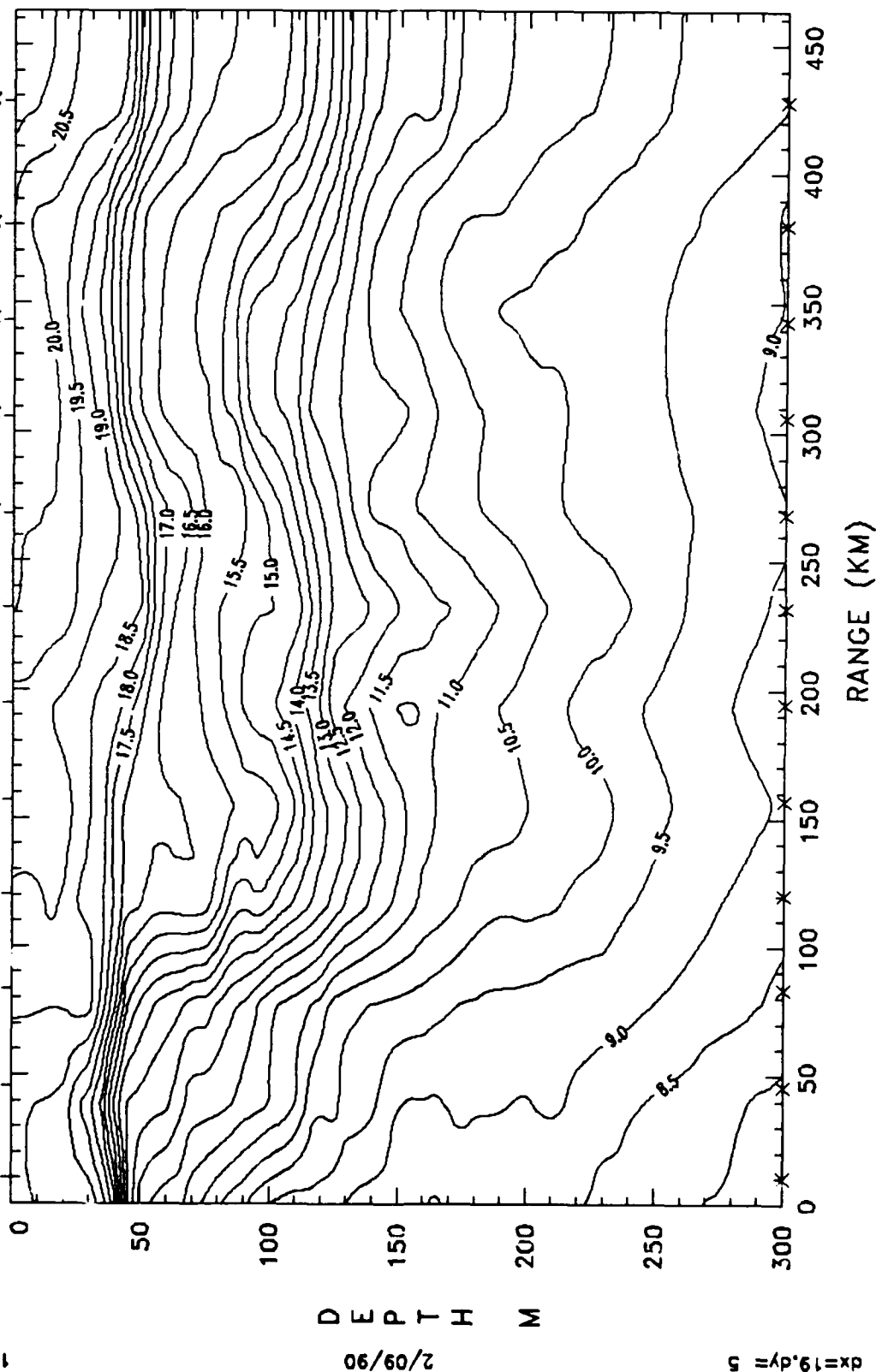
LAT 38.5 38.0 37.5 37.0 36.5 36.0 35.5 35.0
 LONG -142.0 -142.5 -143.0 -143.5 -144.0

NOARL Code 331

Observed Temperatures (deg C)
 GRID 3 TRACK D2-b (2913-2924) 34.50, -143.75

38.25, -141.50

15:57:08



LAT 38.0 37.5 37.0 36.5 36.0 35.5 35.0 34.5
 LONG -141.5 -142.0 -142.5 -143.0 -143.5

NOARL Code 331

Observed Temperatures (deg C)
 GRID 3 TRACK D2-c (2925-2936)

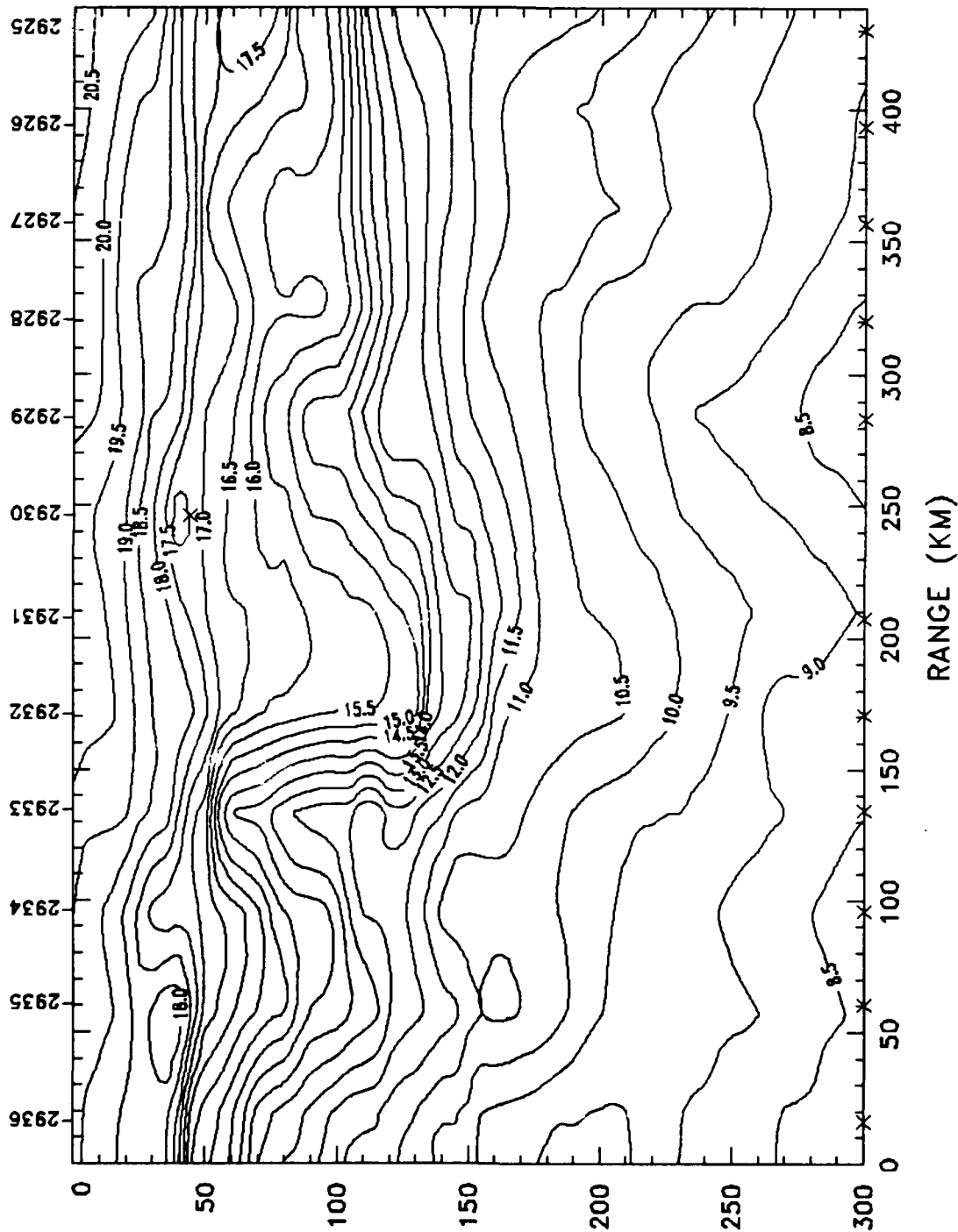
37.75, -140.25

34.25, -142.50

15:58:35

2/09/90

dx=19, dy=5



LAT 37.5 37.0 36.5 36.0 35.5 35.0 34.5

LONG -140.5 -141.0 -141.5 -142.0 -142.5

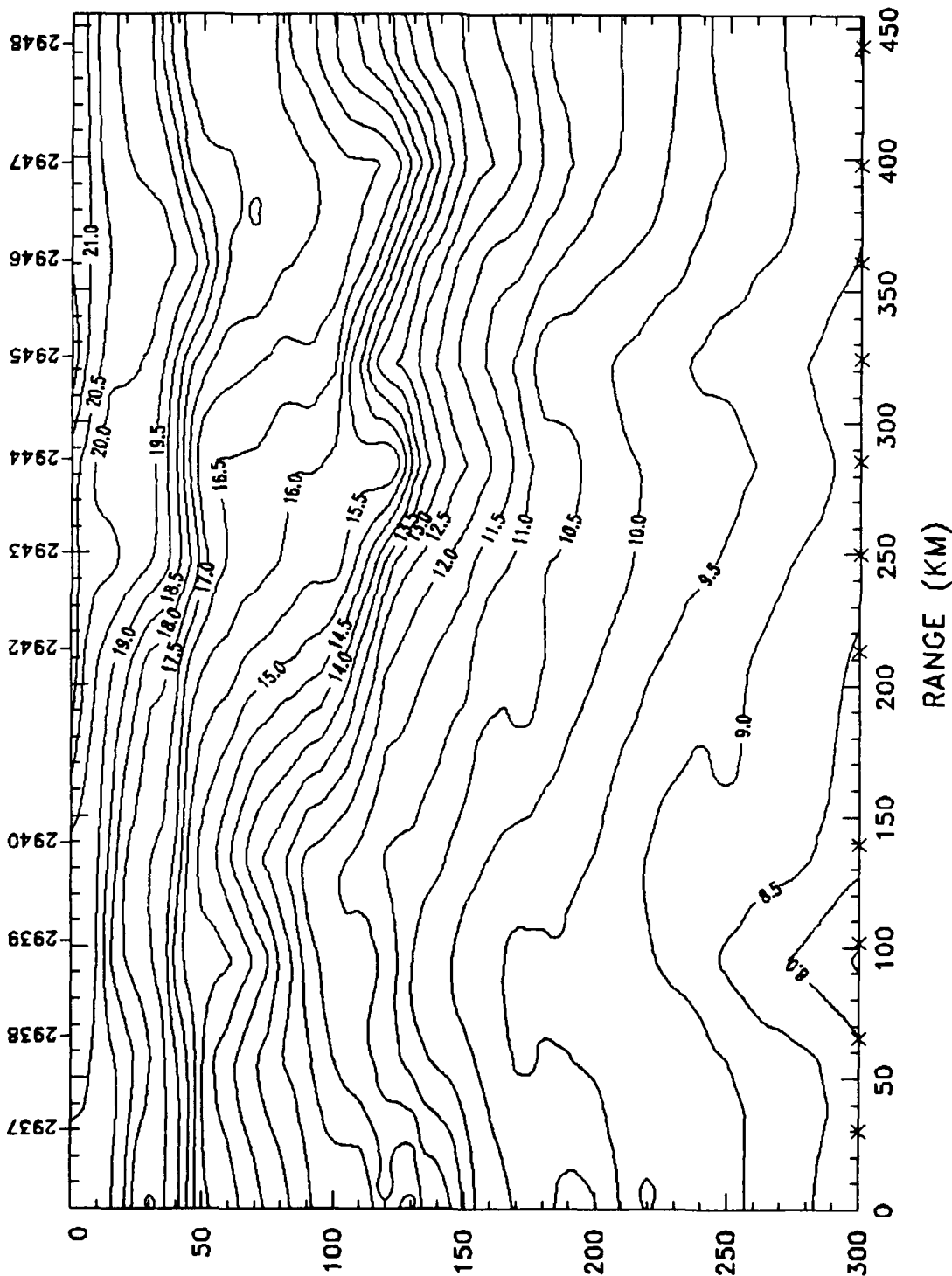
NOARL Code 331

Observed Temperatures (deg C)
 GRID 3 TRACK D2-d (2937-2948)
 37.25,-139.25 33.50,-141.25

16:00:01

2/09/90

dx=19,dy=5



LAT 37.0 36.5 36.0 35.5 35.0 34.5 34.0 33.5
 LONG -139.5 -140.0 -140.5 -141.0

Appendix N

First GEOSAT Underflight, 28 June 1989

Vertical Contours

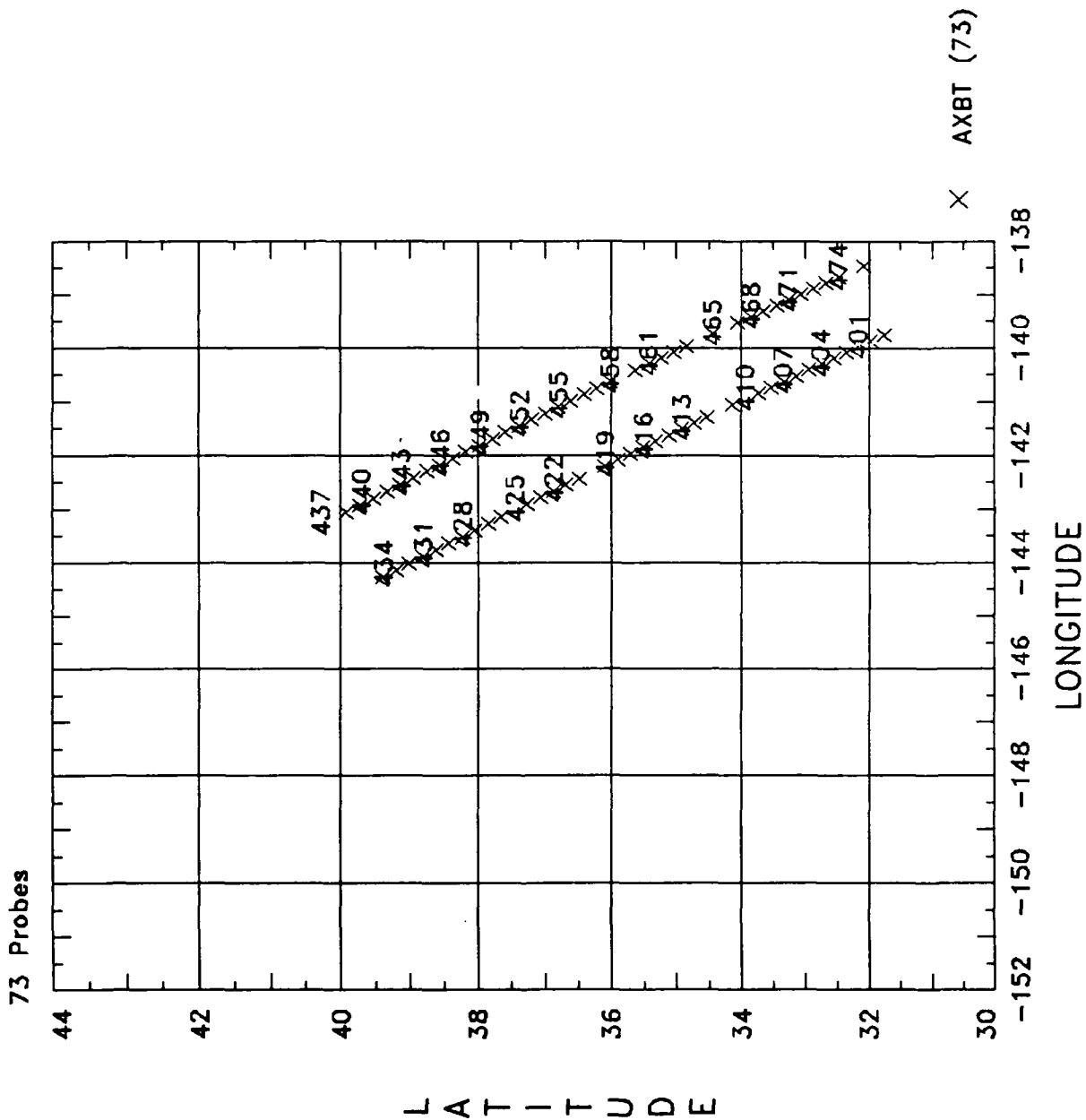
Temperature: Surface to 300 m and Surface to 5500 m

Inferred Salinity: Surface to 5500 m

Calculated Sound Speed: Surface to 5500 m

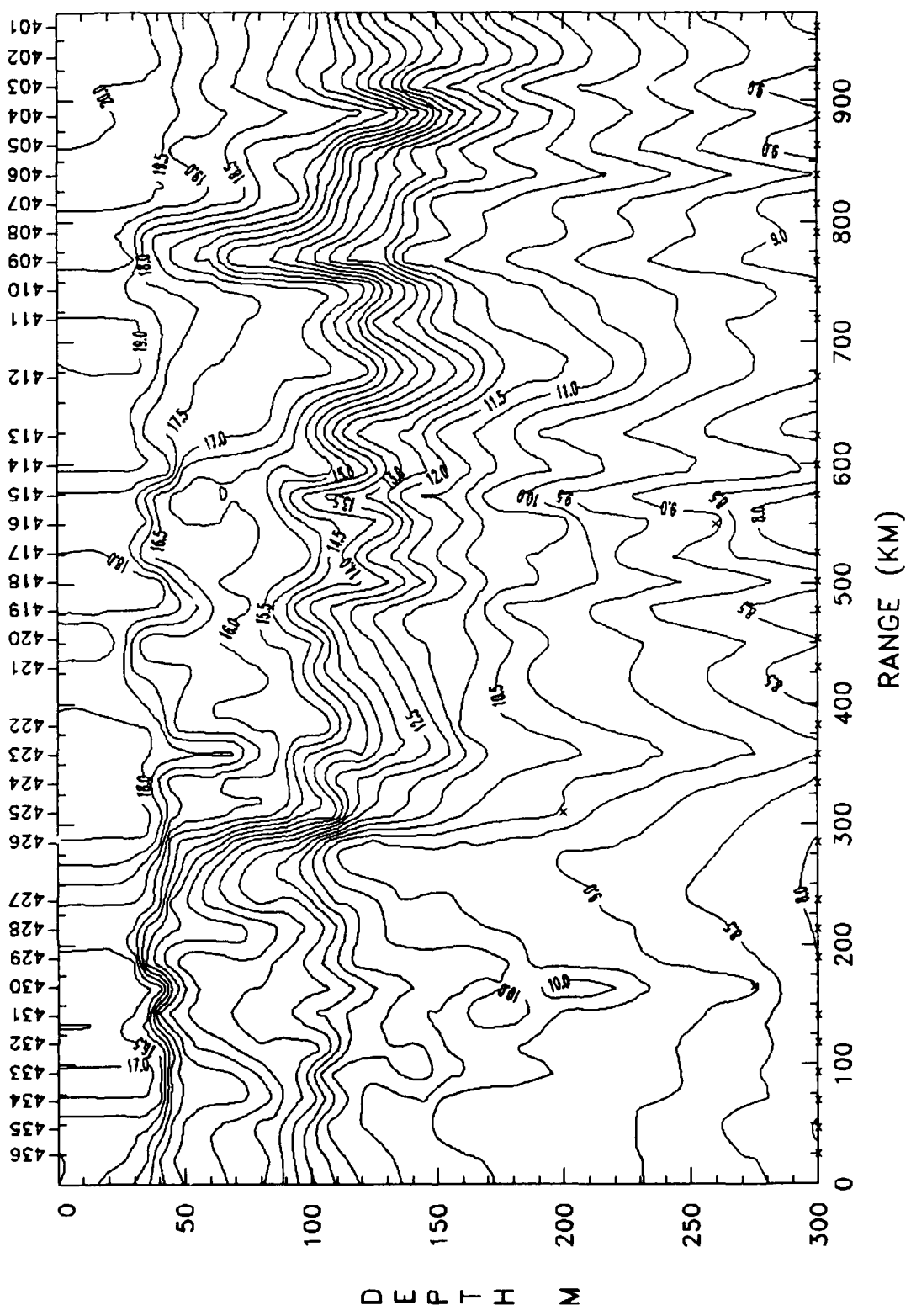
8:20:16

GEOSAT #1 28 June 1989



Observed Temperatures (deg C)
 GEOSAT TRACK G1-a (401-436)

39.50, -144.50 31.75, -139.50



LAT 39.5 39.0 38.5 38.0 37.5 37.0 36.5 36.0 35.5 35.0 34.5 34.0 33.5 33.0 32.5 32.0
 LONG -144.0 -143.0 -142.0 -141.0 -140.0
 NOARL Code 331

8:36:32

12/11/89

dx=11, dy= 5

Observed Temperatures (deg C)
 GEOSAT TRACK G1-b (437-474)

40.00,-143.25

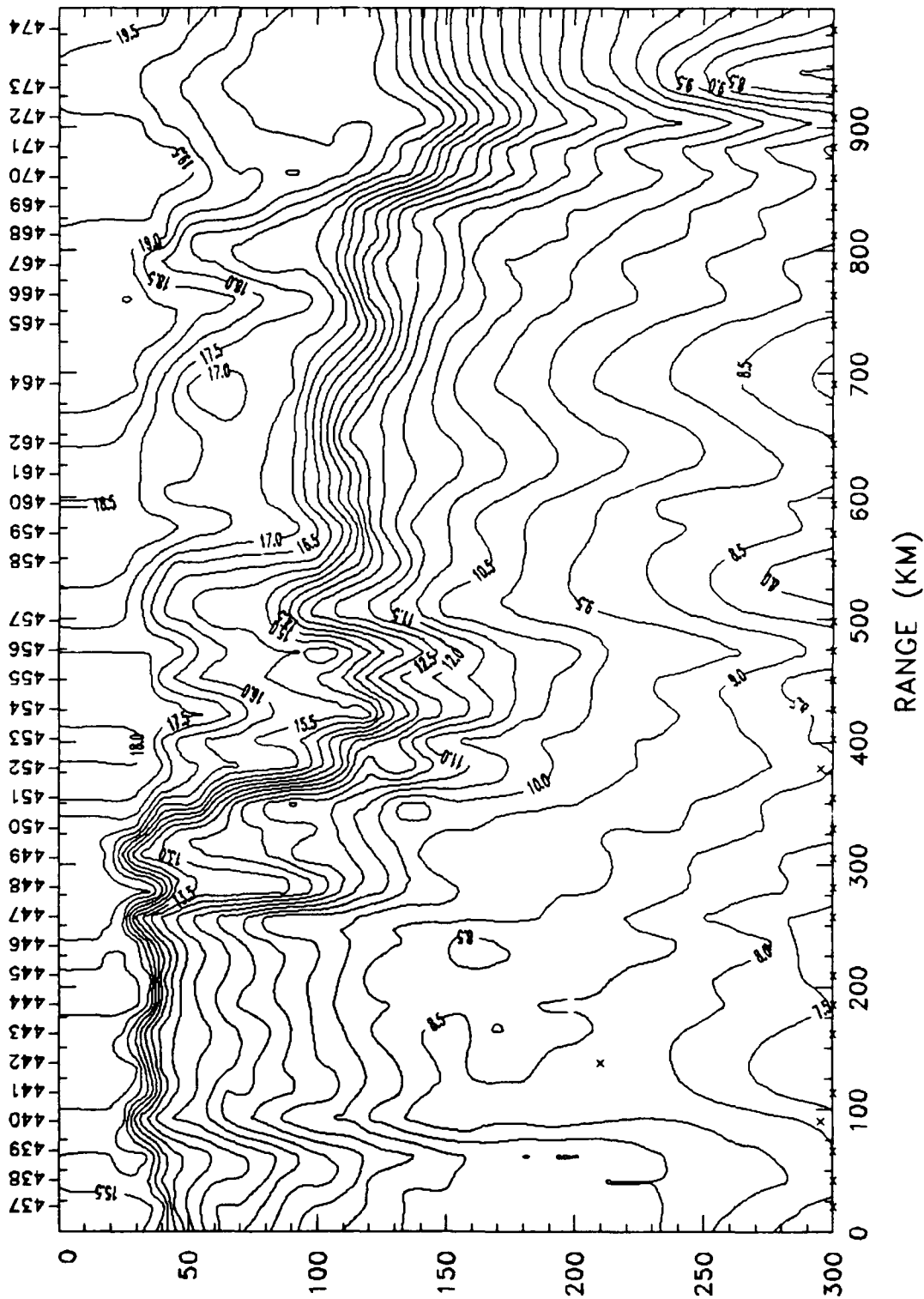
32.00,-138.25

8:39:26

DEPTH M

12/11/89

dx=11,dy=5



LAT 40.0 39.0 38.0 37.0 36.0 35.0 34.0 33.0 32.0

LONG -142.5 -141.5 -140.5 -139.5 -138.5

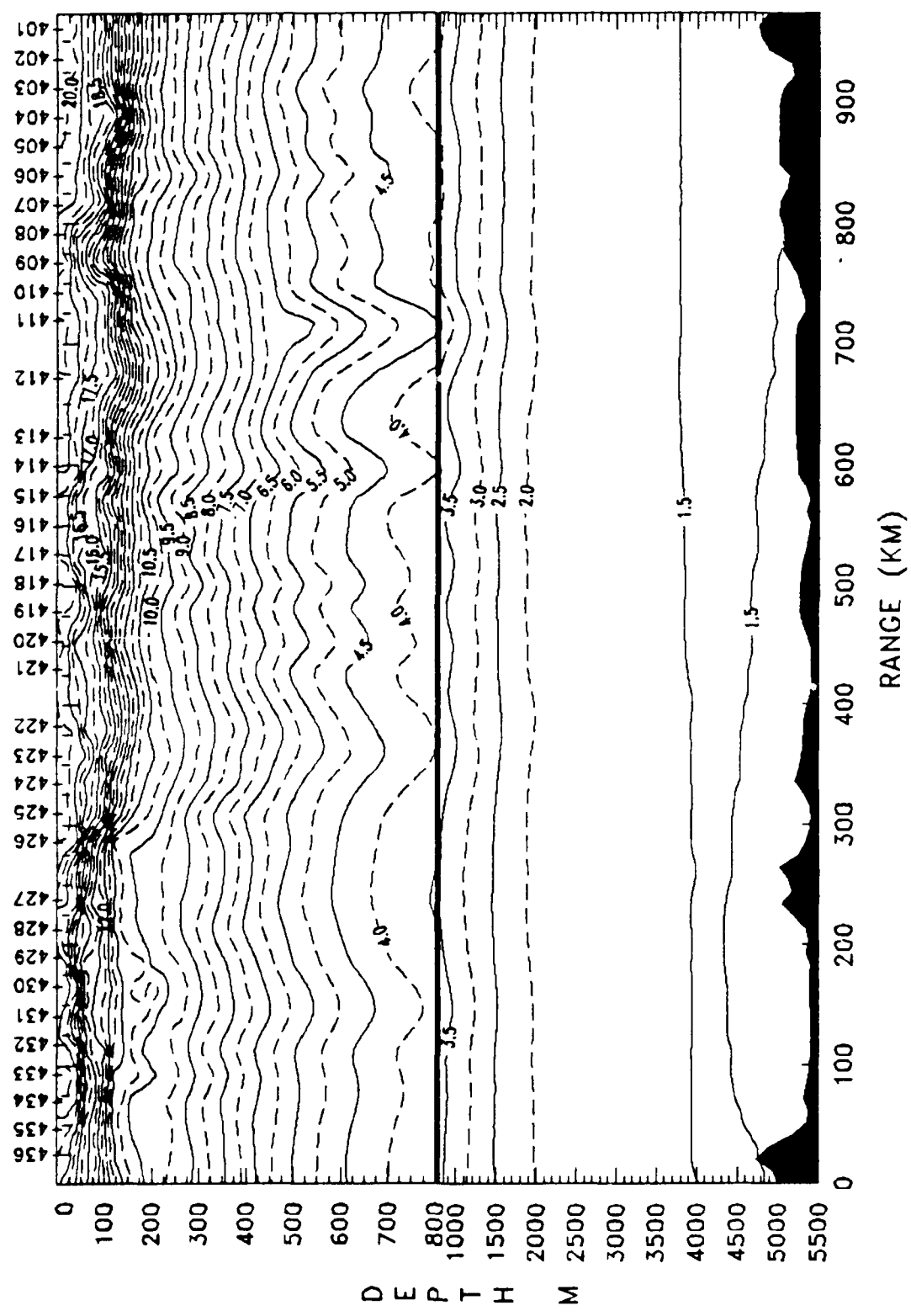
NOARL Code 331

39.50, -144.50 31.75, -139.50
 GEOSAT TRACK G1-a (401-436)

16:25:49

4/17/90

dx=11, dy=20, 100



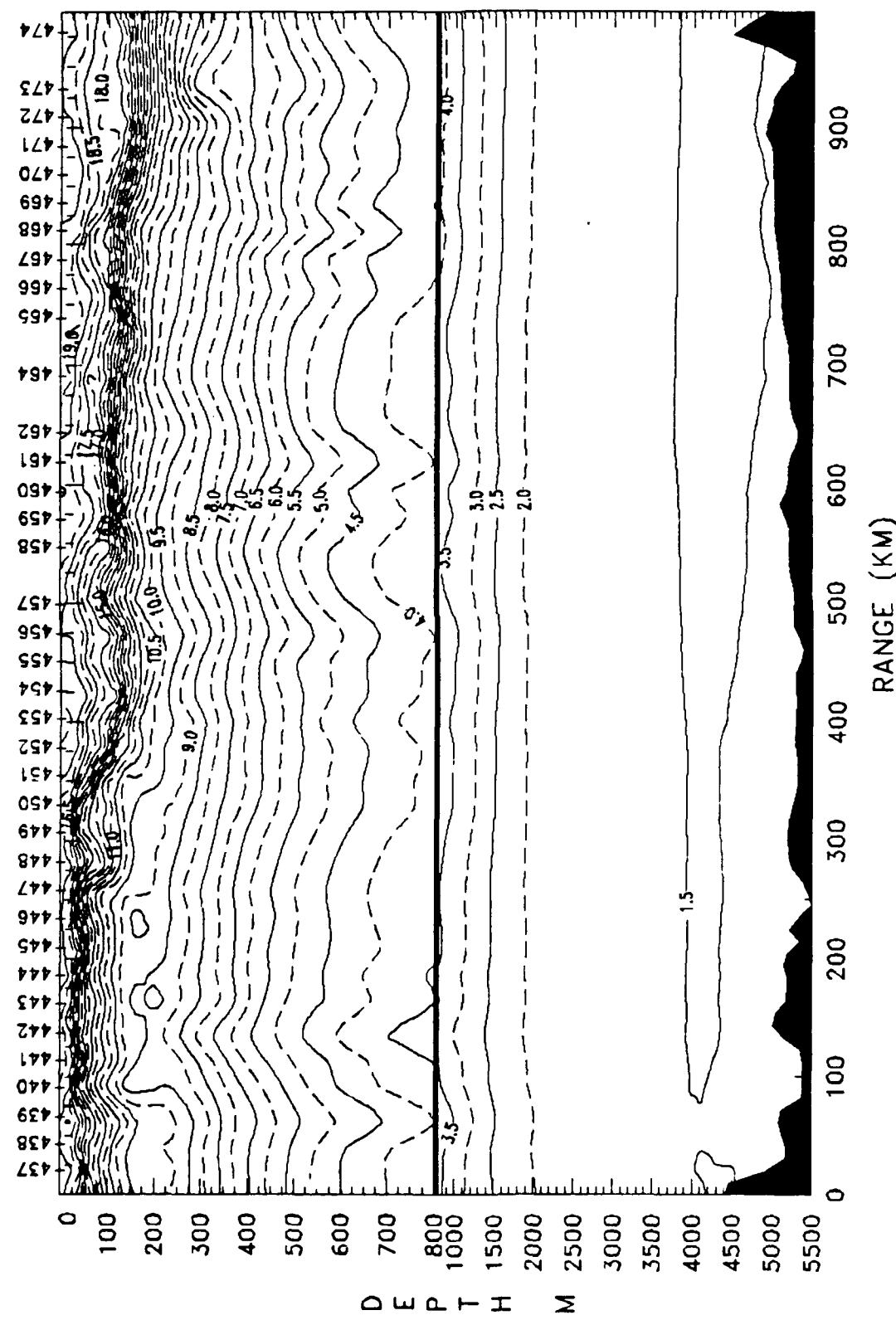
LAT 39.5 39.0 38.5 38.0 37.5 37.0 36.5 36.0 35.5 35.0 34.5 34.0 33.5 33.0 32.5 32.0
 LONG -144.0 -143.0 -142.0 -141.0 -140.0

NOARL Code 331

40.00,-143.25 32.00,-138.25

Temperatures (deg C)

GEOSAT TRACK G1-b (437-474)



LAT 40.0 39.0 38.0 37.0 36.0 35.0 34.0 33.0 32.0
 LONG -142.5 -141.5 -140.5 -139.5 -138.5

NOARL Code 331

15:43:53

4/17/90

dx=11,dy=20,100

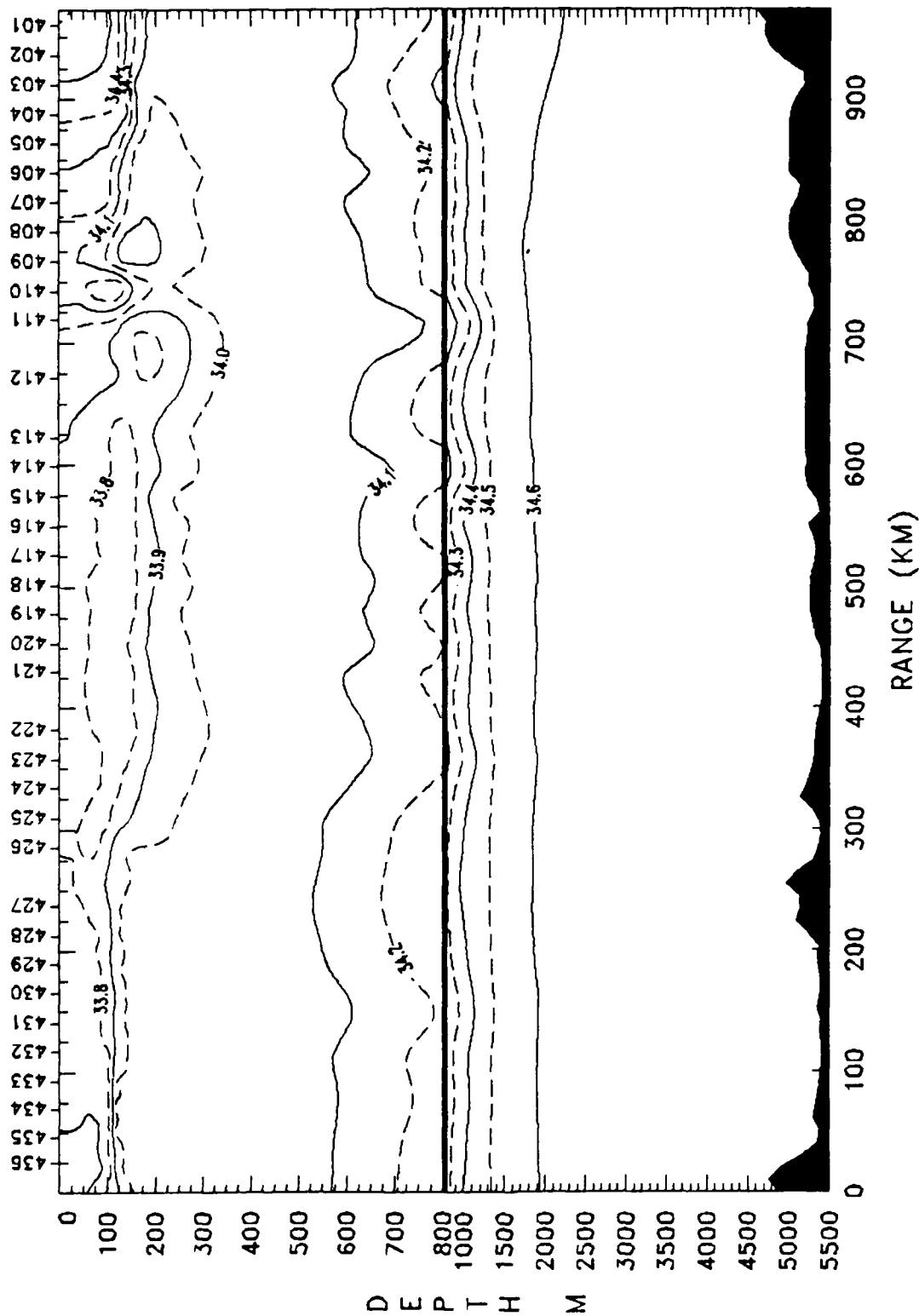
Inferred Salinity (psu)
 GEOSAT TPACK G1-a (401-436)

39.50, -144.50 31.75, -139.50

15:29:44

5/02/90

dx=11,dy=20,100



LAT 39.5 39.0 38.5 38.0 37.5 37.0 36.5 36.0 35.5 35.0 34.5 34.0 33.5 33.0 32.5 32.0

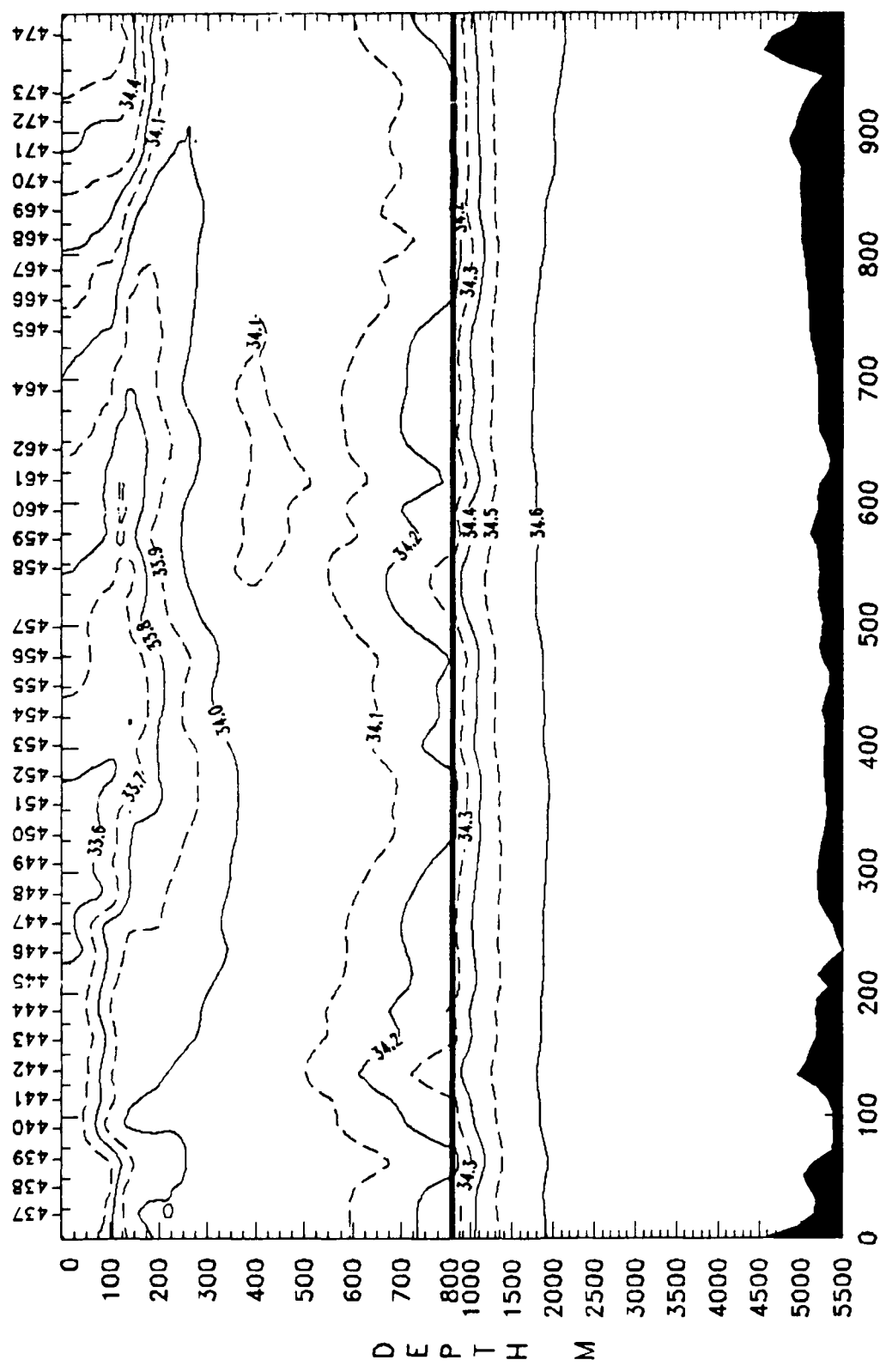
LONG -144.0 -143.0 -142.0 -141.0 -140.0

NOARI. Code 331

Inferred Salinity (psu)
 GEOSAT TRACK G1-b (437-474)

40.00,-143.25 32.00,-138.25

15:33:29



RANGE (KM)

LAT 40.0 39.0 38.0 37.0 36.0 35.0 34.0 33.0 32.0
 LONG -142.5 -141.5 -140.5 -139.5 -138.5

NOARL Code 331

dx=11,dy=20,100

5/02/90

Calculated Sound Speed (m/s)
 GEOSAT TRACK G1-a (401-436)

31.75, -139.50

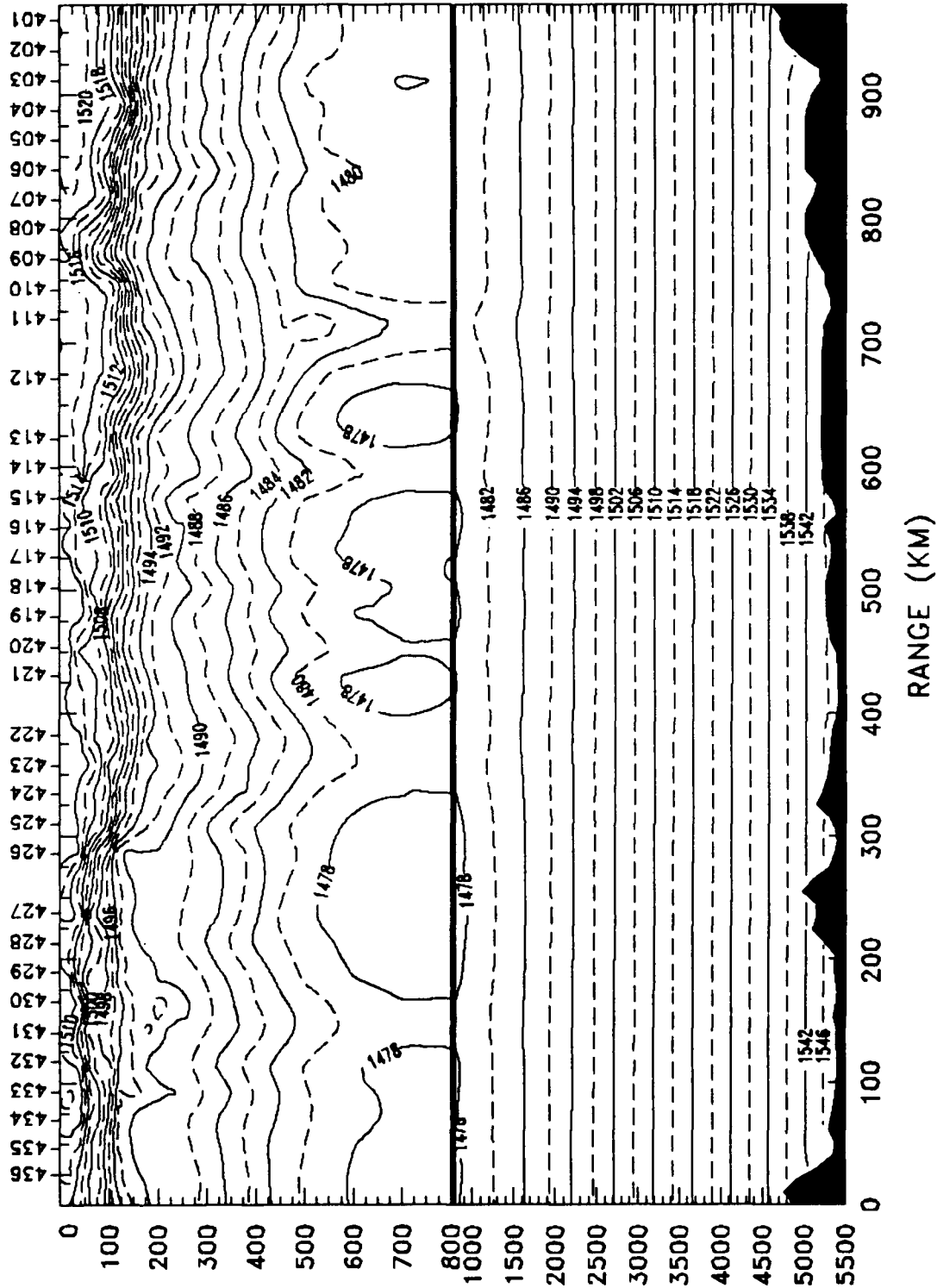
39.50, -144.50

16:05:29

DEPTH M

5/02/90

dx=11, dy=20, 100



LAT 39.5 39.0 38.5 38.0 37.5 37.0 36.5 36.0 35.5 35.0 34.5 34.0 33.5 33.0 32.5 32.0
 LONG -144.0 -143.0 -142.0 -141.0 -140.0

NOARL Code 331

40.00, -143.25

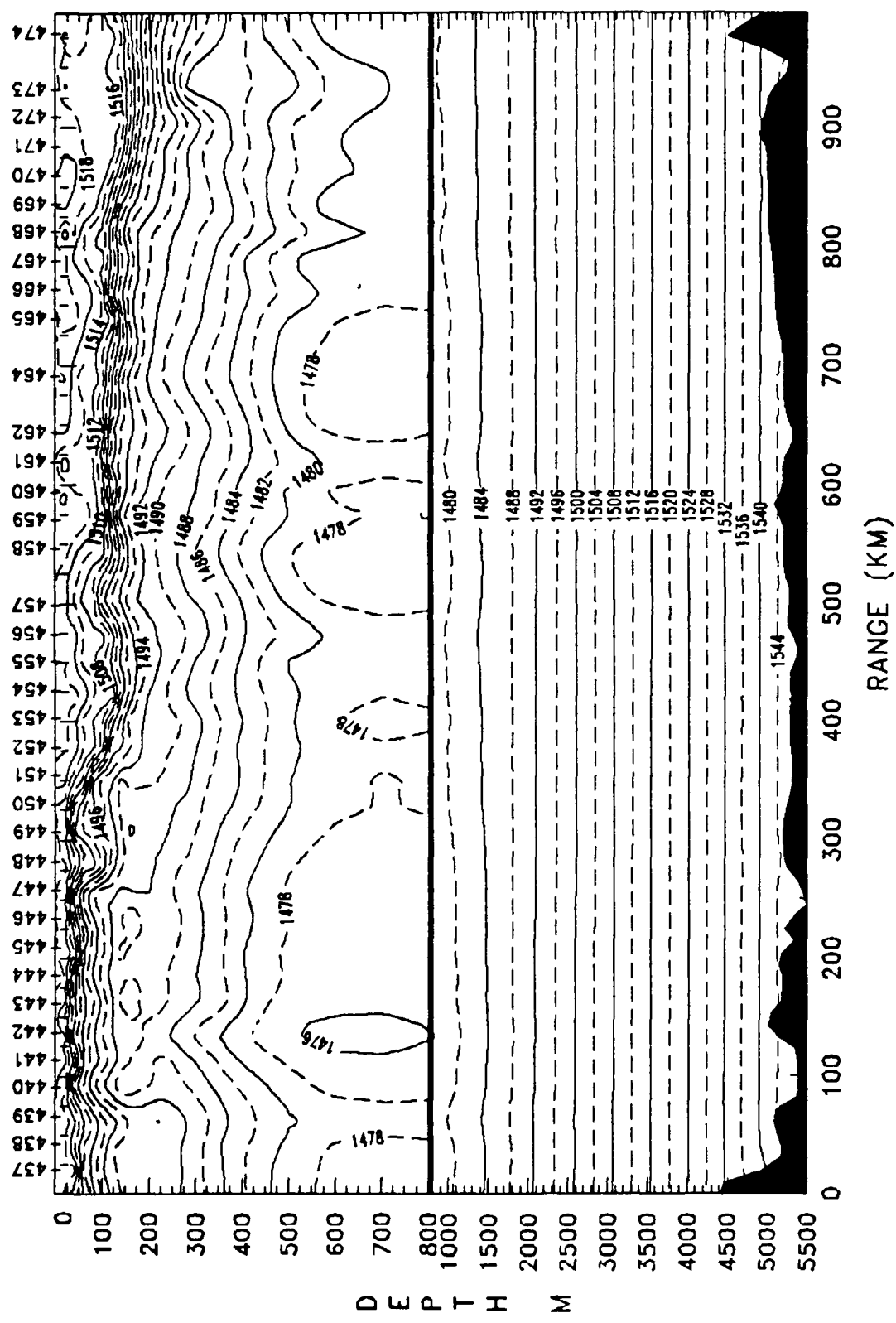
Calculated Sound Speed (m/s)
GEOSAT TRACK G1-b (437-474)

32.00, -138.25

17:01:13

4/17/90

dx=11, dy=20, 100



LAT 40.0 39.0 38.0 37.0 36.0 35.0 34.0 33.0 32.0
LONG -142.5 -141.5 -140.5 -139.5 -138.5

NOARL Code 331

Appendix O.

Second GEOSAT Underflight, 30 June 1989

Vertical Contours

Temperature: Surface to 300 m and Surface to 5500 m

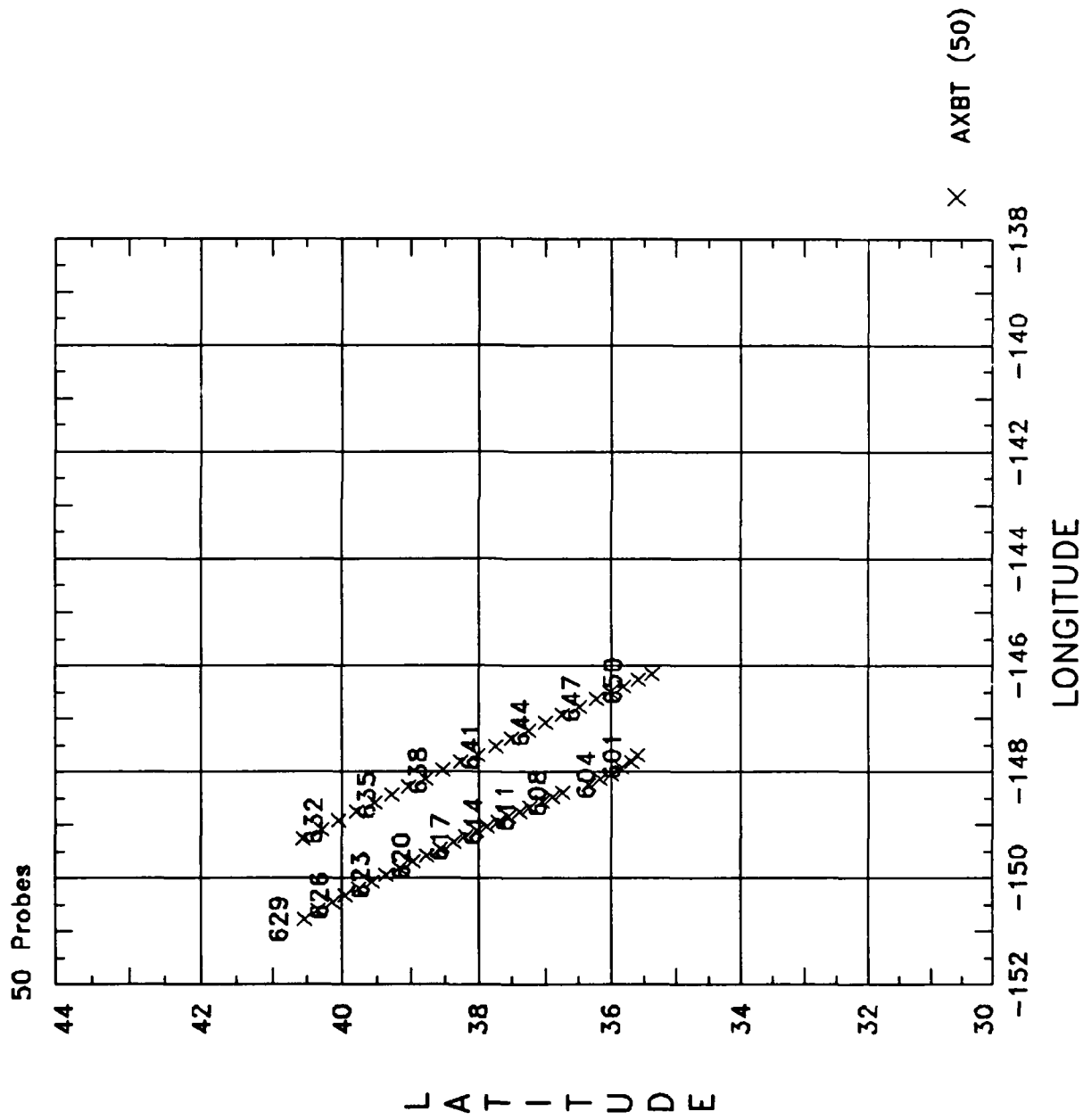
Inferred Salinity: Surface to 5500 m

Calculated Sound Speed: Surface to 5500 m

GEOSAT #2 30 June 1989

8:22:44

4/17/90

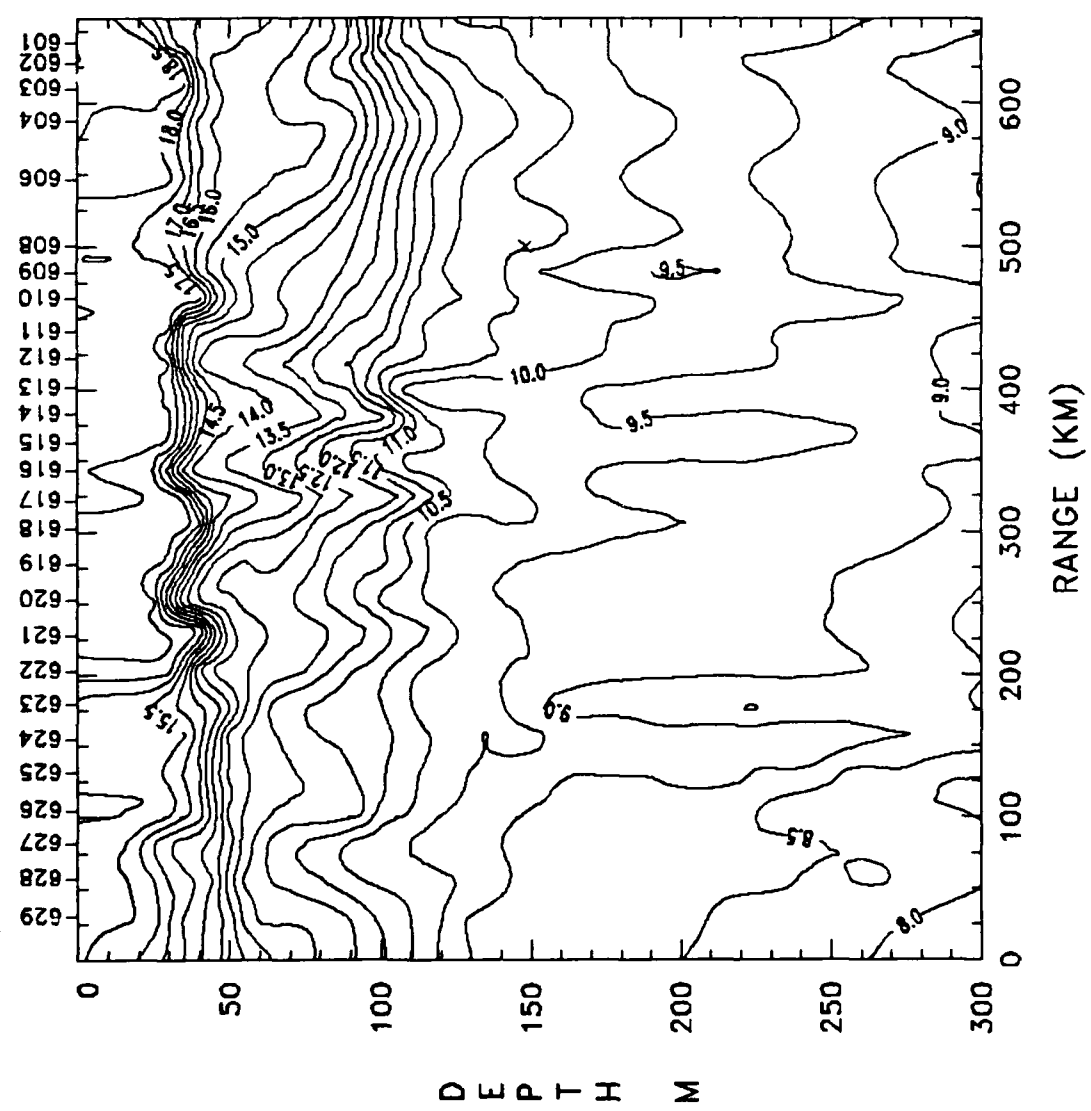


Observed Temperatures (deg C)
 40.75,-151.00 GEOSAT TRACK G2-a (601-629) 35.50,-147.50

11:08:33

5/17/90

dx=10.dy= 5



LAT 40.5 40.0 39.5 39.0 38.5 38.0 37.5 37.0 36.5 36.0 35.5
 LONG -151.0 -150.5 -150.0 -149.5 -149.0 -148.5 -148.0 -147.5

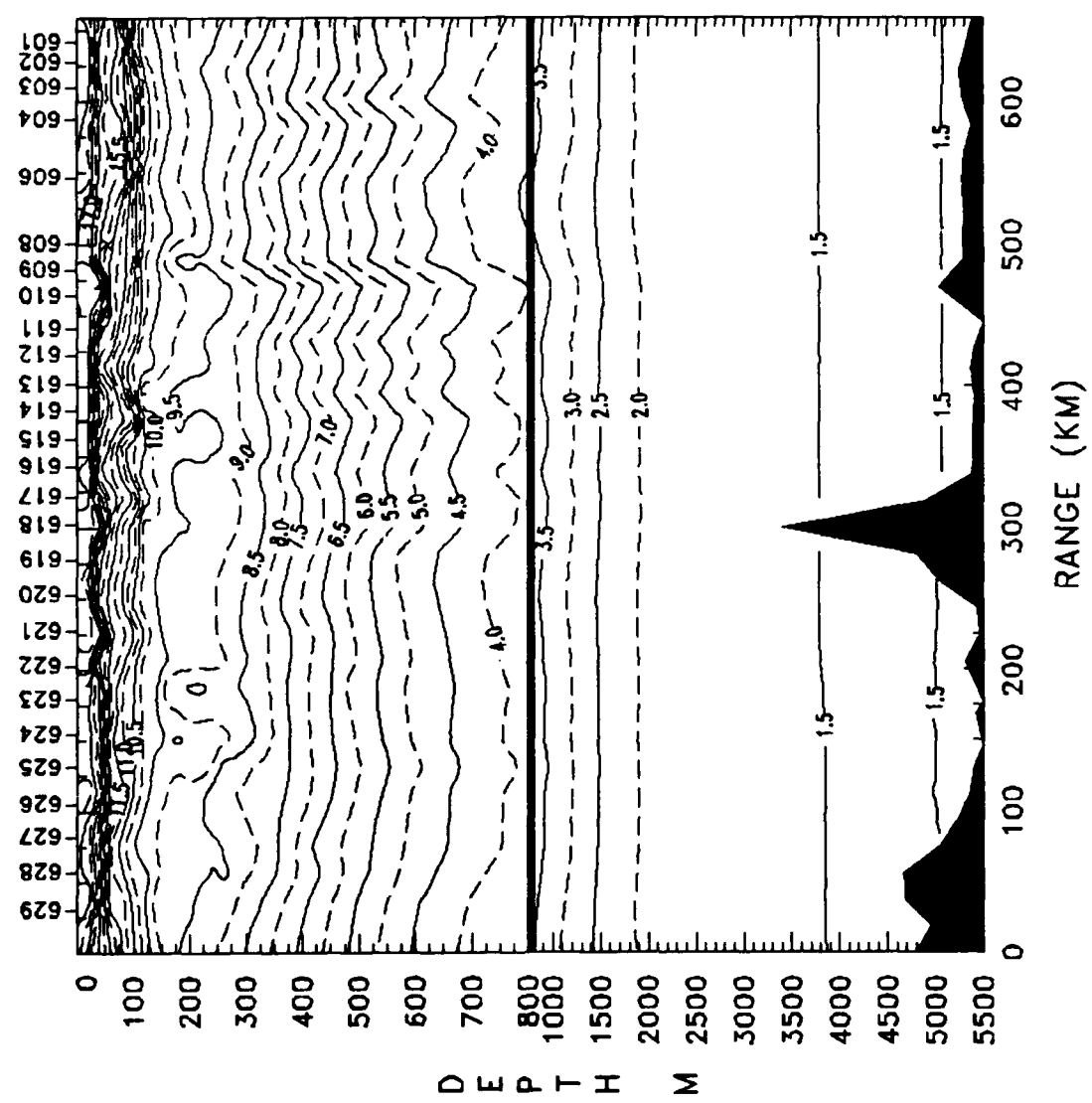
$$S = \lambda p'_{01} = x p$$


Temperatures (deg C)
 40.75,-151.00 GEOSAT TRACK G2-a (601-629) 35.50,-147.50

11:36:34

5/17/90

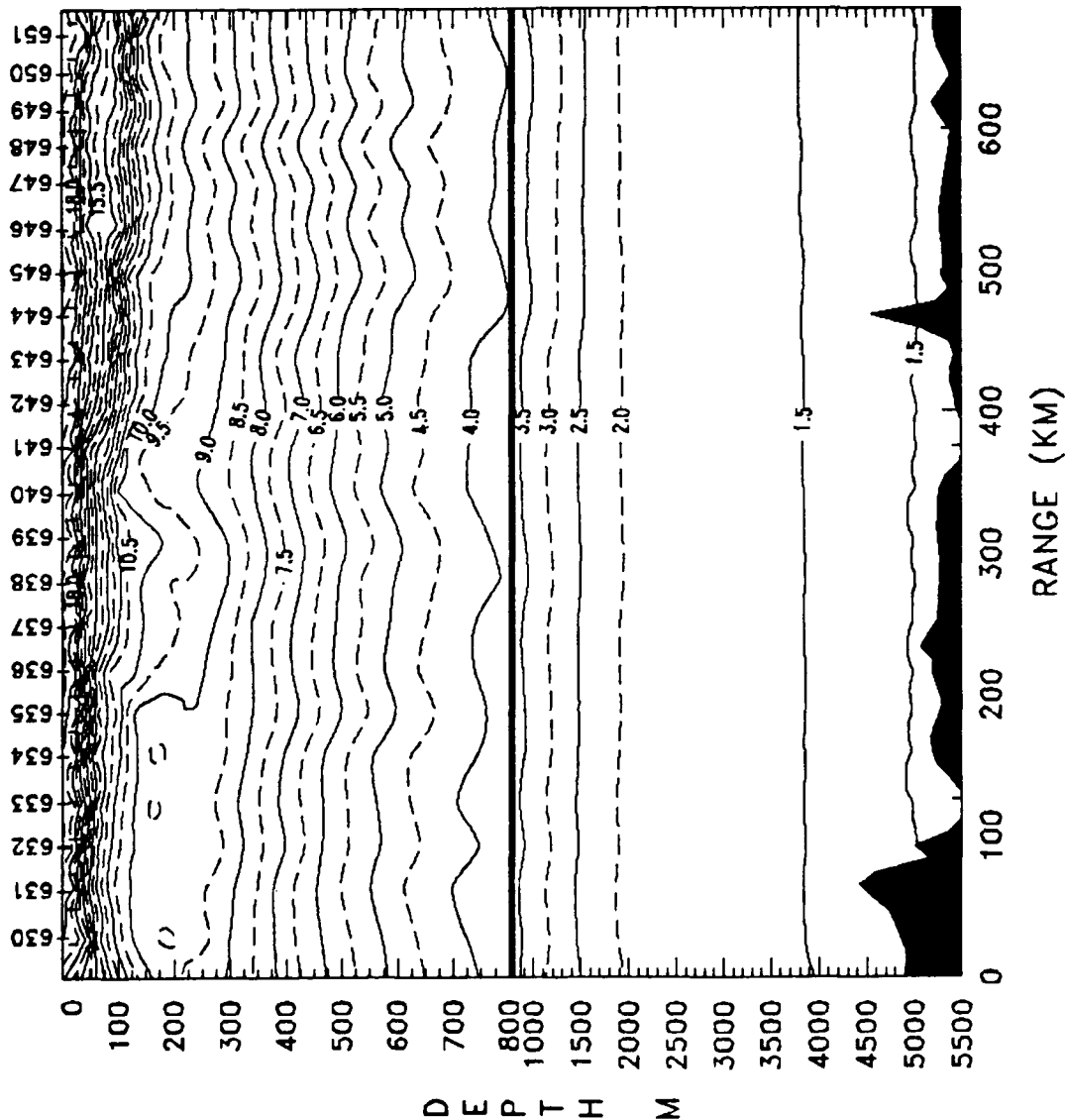
dx=19,dy=20,100



LAT 40.5 40.0 39.5 39.0 38.5 38.0 37.5 37.0 36.5 36.0 35.5
 LONG -151.0 -150.5 -150.0 -149.5 -149.0 -148.5 -148.0 -147.5
 NOARL Code 331

Temperatures (deg C)
 40.75,-149.50 GEOSAT TRACK G2-b (630-651) 35.25,-146.00

16:48:15



4/17/90

dx=10,dy=20,100

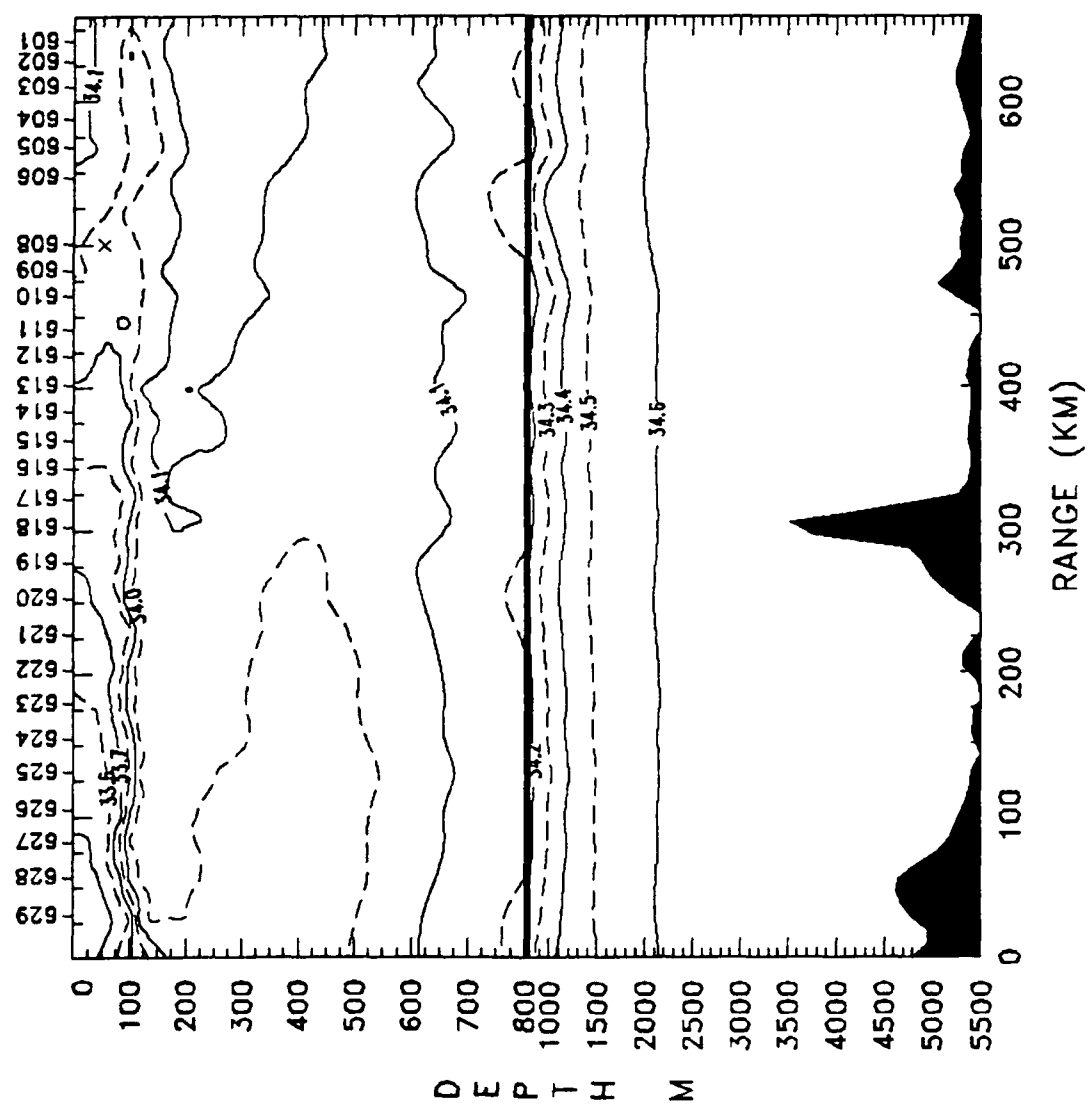
LAT 40.5 40.0 39.5 39.0 38.5 38.0 37.5 37.0 36.5 36.0 35.5
 LONG -149.5 -149.0 -148.5 -148.0 -147.5 -147.0 -146.5 -146.0
 NOARL Code 331

Inferred Salinity (psu)
 40.75,-151.00 GEOSAT TRACK G2-a (601-629) 35.50,-147.50

15:36:42

5/02/90

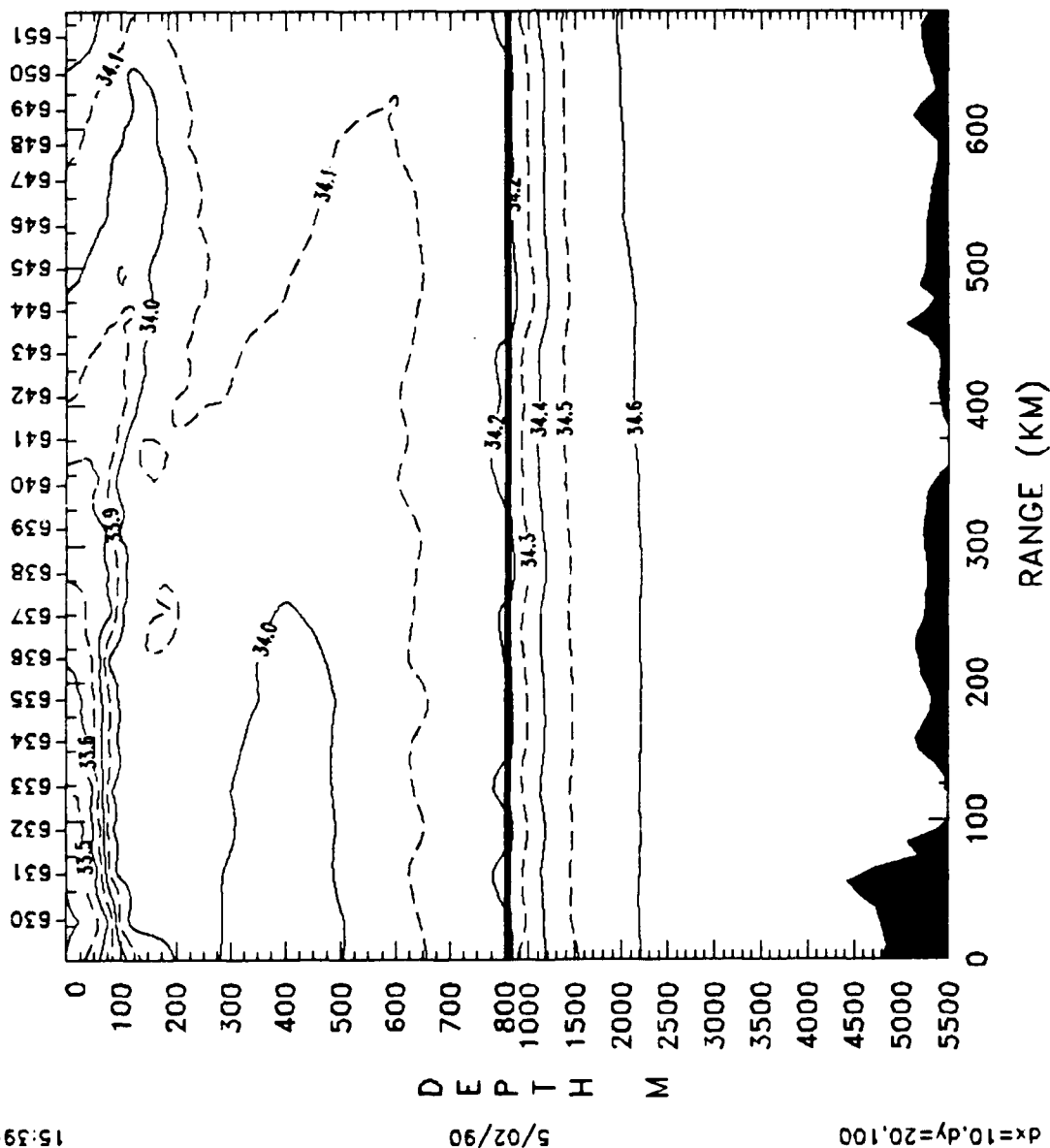
dx=10,dy=20,100



LAT 40.5 40.0 39.5 39.0 38.5 38.0 37.5 37.0 36.5 36.0 35.5
 LONG -151.0 -150.5 -150.0 -149.5 -149.0 -148.5 -148.0 -147.5
 NOARL Code 331

Inferred Salinity (psu)
 40.75,-149.50 GEOSAT TRACK G2-b (630-651) 35.25,-146.00

15:39:37



LAT 40.5 40.0 39.5 39.0 38.5 38.0 37.5 37.0 36.5 36.0 35.5
 LONG -149.5 -149.0 -148.5 -148.0 -147.5 -147.0 -146.5 -146.0
 NOARL Code 331

5/02/90
 DEPTH

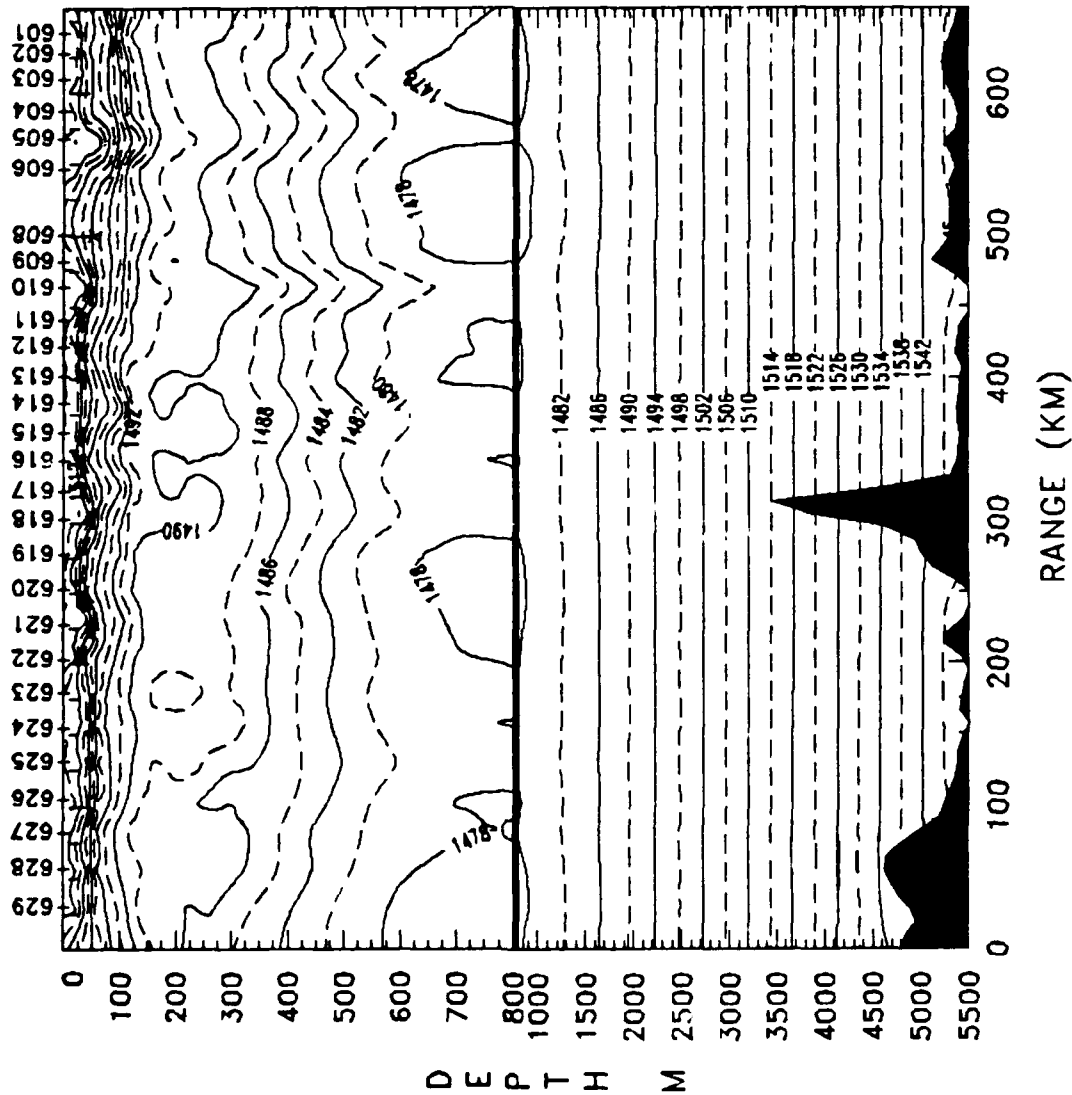
$\Delta x=10, \Delta y=20, 100$

Calculated Sound Speed (m/s)
 40.75,-151.00 GEOSAT TRACK G2-a (601-629) 35.50,-147.50

17:03:36

4/17/90

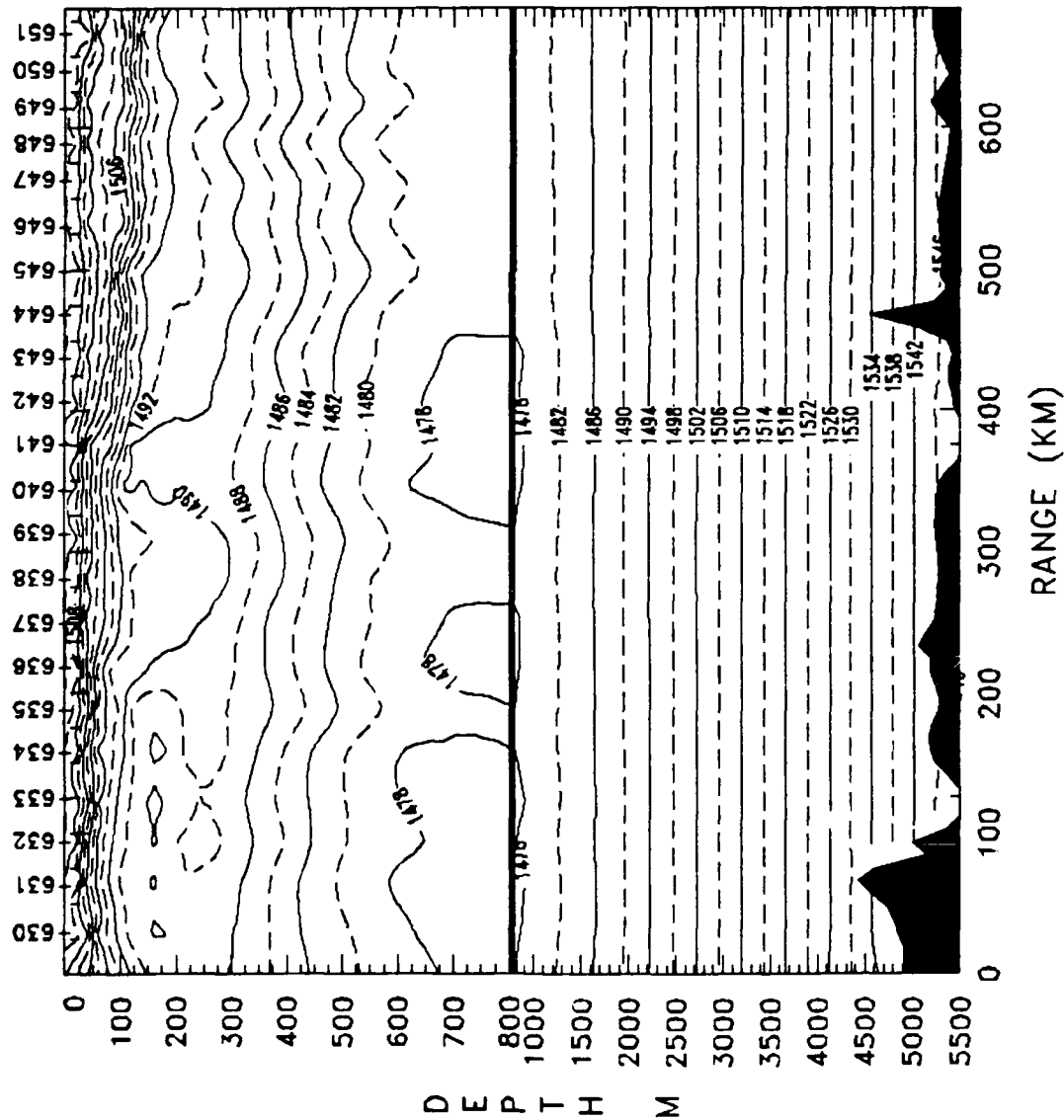
dx=10,dy=20,100



LAT 40.5 40.0 39.5 39.0 38.5 38.0 37.5 37.0 36.5 36.0 35.5
 LONG -151.0 -150.5 -150.0 -149.5 -149.0 -148.5 -148.0 -147.5
 NOARL Code 331

Calculated Sound Speed (m/s)
 40.75,-149.50 GEOSAT TRACK G2-b (630-651) 35.25,-146.00

17:05:4



4/17/90

dx=10,dy=20,100

LAT 40.5 40.0 39.5 39.0 38.5 38.0 37.5 37.0 36.5 36.0 35.5
 LONG -149.5 -149.0 -148.5 -148.0 -147.5 -147.0 -146.5 -146.0
 NOARL Code 331

Appendix P

Third GEOSAT Underflight, 11 July 1989

Vertical Contours

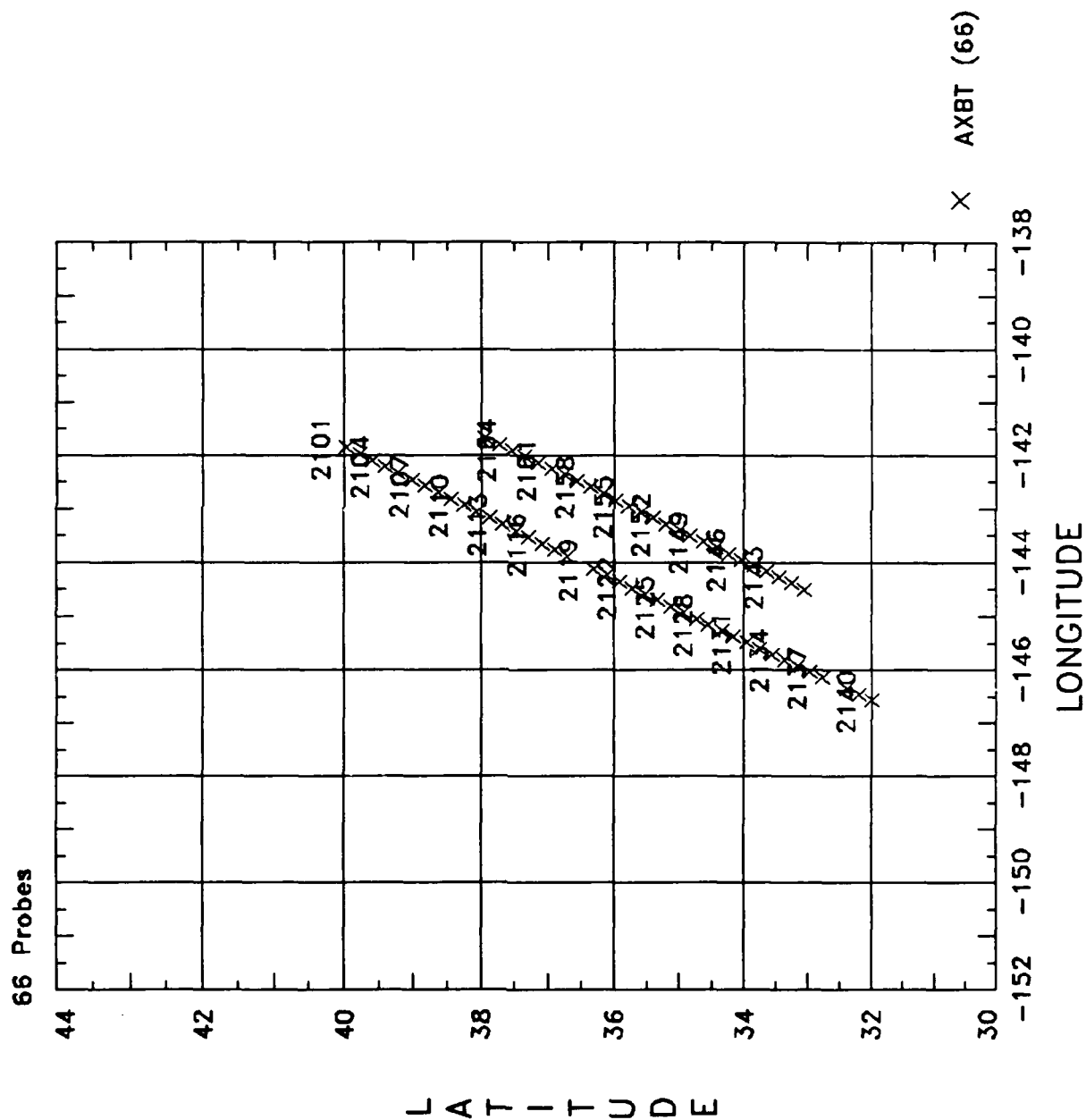
Temperature: Surface to 300 m and Surface to 5500 m

Inferred Salinity: Surface to 5500 m

Calculated Sound Speed: Surface to 5500 m

8:25:06

GEOSAT #3 11 July 1989



4/17/90

Observed Temperatures (deg C)
 GEOSAT TRACK G3-a (2101-2140)

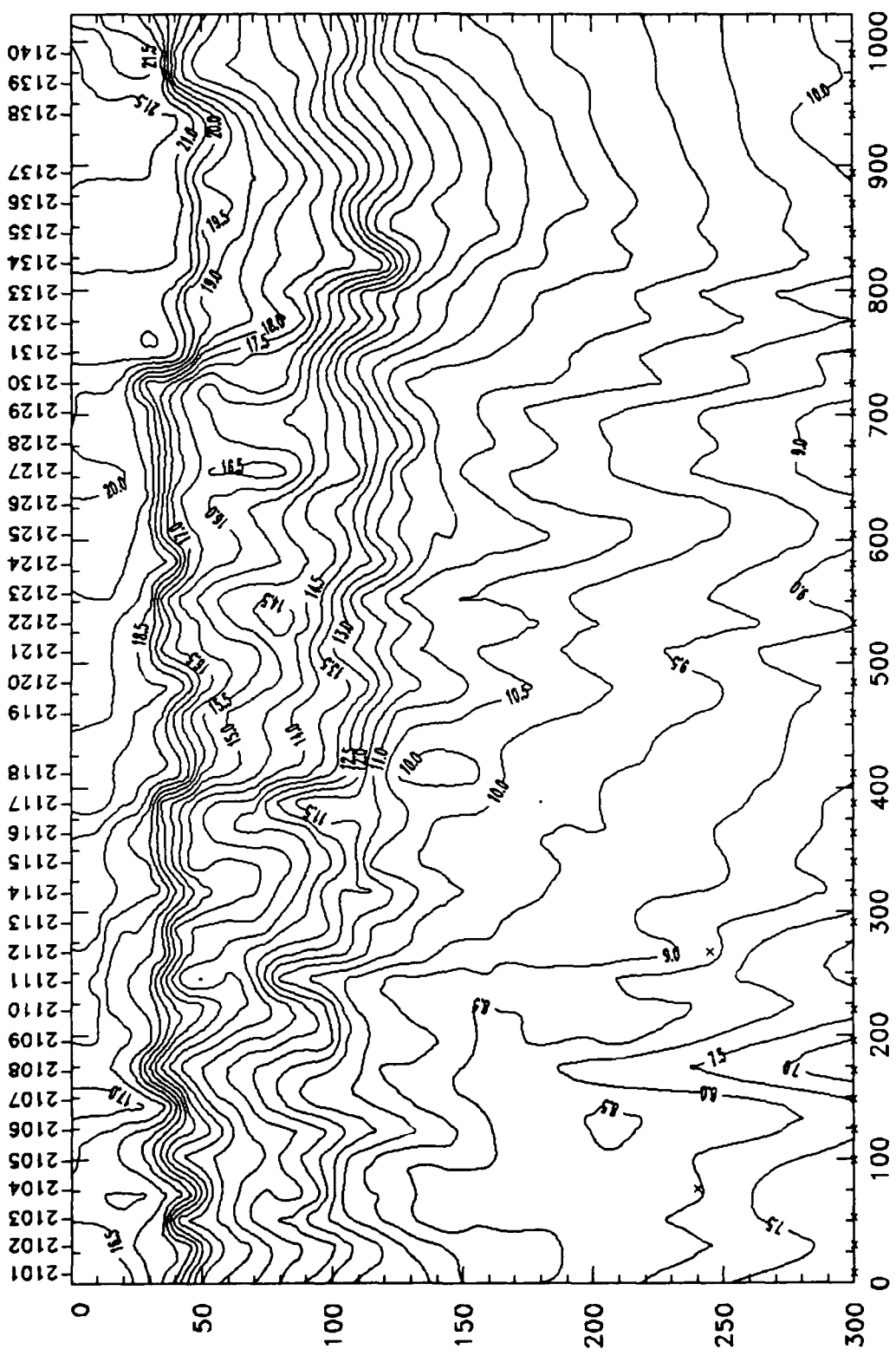
40.00, -141.75 31.75, -146.75

9:03:40

DEPTH M

12/11/89

dx=11,dy=5



RANGE (KM)

LAT 40.0 39.0 38.0 37.0 36.0 35.0 34.0 33.0 32.0
 LONG -142.5 -143.5 -144.5 -145.5 -146.5

NOARL Code 331

Observed Temperatures (deg C)

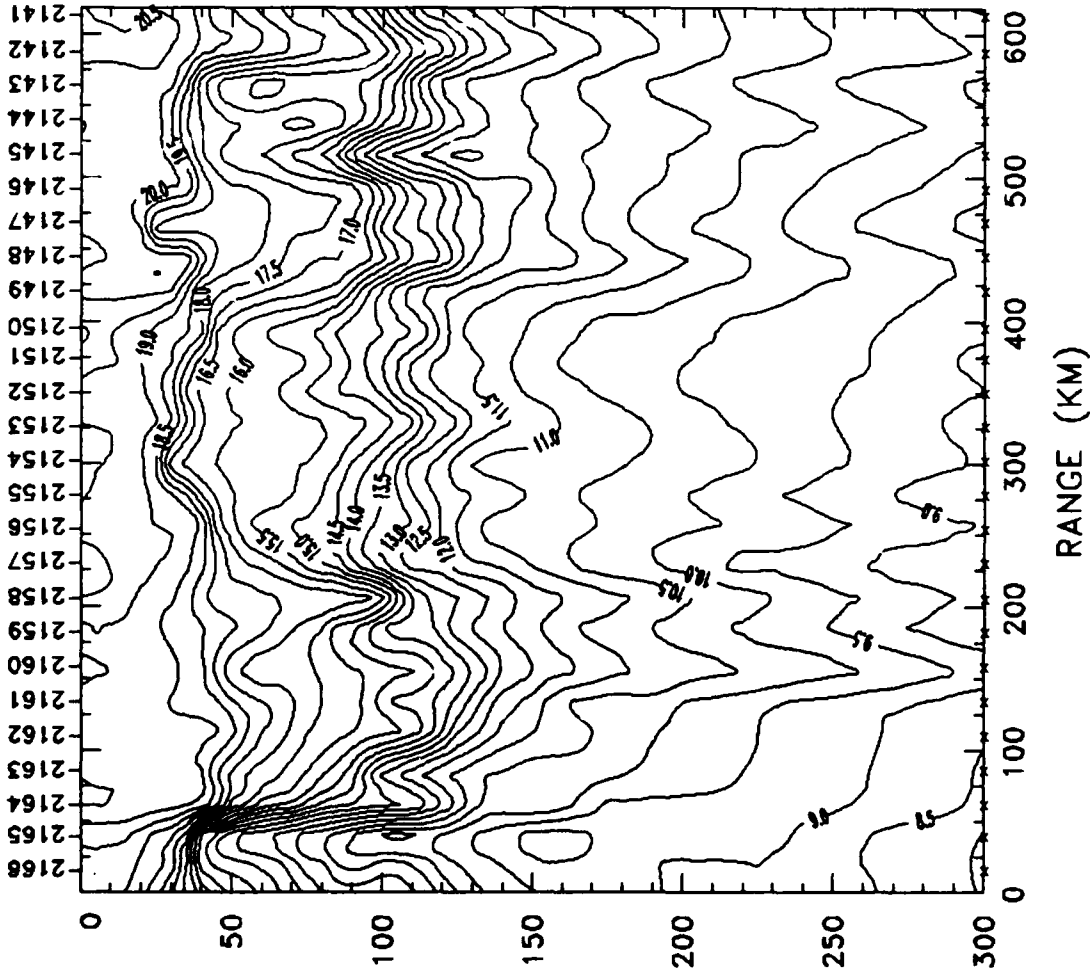
38.00,-141.50GEOSAT TRK G3-b (2141-2167) 33.00,-144.50

9:06:25

DEPTH M

12/11/89

dx=11,dy=5



LAT 38.0 37.5 37.0 36.5 36.0 35.5 35.0 34.5 34.0 33.5 33.0
 LONG -141.5 -142.0 -142.5 -143.0 -143.5 -144.0 -144.5

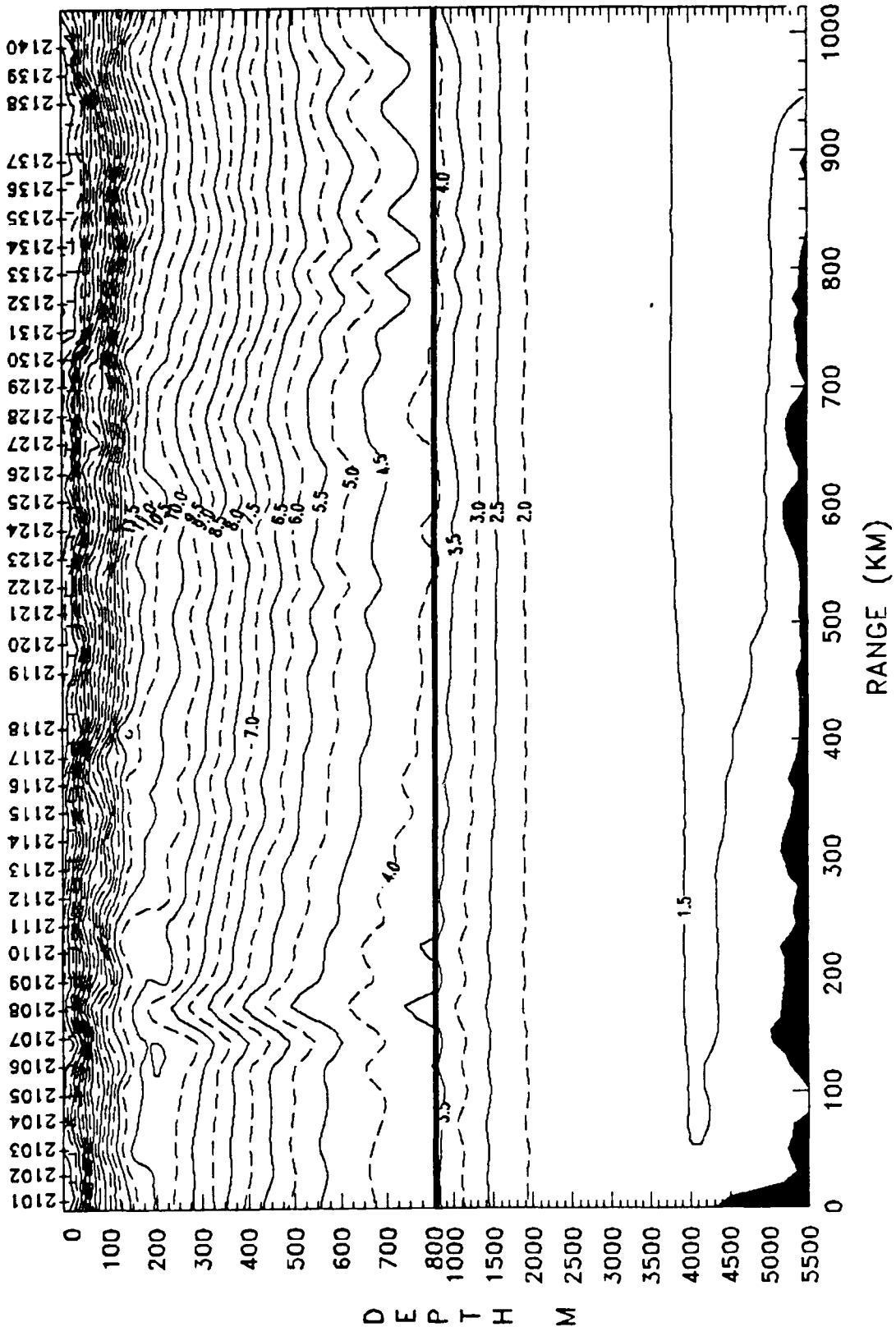
NOARL Code 331

40.00, -141.75
 GEOSAT TRACK G3-a (2101-2140)
 Temperatures (deg C)
 31.75, -146.75

16:50:47

4/17/90

dx=11, dy=20, 100



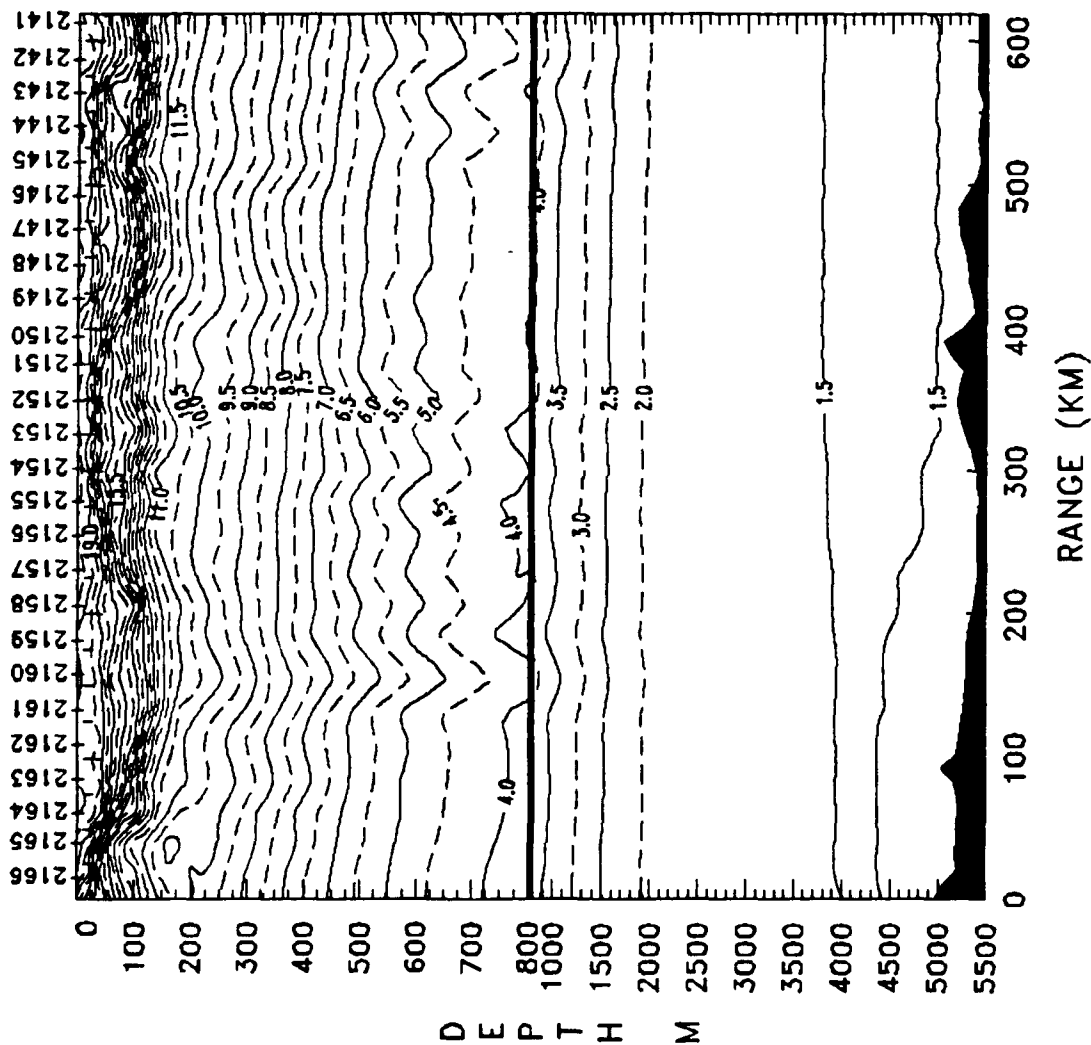
LAT 40.0 39.0 38.0 37.0 36.0 35.0 34.0 33.0 32.0
 LONG -142.5 -143.5 -144.5 -145.5 -146.5

Temperatures (deg C)
 38.00,-141.50 GEOSAT TR G3-b (2141-2166) 33.00,-144.50

12:20:04

4/23/90

dx=11,dy=20,100



LAT 38.0 37.5 37.0 36.5 36.0 35.5 35.0 34.5 34.0 33.5 33.0
 LONG -141.5 -142.0 -142.5 -143.0 -143.5 -144.0 -144.5
 NOARL Code 331

Inferred Salinity (psu)
 GEOSAT TRACK G3-a (2101-2140)

40.00, -141.75

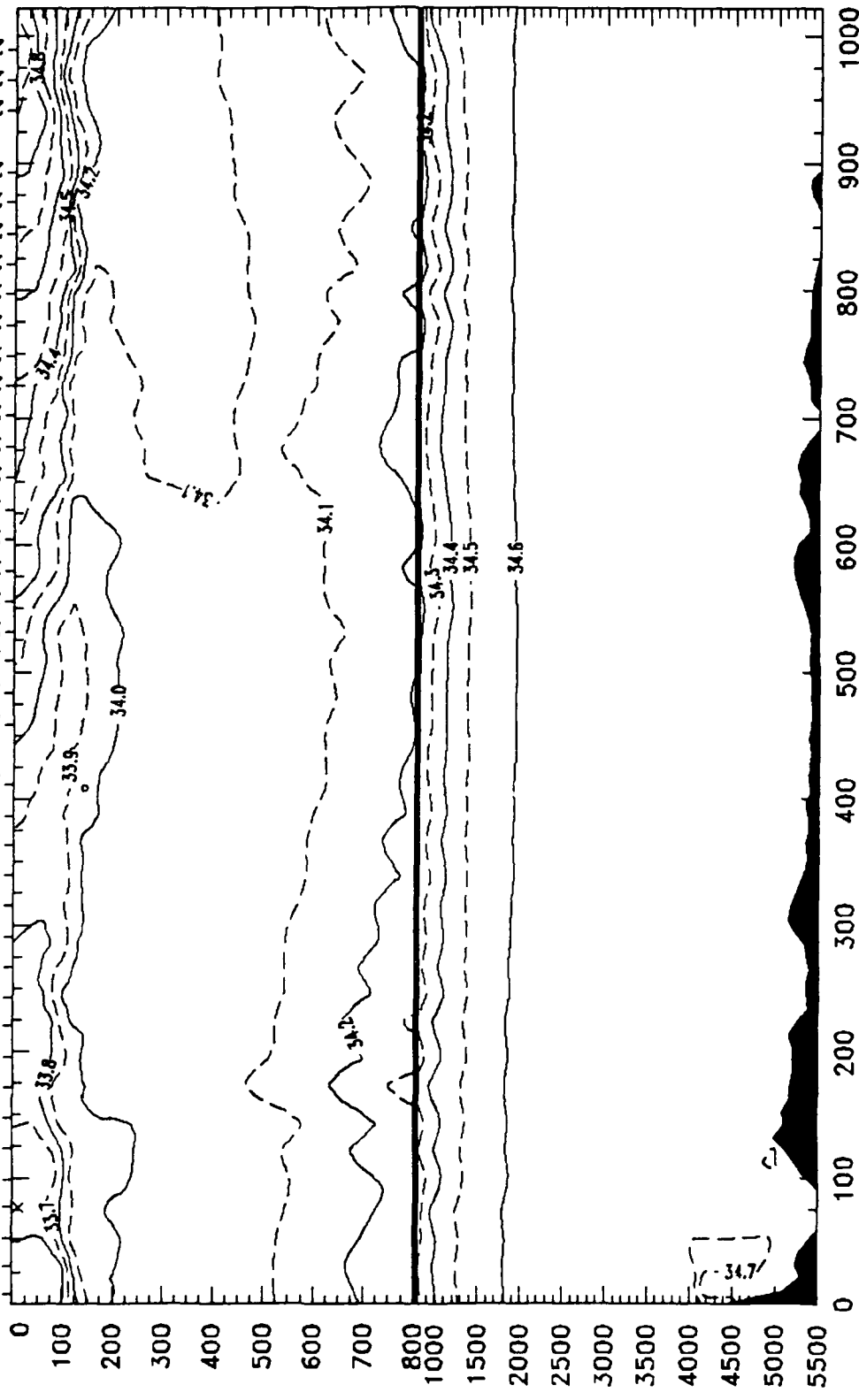
31.75, -146.75

15:43:09

DEPT M

5/02/90

dx=11, dy=20, 100



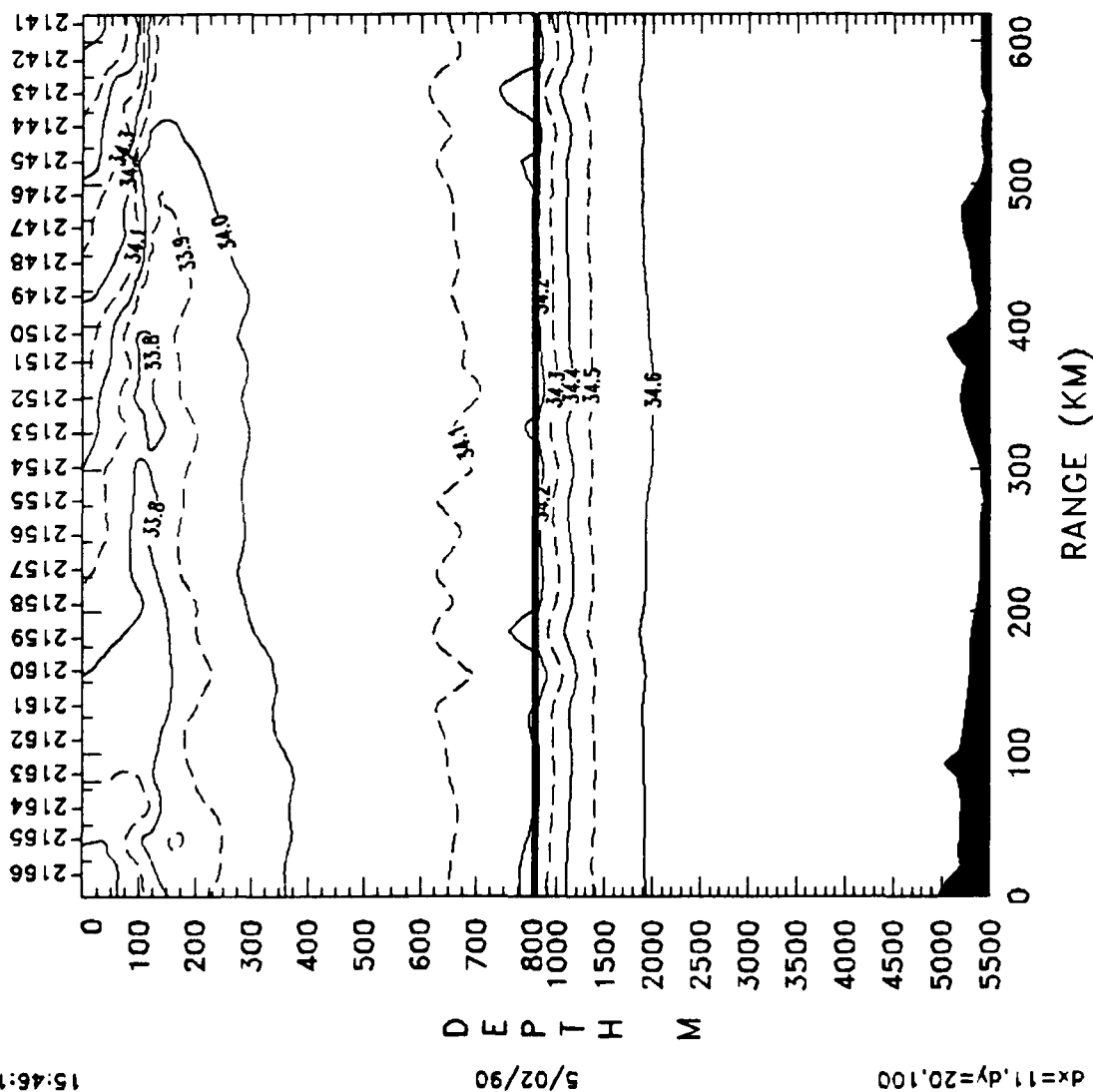
RANGE (KM)

LAT 40.0 39.0 38.0 37.0 36.0 35.0 34.0 33.0 32.0
 LONG -142.5 -143.5 -144.5 -145.5 -146.5

NOARL Code 331

Inferred Salinity (psu) 38.00,-141.50GEOSAT TRK G3-b (2141-2166) 33.00,-144.50

15:46:12



LAT 38.0 37.5 37.0 36.5 36.0 35.5 35.0 34.5 34.0 33.5 33.0

LONG -141.5 -142.0 -142.5 -143.0 -143.5 -144.0 -144.5

NOARL Code 331

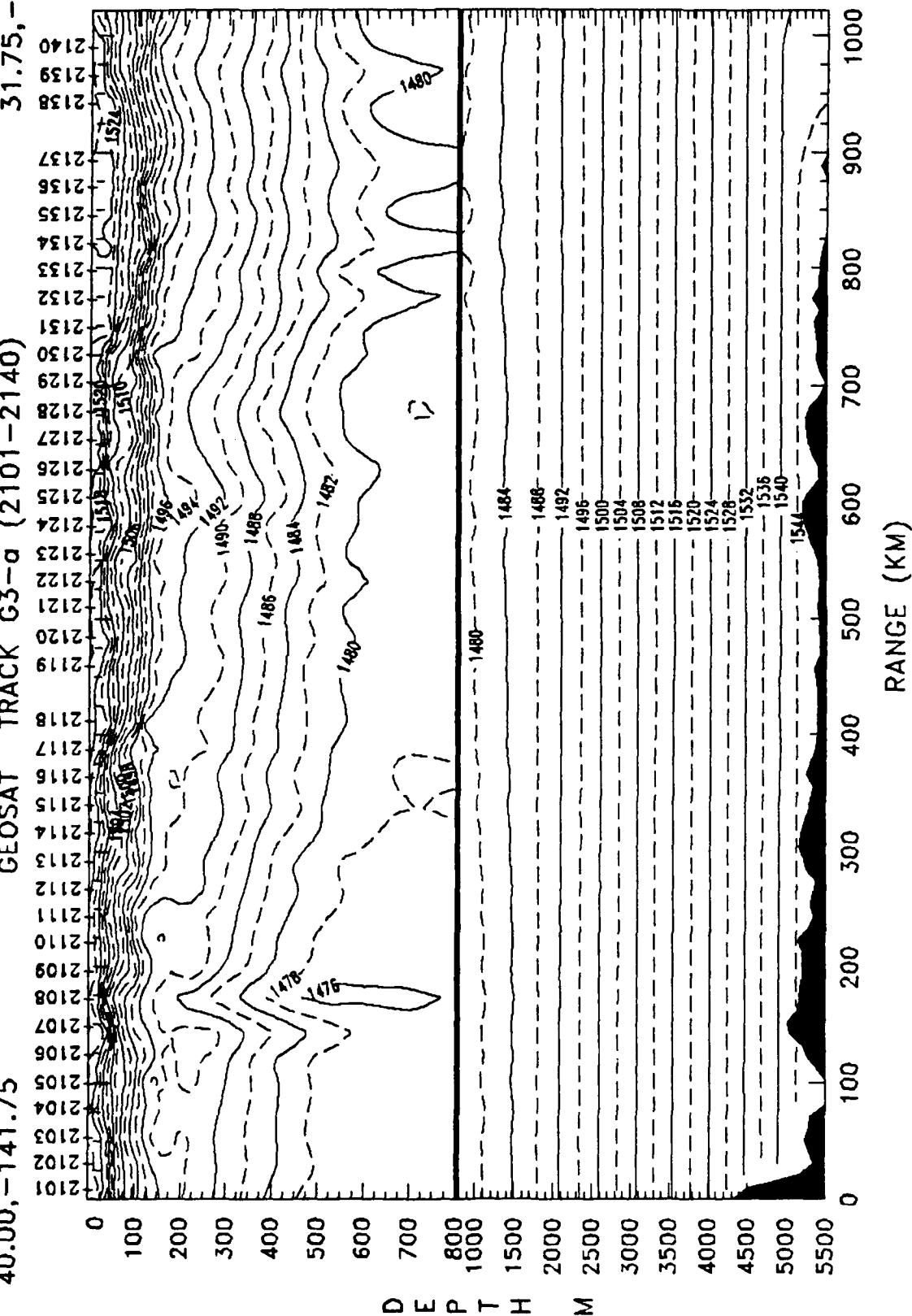
dx=11,dy=20,100

5/02/90

Calculated Sound Speed (m/s)
 GEOSAT TRACK G3-a (2101-2140)

40.00, -141.75

31.75, -146.75



LAT 40.0 39.0 38.0 37.0 36.0 35.0 34.0 33.0 32.0
 LONG -142.5 -143.5 -144.5 -145.5 -146.5

NOARL Code 331

17:08:19

4/17/90

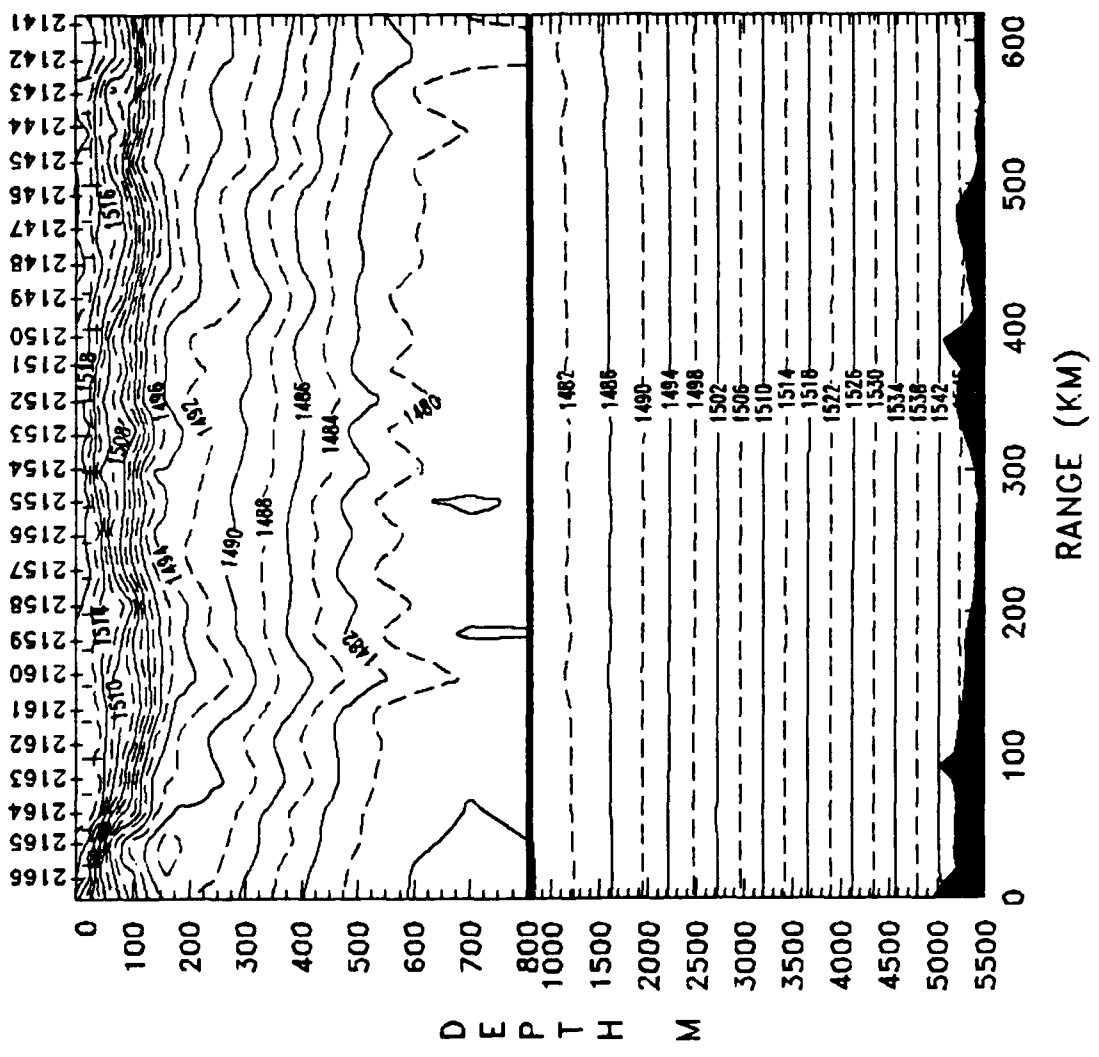
dx=11, dy=20, 100

Calculated Sound Speed (m/s)
 38.00, -141.50 GEOSAT TR G3-b (2141-2166) 33.00, -144.50

12:29:41

4/23/90

dx=11, dy=20, 100



LAT 38.0 37.5 37.0 36.5 36.0 35.5 35.0 34.5 34.0 33.5 33.0
 LONG -141.5 -142.0 -142.5 -143.0 -143.5 -144.0 -144.5

NOARL Code 331

Distribution List

Office of Naval Research
Attn: R. Peloquin
800 N. Quincy Street
Arlington, VA 22217-5000

Office of Naval Technology
Attn: CDR L. Bonds
800 N. Quincy Street
Arlington, VA 22217-5000

Office of Naval Technology
Attn: Dr. R. Doolittle, Code 230
800 N. Quincy Street
Arlington, VA 22217-5000

Space and Naval Warfare Systems Command
Attn: LCDR W. Cook
Washington, DC 20363-5100

Naval Research Laboratory
Attn: Dr. Orest Diachok, Code 5120
Washington, DC 20375-5000

Dr. Bruce Howe
Applied Physics Laboratory
U. of Washington
1013 NE 40th Street
Seattle, WA 98107

Dr. Jim Mercer
Applied Physics Laboratory
U. of Washington
1013 NE 40th Street
Seattle, WA 98107

Dr. Peter Wooster
Scripps Institution of Oceanography, A-013
University of California at San Diego
La Jolla, CA 92093

AEAS Program Office
Attn: Dr. E. Chaika
Bldg 1020
Stennis Space Center, MS 39529-7050

NOARL Code 125L (10)
Code 125P
Code 211 Dr. G. Morris
Code 331 Dr. J. Boyd (14)

Code 331 Dr. R. Hollman
Code 330 Dr. A.W. Green
Code 323 Dr. D.W. Blake (63)

REPORT DOCUMENTATION PAGEForm Approved
O&M No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. Agency Use Only (Leave blank).		2. Report Date. July 1990	3. Report Type and Dates Covered.	
4. Title and Subtitle. Aircraft Measurements in the Northeast Pacific, Summer 1989			5. Funding Numbers. Program Element No. 63207N Project No. X2008 Task No. Accession No. DN258048	
6. Author(s). J. D. Boyd			8. Performing Organization Report Number. NOARL Technical Note 40	
7. Performing Organization Name(s) and Address(es). Naval Oceanographic and Atmospheric Research Laboratory Ocean Science Directorate Stennis Space Center, Mississippi 39529-5004			10. Sponsoring/Monitoring Agency Report Number. NOARL Technical Note 40	
9. Sponsoring/Monitoring Agency Name(s) and Address(es). Space and Naval Warfare Systems Command PDW 141 Washington, DC 20363-5100				
11. Supplementary Notes.				
12a. Distribution/Availability Statement. Approved for public release; distribution is unlimited.			12b. Distribution Code.	
13. Abstract (Maximum 200 words). Between 25 June - 19 July 1989, an experiment deploying over 800 deep shallow AXBTs was conducted in the subarctic frontal zone of the Northeast Pacific, between approximately 32° - 43° N, 138° - 151° W. The operation was part of the validation phase of the Naval Oceanographic and Atmospheric Research Laboratory's (NOARL's) Northeast Pacific Modeling Project (NEPAC). This document describes the experimental plan and the data acquisition and processing techniques used for the NEPAC experiment and presents the resulting data in graphical form.				
14. Subject Terms. (U) Physical Oceanography, (U) Environmental Acoustic Prediction System (U) Environmental Numerical Forecast Models			15. Number of Pages. 219 16. Price Code.	
17. Security Classification of Report. Unclassified	18. Security Classification of This Page. Unclassified	19. Security Classification of Abstract. Unclassified	20. Limitation of Abstract. SAR	