SUMMIT CAMP TRAVERSE INFORMATION

FOR THE

AWS AND MAGIC SITES

PICO
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PICO
OR-95-01

February 1995

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INTRODUCTION

This report was prepared by the Logistics Department of the Polar Ice Coring Office at the University of Alaska Fairbanks through a contract from the National Science Foundation, Office of Polar Programs. This report provides information on traverses made from Summit Camp for the automatic weather station and MAGIC sites.

1994 TRAVERSE REPORT AND PREPARATION GUIDE

It was directed by the Logistics Manager, Scott A. Jackson, after discussion with Robert Clauer and Bob Sitar from the MAGIC project, that all traverse routes to the automatic weather station (AWS) and MAGIC sites should be flagged for safety reasons. All routes were in need of reflagging, thus 1200 flags were made to mark the 587 kilometers of trails at half-kilometer intervals. (A half-kilometer is the minimum distance for good trail visibility during average conditions.) These newly flagged trails should be in good shape for the next two to three years.

It has been argued that in the event of accident or misfortune the cavalry could effect easier rescue by being able to follow the flag line to the pioneers. However, on the completed 1200 kilometers (round trips) of traverses, the GPS system was used as the safeguard when flags could not be seen well due to weather conditions. It quickly became apparent that in conditions of poor visibility it was the GPS that could be turned to and relied upon for direction. In such conditions, it is also easier and quicker for either party (cavalry or pioneers) to follow the GPS, rather than try to find the flags in a blizzard.

As far as location of the party in need of assistance goes, the latitude and longitude can be given over the radio as easily as other distances and directions, and the cavalry can then head straight to those coordinates. As a safeguard, the camp manager and medic should make sure before traverses begin that the camp GPS receivers are set up to be powered externally by connection with a snow machine battery. (The internal batteries of these units will only last a couple of hours in the cold.)

The radio currently being used for traverse communications is an old Navy SC-120 unit that is probably more than 20 years old. The last Navy calibration on it was performed 18 years ago. In recent years, it has been difficult to establish satisfactory communication with base camp at GISP. Scott Jackson has recommended to the National Science Foundation that Standard-C telexes be purchased for traverse parties.

Radio communications were set for three times daily when traverse camp had been established. ATM, DYE2, and the Greenland Field Camp (GFC) at Sondrestrom were also notified of the schedule so that they could monitor traverse communications at the allotted times. Communications were attempted for 7.5 minutes on frequency 8093, then for a further 7.5 minutes on frequency 4753 at each of the times allocated.

The current latitude and longitude positions for the AWS and the MAGIC stations are as follows (note that seconds are expressed in 1/100th of a minute):

MAGIC North	73°56'00" N 37°37'50" W Actual distance by snow machine is 163 kilometers
MAGIC East	72°34'06" N 33°54'19" W Actual distance by snow machine is 162 kilometers
MAGIC West	72°00'00" N 42°35'45" W Actual distance by snow machine is 162 kilometers
AWS North	73°28'98" N 37°37'55" W
AWS East	72°34'09" N 34°38'20" W
AWS West	72°21'19" N 40°30'15" W
AWS South	71°41'04" N 38°11'92" W Actual distance by snow machine is 100 kilometers

The routes were relatively smooth and easy going all except for the east, where larger and harder sastrugi caused much bouncing and wear on the suspension of the snow machines. The suspension and track system of one of the old Alpine IIs fell apart en route, and the machine had to be loaded onto a sled and hauled back to GISP. The mechanic informs me that the suspension and track had obviously been worked on before and that the machine has become old and worn and in need of replacement. It was the mechanic's opinion that parts could be continue to be replaced, but that it might be less expensive to buy a new machine.

The western and southern routes, which in the past partially followed a defunct Bolzan line that took us out of our way and caused the trails to zigzag, have been straightened. The beginning of the western route (marked by a group of three flags) now goes directly from the northwestern side of the skiway straight to the AWS site and onto MAGIC West.

The southern AWS site is reached by following the ATM route south to the old ATM station and continuing straight on in a southerly direction. By rerouting we have saved more than 20 kilometers of travel time and flagging and have also simplified the journey.

The northern route begins just across the skiway about one-half kilometer from the Big House and is marked with a group of three flags.

The eastern route follows the GRIP flag line over to GRIP and then ends, beginning again a kilometer or so from their camp across their skiway in an easterly direction. This second trail head is marked with a group of three flags.

While on a traverse, we take the following supplies:

- Enough food for the accompanying people for two weeks, in case of delay by storms. The easiest food to prepare on traverse was the boil-bags of leftovers of the type used by the ATM remote crew. Food and water were heated on a Coleman stove (took three gallons of fuel-check on pallet line and filled small containers from the bulk can).

- Enough fuel for the machines to average 75 kilometers per 5 gallons (which is what the Alpine II and Skandic II will use under load). That is only 15 kilometers (or 10 miles) to the gallon, not uncommon fuel consumption for a 2-stroke engine of this size. We also took along some snowmachine tools (metric) and parts, such as spare belts, plugs, and filters.

- One two-person survival bag for every two people, a small first aid kit, the Southcom SC-120 radio, and a hand-held radio with extension antenna. We used Scott tents, foam pads, and sleeping bags for berthing.

On each trip out, it is necessary to make sure that everyone is personally prepared with lunch sandwiches, thermoses, adequate clothing for 100 miles on a snowmachine (for example, windproof outerwear, extra socks, gloves, mitts, face protection). Sunscreen and good sunglasses or goggles are also essential.

Remember that some of the scientific staff may have extremely limited experience with polar weather, with snowmachine travel, and even with camping. It is our responsibility to assist them in making the journey safe and productive.

AWS UPGRADES IN GREENLAND FOR 1992 FIELD SEASON

Site name: Kenton ARGOS I.D.# 8922

Direction: South at ATM, LAT: 72.28°N LON. 38.82°W Alt. 3185 m

People and supplies: Jay Klinck, Dave Koester, Scott and Jim assisted from ATM 2 Ski-doos and required tools for upgrades, no food or camping gear was taken as ATM was available.

Time and conditions:
Only one and a half sections were visible and the flagging to the dead men were completely buried. This was the first AWS that we extended 2 tower sections. 24 man hours.

Site name: Klinck ARGOS I.D.# 8938

Direction: Western LAT: 72.31°N LON. 40.48°W Alt. 3170 m

People and supplies: Jay Klinck, Dave Koester, Bob Clouer and John Larribeau This trip was done in conjunction with the Clauer magnetometer installation. Bob and John assisted us in make the upgrades to the AWS; this was completed prior to making camp that night.

Time and conditions:
Buried to the top tower section, the main power lead was chewed nearly in half by a fox, this cable was sliced. Bob and John both assisted and the modifications were completed in 20 man hours. It takes one day travel out to the site and one day travel to return to camp. This was a combined trip with the Clauer traverse.

Site name: Barber ARGOS I.D.# 8939

Direction: Southern LAT: 71.67°N LON. 3.17°W Alt. 3170 m

People and supplies: Jay Klinck, Jeff Thomas.
The installation and trip were completed in one day, however the arrangements were made to stay in the event the upgrades could not completed in one day.

Time and conditions: PICO time 15 hours. Snow sampling was completed during the return trip to GISP2 by Jeff. We helped each other getting ready for the trip, completing the sampling and raising the AWS.

Site name: Julie ARGOS I.D.# 3100

Direction: Eastern LAT: 72.57°N LON. 34.64°W Alt. 3100 m

People and supplies: Jay Klinck, Chuck Stearns and Mark Piper.

Time and conditions:
Travel and establishing camp was one day, one day to make the upgrades and return travel to GISP2 camp.

Site name: Matt ARGOS I.D.# 8928

Direction: Northern LAT: 73.48°N LON. 37.62°W Alt. 3100 m

People and supplies: Kevin Killilea, Check Strearns and Mark Piper.

Time and conditions:
Travel and establishing camp was one day, one day to make the upgrades and return travel to GISP2 camp.

Note:
It takes a minimum of 6 man hours to assemble required supplies for a traverse for 3 days with 3 to 4 people.

1992 MAGIC TRAVERSE INFORMATION

Arrived of the 6/23/92 to 7/27/92 for personnel.

Note that Bob Sitar returned early to Sondy. What should the daily cost be to maintain one person at GISP2.

Freight cost by MAC and C-130 to GISP2

Northern Site:
Out on 6/30/92 and returned 7/1/92
Two Cheyenne Ski-doo Gas 50 gallons
Bruce Wilson
Bob Clauer
John Larribeau
Bob Sitar

Bob Sitar broke his leg when the Ski-doo flipped over and was then flown out on the Twin Otter back to Sondy the following day.

Eastern Site:
2 days Out the 7/8/92 and returned on the 7/10/92
Two Cheyenne Ski-doo Gas = 40 Gallons, Food = , Bamboo and Flags, other
Bruce Wilson
Bob Clauer
John Larribeau

Western Site:
4 days with 3 nights out 7/14/92 and return the 7/17/92
Two Alpine and one Cheyenne Ski-doos: additional Gas was 55 gallons, Flags and bamboo 230 each
Jay Klinck
Dave Keoster
Bob Clauer
John Larribeau

ATM:
Dave Keoster
Bob Clauer
1 Cheyenne to remove batteries for use in the Northern site

Northern Site:
Out the 7/21/92 return 7/22/92
Two Cheyenne Ski-doos: Gas = 35 Gallons
Pat Galagher
Bob Clauer
John Larribeau

1990 Field Report
for
Greenland Automatic Weather Stations
by
Charles R. Stearns
and
George A. Weidner

1. Introduction:

Automatic weather station (AWS) units are installed on the Crest of Greenland in support of the ice coring activities of the United States and Western Europe. In May 1987 one AWS unit was installed at Cathy site on the crest of Greenland.

2. 1989 Activities

In June 1989 the unit at Cathy site was moved to the ATM-Fresh Air-Kenton site and two additional units were installed at GISP2 and GRIP. The sites are shown in Figure 1. The AWS units all measure the wind speed, wind direction, air temperature, relative humidity at a nominal height of 3.6 m, air pressure at the electronics enclosure and the vertical temperature difference between 0.5 and 3.6 m. The unit at Kenton site is equipped with an acoustic depth gauge for measuring the distance to the snow. The units at GRIP and GISP2 measure snow temperatures at seven depths and solar radiation.

The AWS unit at GRIP was not received regularly three months after installation in July 1989. The AWS units at GISP2 and Kenton sites were received continuously.

3. 1990 Activities

C.R. Stearns and G.A. Weidner left Madison Wisconsin for Scotia, N.Y. on 16 July 1990 and flew to Sondestrom, Greenland with the 109th TAG on 17 July 1990. We arrived at the GISP2 site on 19 July 1990 flying in with the 109th TAG. On 21 July 1990 we went to GRIP and found that AWS 8937 was cycling properly but that the transmitter output was very weak. Repairs could not be made at that time because we did not have an extra transmitter. The electronics was removed for repairs.

The Telonics ARGOS receiver correctly received AWS 8936 from the "Big House" at GISP2. This means that the addition of a properly programed computer will allow the display of the GISP2 AWS data at ten minute intervals. The recieved data showed that the wind speed was zero. Examination of the aerovane showed that there was a broken wire in the unit which was then repaired and the aerovane reinstalled on AWS 8936.

The two year wind direction frequency rose in Figure 1 for Cathy site showed that the wind direction was similar within the quadrants from N to E, E to S, S to W, and W to N and differed between the quadrants. As a result of the wind rose information one AWS unit was planned to be located 100 km south of GRIP and the second unit to be located 100 km west of GRIP. The sites would take advantage of trails that are already flagged. The AWS unit at GRIP along with the two AWS units 100 km south and west of GRIP form a triangle that can be used to estimate the divergence of the surface wind field for comparison to precipitation events detected by the acoustic depth gauge at Kenton site.

On 24 July 1990 an attempt was made to install AWS 8939 100 km south of GRIP. After starting to flag the trail south of ATM to one of John Boltzan's flag lines near strain site 53, the fog rolled in until the visual range was less than 200 m. Upon returning to ATM the top of the bottom delta T was even with the snow and the acoustic depth gauge was 0.79 m above the snow at Kenton AWS. The tower was raised six feet so that there was plenty of clearance above the snow for at least two more years. After raising the tower and installing the equipment the bottom delta T was at 1.0 m and the acoustic depth gauge was 1.5 m above the snow surface.

On 25 July 1990 G.A. Weidner started the return trip to Madison, WI so that the transmitter for the GRIP AWS unit could be repaired and returned in time for installation during 1990. The transmitter was not putting out sufficient power to reliably reach the satellite. Otherwise the unit was operating properly. A new transmitter was installed and on 8 August 1990 the AWS electronics was returned to the 109 Air National Guard for transportation to Sondestrom, Greenland on 12 August 1990. The unit was installed at GRIP by J. Klinck in about 12 August 1990 but was not receive by the ARGOS sytem and will be returned for repairs again. The unit will not be installed until the 1991 Greenland field season.

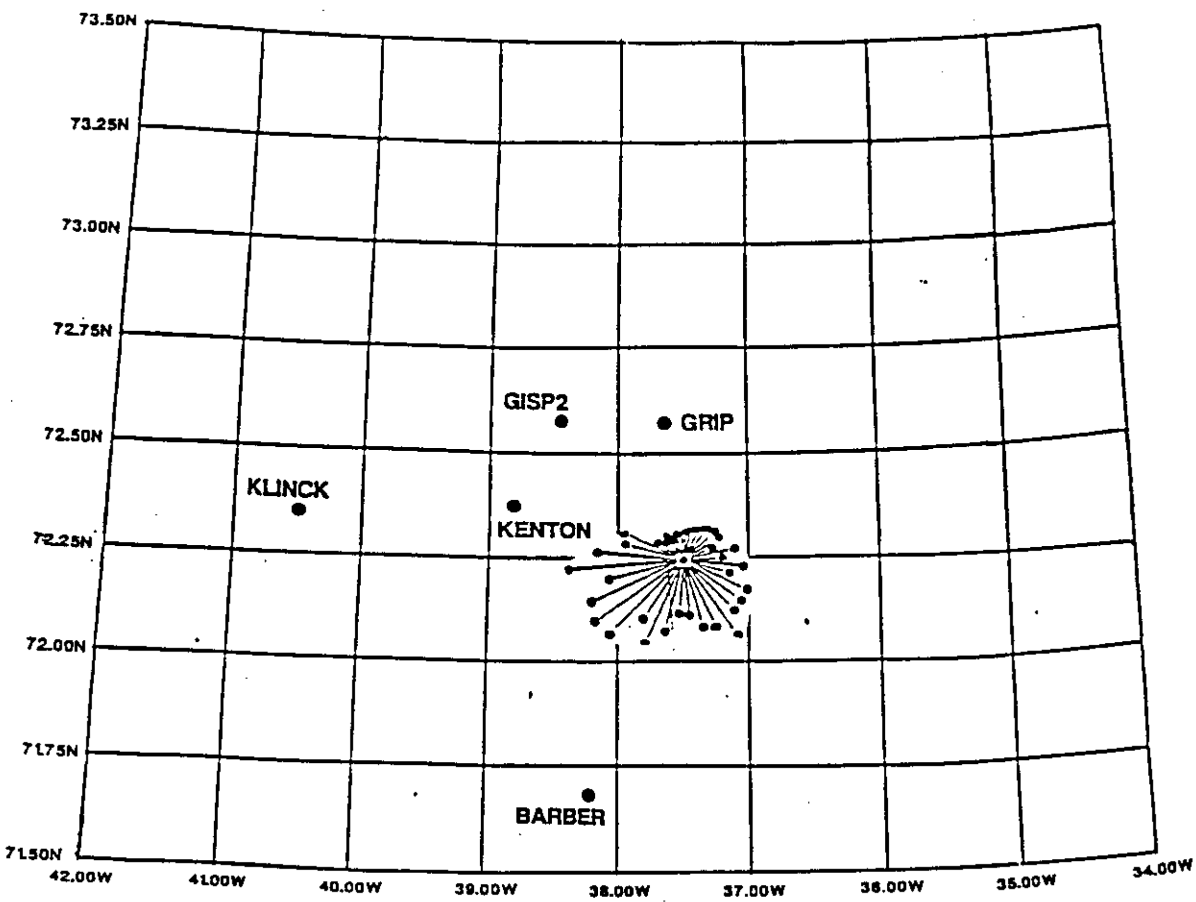
C.R. Stearns and Bill Barber went south to install the AWS unit 100 km south of GRIP. The selected location was on John Boltzan's flag line and between strain sites 63 and 73. The site was reached about 16:30 and AWS 8939 was installed by 20:00.

On 26 July 1990 C.R. Stearns showed Bill Barber and Jay Klinck how to install the AWS unit so that they could put in the unit shown in Figure 1 as Klinck site. C.R. Stearns left for Sondestrom, Greenland with the 109th TAG on 27 July 1990 as it was uncertain when there would be another flight. Upon arrival at Sondestrom it was learned from George Weidner that the Barber site was operating properly and that AWS 8938 was received correctly when under test. On 9 August 1990 AWS 8938 was installed by Bill Barber, Jay Klinck, and Julie Palais.

Figure 1 shows the AWS locations on Greenland along with the two year wind direction frequency for Cathy site The ARGOS location system was used to determine the latitude and longitude of the sites. Table 1 gives the site name, ARGOS ID, location, elevation and the site start date which is the same as the ID start date. The two new AWS sites for 1990 are named Barber and Klinck in honor of their services in installing the AWS units.

Table 1.
Site name, ARGOS identification number (ID), latitude, longitude, elevation, and start date for the AWS sites on the Greenland summit in 1990.

Site Name	ARGOS ID	Latitude degrees	Longitude degrees	Elev. meters	Site Start Date
GISP2	8936	72.58°N	38.45°W	3208	08 Jun 90
GRIP	8937	72.57°N	37.63°W	3233	10 Jun 90
Kenton	8922	72.36°N	38.80°W	3175	09 Jun 90
Barber	8939	71.68°N	38.20°W	3170	25 Jul 90
Klinck	8938	72.35°N	40.50°W	3100	09 Aug 90



GREENLAND SUMMIT 1990

Figure 1. Map of Greenland showing the locations of GISP2, GRIP, Kenton, Barber, and Klink AWS units. GISP2, Kenton, and GRIP sites were installed in June 1989. Barber and Klinck sites were installed in August 1990. The wind direction frequency rose is show for Cathy site (72.3°N, 38°W) which operated from May 1987 to June 1989. The longest line in the wind rose corresponds to a wind direction frequency of 7% of the time that the wind speed is above 0.5 m/s. The line is in the direction the wind is coming from and represents a sector 10° wide. The AWS unit from Cathy site was installed at Kenton site in June 1989.

Snow Temperature Profiles and Heat Fluxes Measured on the Greenland Crest by Automatic Weather Stations

by

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Abstract:

In June 1989 two automatic weather station (AWS) units were installed on the Greenland crest at the GISP2 (78.58°N, 38.46°W, 3205 m) and GRIP (72.57°N, 37.62°W, 3230 m) ice coring sites. The purpose of the AWS units is to measure the local meteorological variables including snow temperatures in support of the ice coring studies. The two AWS units measure wind speed and direction, air temperature, and relative humidity at a nominal height of 3.6 meters, air pressure at the electronic enclosure, air temperature difference between 0.5 m and 3.6 m, solar radiation, and seven snow temperatures from the surface to approximately four meters depth. The data are updated at 10 minute intervals and transmitted to the ARGOS data collection system on board the NOAA series of polar orbiting satellites.

Introduction:

Two automatic weather station (AWS) units were installed in June 1989 at GISP2, the U.S. ice coring site, and at GRIP, the European ice coring site on the crest of Greenland. Stearns and Weidner, 1990, show the locations of the two sites on Greenland. The purpose of the AWS units is to monitor the meteorology at the two sites. The two AWS units measure wind speed and direction, air temperature, and relative humidity at a nominal height of 3.9 meters, air pressure at the electronics enclosure, the vertical air temperature difference between 3.6 and 0.5 meters, solar radiation, and seven levels of snow temperature from the snow surface to a depth of about four meters. The data are transmitted to the ARGOS data collection system on board the NOAA series of polar orbiting satellites. More details on the AWS unit are given in Stearns and Weidner, 1990.

Snow Temperature Measurement:

The two AWS units are equipped with an Inters[illegible] ICL-7605 differential amplifier with a gain of 480 and an RCA-CD4097B eig[illegible]el differential multiplexer. The snow temperature difference sensors [illegible] junction copper-constantan thermocouples inserted into 1/4 [illegible] al[illegible] tubing 30 cm long, and potted with room temperat[illegible]nizing rubb[illegible]. [illegible] sensor depths are 0.20, -0.05, -0.30, -.55[illegible]05, and -4.05 m. The [illegible]sors from -0.05 m to -2.05 were inserted horizont[illegible] [illegible]rner of a t[illegible] meter deep pit about four meter from the AWS tow[illegible]ing a [illegible] board to determine the sensor depth relative to the snow surface at the time of installation. Negative depths are below the snow surface and positive depths are above the snow surface at the time of installation. The 0.20 m and 0.45 sensors were supported above the snow with a styrafoam frame. The -4.05 m sensor was installed by drilling a 6 inch hole in the bottom of the two meter pit to a depth of -4.05 m. The exact depth of the -4.05 m temperature sensor is not known but based on the preliminary results the depth appears to be about -3.05 m. The thermocouple voltages are measured between adjacent depths except the voltage between 0.20 m and 0.45 m was not measured. The snow temperature is measured at the -1.05 m level with a resistance thermometer of 1000 Ohms at 0°C. Solar radiation, measured with a Kipp and Zonen solarimeter, and the air temperature thermocouple output between 0.5 and 3.6 m complete the eight multiplexer channels. The present value and the value 20 minutes earlier are stored in memory along with the air temperature and the snow temperature. The data are transmitted to the ARGOS system on the polar orbiting satellites in every third transmission between data updates.

Data are used from 8 June 1989 to 30 April 1990 for the AWS unit at GRISP2. GRIP AWS data are not presented because the unit was received intermittently. The thermocouple voltages were converted to temperature differences based on the thermocouple voltage output as a function of temperature for copper-constantan junctions. Considering the vertical axis as positive upwards a positive thermocouple output resulted when the higher sensor was warmer. Starting with the -1.05 m temperature the temperature differences were added to obtain the temperature at the next level up or down. The several temperatures at each level in the snow and air for each day are averaged to obtain the mean temperature for the day.

The sensible heat flux into the snow at the 0.20 m level is based on the assumption that the snow density is 0.3 of the density of water. A depth interval corresponding to one half the depth interval between the sensors above and below the level of temperature measurement is assigned to each level including the weighting for the heat capacity of the snow. The weighting factor multiplied by the temperature at that depth and summed over all depths gives the heat storage in the snow below the 0.20 m level. Then the difference in the heat storage between the present day and the previous day divided by the number of seconds in 24 hours gives the heat flux at the 0.20 m level for the day.

The surface of the snow is changing relative to the snow temperature profile during the course of the year and can amount to as much as 0.75 m increase in the height of the surface in one year on the crest of Greenland. The actual snow accumulation around the AWS units has not been measured since installation. The change in the snow surface height is not considered at this time.

The data scale is the Julian Day for 1989 and the count continued into 1990. To obtain the Julian Day for 1990 subtract 365. The starting Julian Day of 160 corresponds to 8 June 1989. In 1990 Julian Day 366 corresponds to 1 January 1990, 460 to 5 April 1990, and 485 to 30 April 1990 which is the last day for which data is available. The date scale will be referred to as the day number.

The air temperature at a height of 3.6 m and the snow temperatures at seven levels in the snow versus the day number are shown in Figure 1. The 0.20 m sensor was above the snow at the time of installation. Within a few days the sensor was covered with snow. The area was disturbed by the installation of the AWS unit and may have been a factor in the rapid accumulation of snow. The 0.20 m temperature and frequently the -0.05 m temperature are warmer than the air temperature until after day number 250. The solar radiation was strong and may have been an important factor in increasing the snow temperature above the air temperature. The air temperature also shows the large changes in temperature after day number 250 and the snow temperatures, as expected, reflect the changes.

The tautachrones or lines of constant time are shown in Figure 2 at 30 day intervals. The swing in the tautachrones from day number 310 to 340 to 370 reflect the large swing in air temperature during the same period shown in Figure 1.

The ten day average heat flux into the snow at the 0.20 m level is shown in Figure 3. Positive values are into the snow. The difference in the daily mean snow temperatures five days later minus the daily mean snow temperature five days early times the weighting factor for each depth divided by the number of days determines the value of the heat flux at the 0.20 m level. The values are largely positive between day numbers 160 and 250 then negative until day number 470 when the snow heat flux appears to become positive at the end of the record.

The snow temperature data for a full year will be analyzed harmonically to obtain relationships between the logarithm of the snow temperature amplitude and the phase angle to see if factors other than thermal conductivity are important in the transfer of heat in the snow. One possible mechanism for the transfer of heat in the snow is the sublimation of moisture at one level and the deposition at another level.

A sonic system for measuring the distance to the snow surface relative to the AWS tower will be added in July 1990. Once the height relationship between the snow surface and the snow temperatures profile is known the snow profile data can be reasonable analyzed. The first 11 months of data does show that the system for measuring the snow temperatures worked far better than expected. The addition of a second eight channel multiplexer will allow for additional temperature differences and heat flux plates.

Acknowledgments

The AWS program is supported by National Science Foundation Division of Polar Program grant 8821804. The Polar Ice Coring Office provided transportation and field support.

References:

Stearns, C.R. and G.A. Weidner, 1990: The polar automatic weather station project of the University of Wisconsin, Conference Proceedings, The Role of Polar Regions in Climate Change, June 9 to 13,1990, Fairbanks, Alaska.

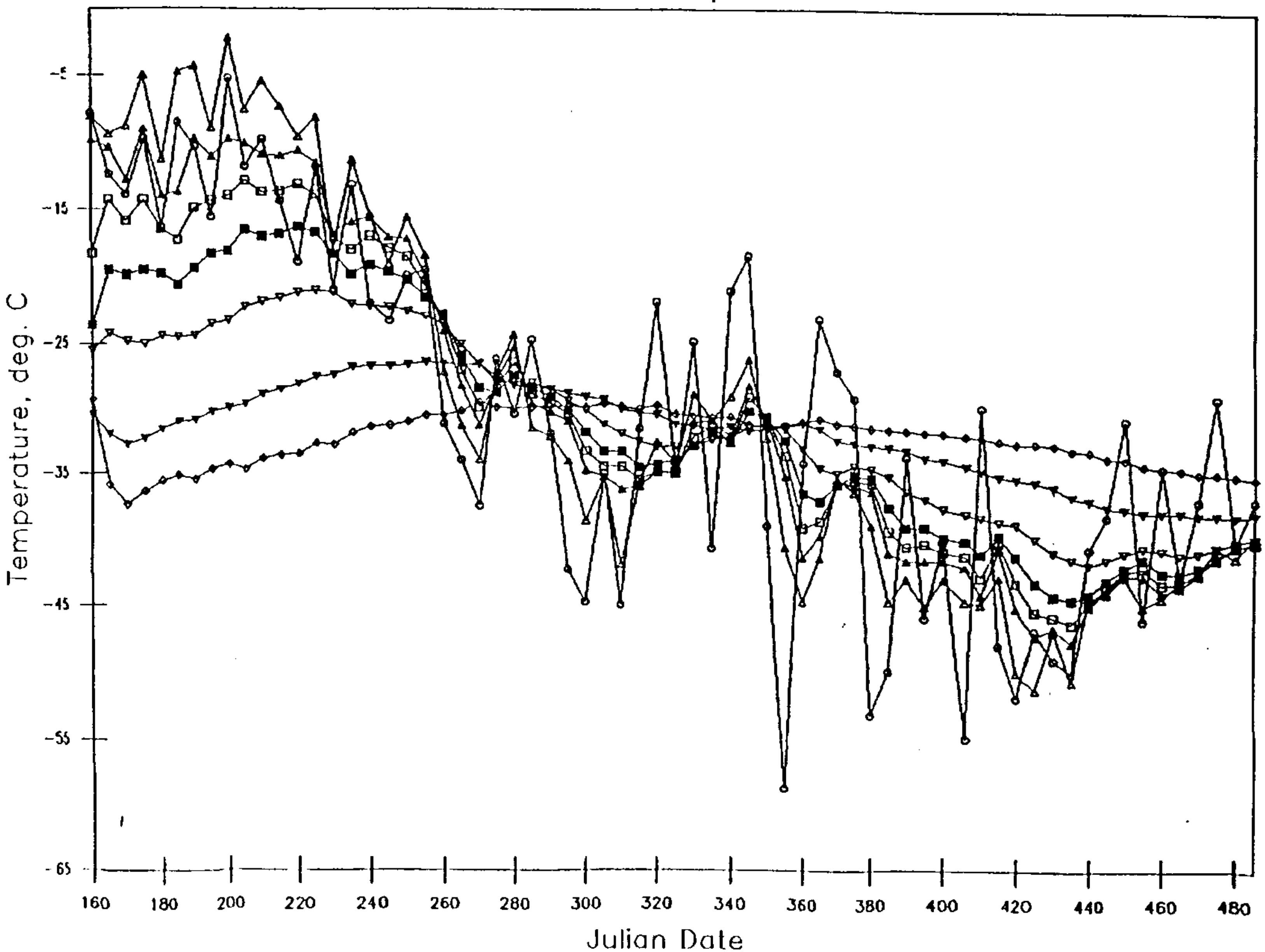
Figure Legends

Figure 1. Average daily temperature at five day intervals for the air and seven levels in the snow at the installation depth as a function of day number at GISP2, Greenland from 10 June 1989 to 30 April 1990. The symbols are as follows: open circle, air temperature at 3.6 m: upright open triangle, 0.20 m temperature; upright closed triangle, -0.05 m temperature; open square, -0.30 m temperature; closed square, -0.55 m temperature; inverted open triangle, -1.05 m temperature; closed inverted triangle, -2.05 m temperature; open diamond, temperature at the assumed depth of -4.05 m.

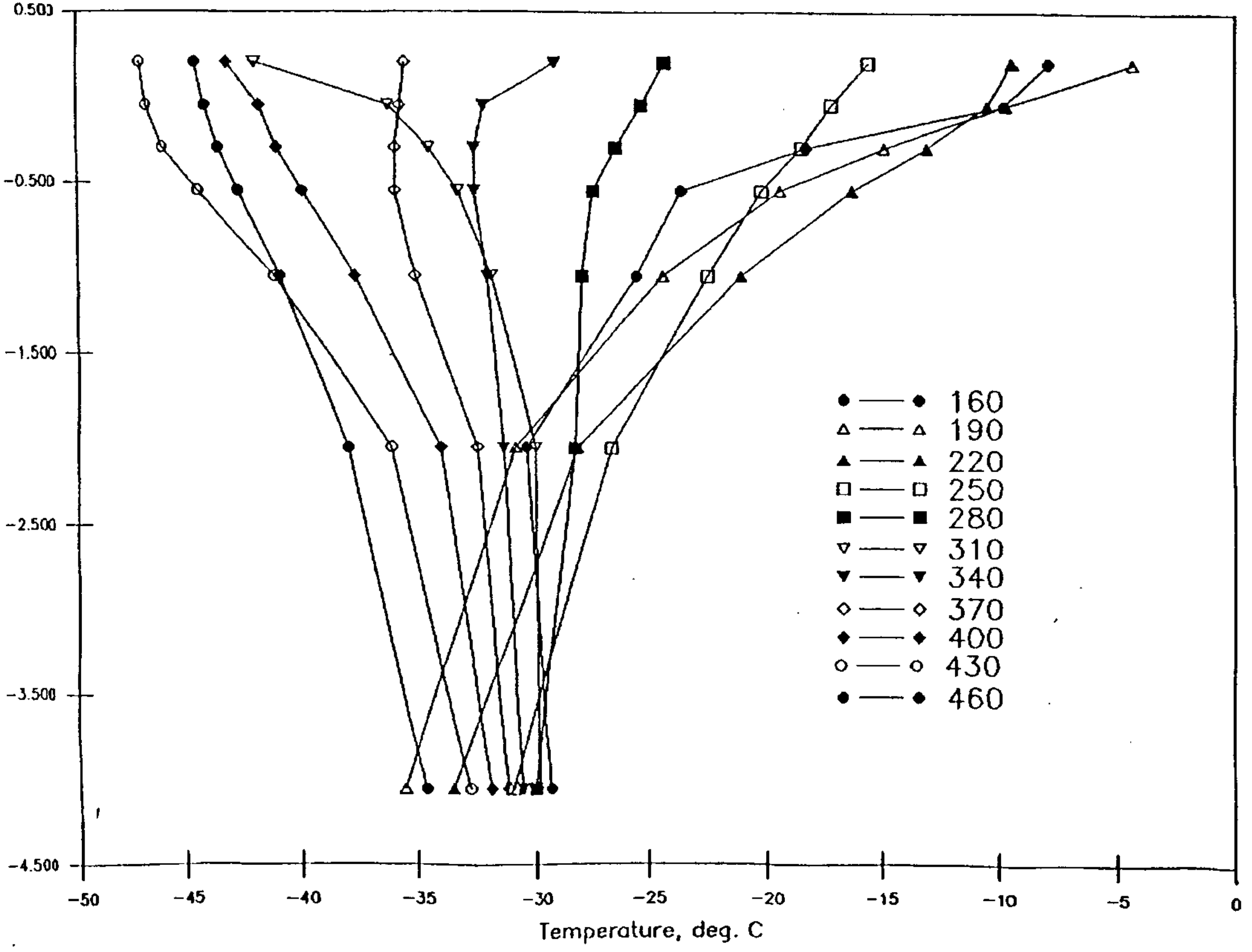
Figure 2. Temperature versus depth for snow temperature tautachrones at GISP2, Greenland from 8 June 1989 to 6 April 1990 at 30 day intervals. Day number is related to the symbols for each tautachrone. Day number 160 and 460 have the same symbol but day number 160 is warmer than day number 460.

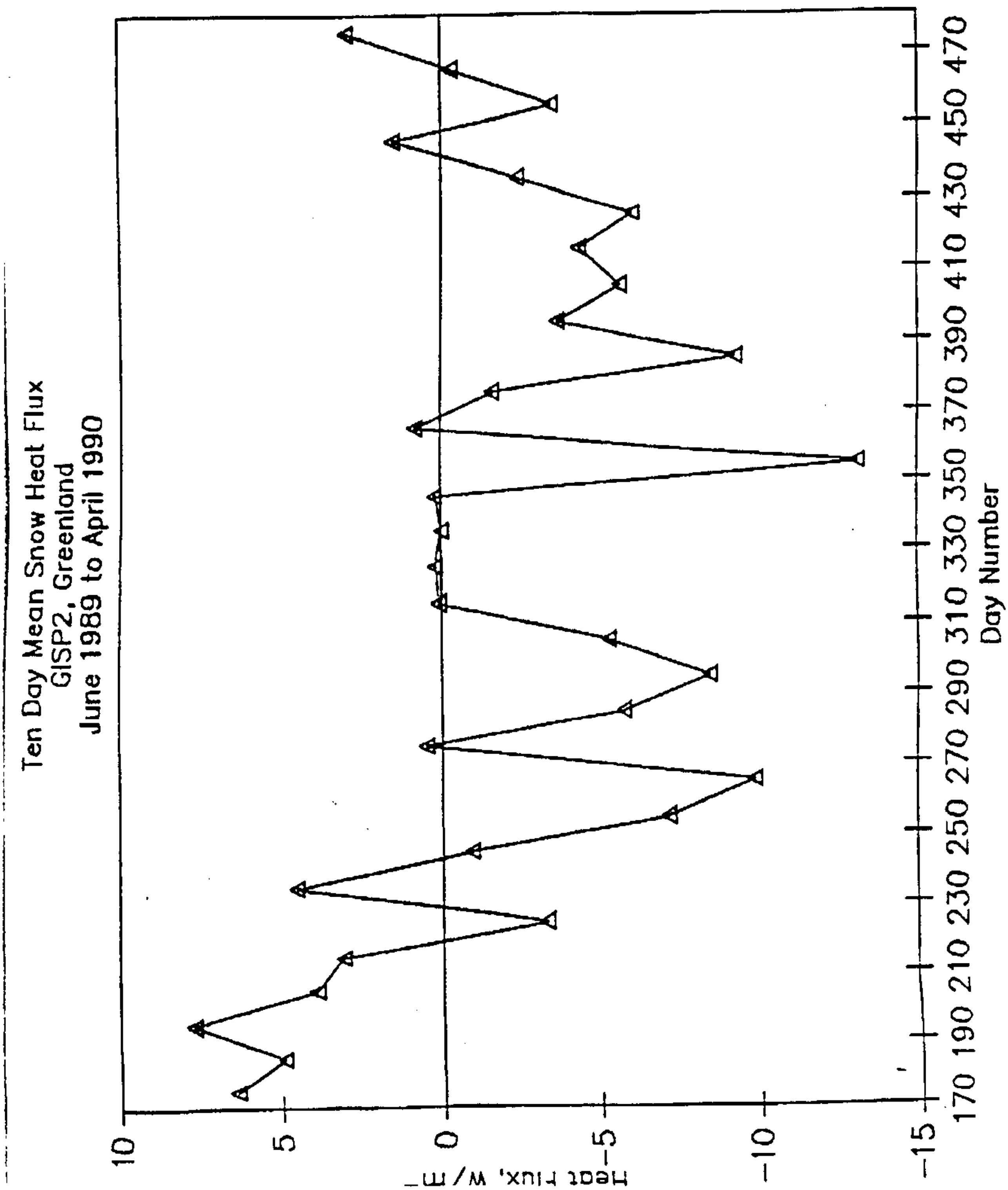
Figure 3. Ten day mean heat flux into the snow at the 0.20 m level centered on the day number.

Snow Temperature at Constant Depth
GISP2, Greenland
June 1989 to April 1990



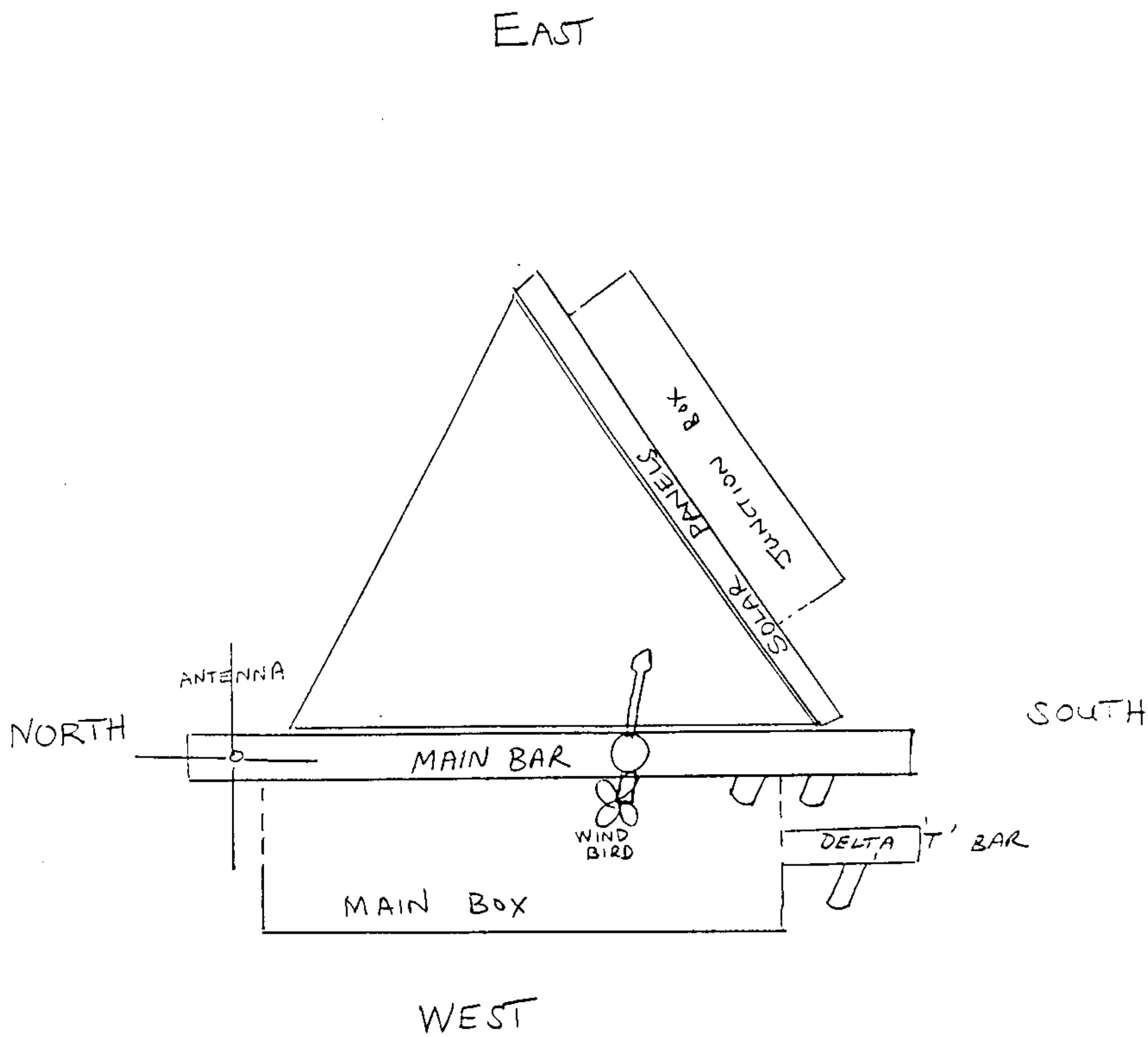
Snow Temperature Isotachrones
GISP2, Greenland
June 1989 to April 1990





Ten Day Mean Snow Heat Flux
GISP2, Greenland
June 1989 to April 1990
Heat Flux, W/m
10
5
0
-5
-10
-15
170 190 210 230 250 270 290 310 330 350 370 390 410 430 450 470
Day Number

PLAN VIEW OF AWS (WEST)



GREENLAND 1987 GRID POSITIONS

Network reduction using 3 fixed points and all passes.
Y axis north-south (X,Y) in km with Summit at (0,0)

Input fixed point coordinates (floated during network adjustment):

Summit	72 17 38.187	37 55 18.574	3260.72 (3212.48)
Sondrestrom	66 59 47.165	50 36 46.264	343.65 (308.01)
Angmagssalik	65 36 42.583	37 37 12.879	65.90 (12.06)

NORTHEAST QUAD

	Sigma			Number of Simultaneous Passes										Height	Height		
Site	Lat	Long	Ht	Sm	Sfj	Ang	15	25	35	36	37	Latitude	Longitude	WGS72	(m asl)	X	Y
15	0.34	0.35	0.22	10	10	11	20	17	0	0	0	72 58 52.583	37 42 16.215	3227.69	3180.92	7.28	76.82
25	0.33	0.31	0.19	23	14	20	17	36	0		0	72 46 00.688	37 32 33.311	3257.53	3210.13	12.82	52.92
35	0.33	0.30	0.19	28	22	20	0	0	37	0	0	72 33 05.772	37 22 59.189	3272.33	3224.31	18.39	28.95
36	0.34	0.30	0.22	22	13	13	0	0	0	29	22	72 35 52.271	36 39 42.016	3247.08	3198.64	42.80	34.47
37	0.34	0.33	0.22	18	9	9	0	0	0	22	24	72 38 27.038	35 56 42.002	3216.46	3167.61	66.91	39.99

Fixed point shift (m).

	Del Lat	Del Long	Del Height
Summit	0.65	0.03	0.06
Sondrestrom	0.59	-0.15	0.11
Angmagssalik	0.59	0.08	0.03

SOUTHEAST QUAD

	Sigma			Number of Simultaneous Passes										Height	Height		
Site	Lat	Long	Ht	Sm	Sfj	Ang	55	56	57	561	571	Latitude	Longitude	WGS72	(m asl)	X	Y
55	0.34	0.35	0.21	2	16	18	22	0	0	0	0	72 02 42.726	37 26 04.515	3243.45	3194.26	17.13	-27.53
56	0.34	0.31	0.22	20	14	11	0	24	18	0	0	71 59 03.683	36 41 40.873	3201.52	3151.64	43.14	-33.97
57	0.33	0.30	0.19	25	22	22	0	18	35	0	0	71 55 13.811	35 57 35.562	3144.24	3093.66	69.16	-40.39
561	0.34	0.34	0.21	18	11	14	0	0	0	23	15	72 10 17.477	36 22 18.657	3191.13	3141.46	53.91	-12.83
571	0.34	0.33	0.23	22	12	10	0	0	0	15	24	72 12 43.339	35 40 05.881	3145.37	3095.28	78.13	-7.49

Fixed point shift (m):

	Del Lat	Del Long	Del Height
Summit	0.26	-0.07	0.16
Sondrestrom	0.17	-0.08	0.20
Angmagssalik	0.22	-0.02	0.11

SOUTHWEST QUAD

		Sigma				Number of Simultaneous Passes								Height	Height		
Site	Lat	Long	Ht	Sm	Sfj	Ang	51	52	53	63	73	Latitude	Longitude	WGS72	(m asl)	X	Y
51	0.33	0.31	0.20	29	20	17	31	30	0	0	0	71 55 35.802	39 50 07.311	3149.82	3102.13	-67.25	-39.76
52	0.33	0.30	0.20	36	23	21	30	39	0	0	0	71 58 48.938	39 08 52.586	3192.00	3143.92	-42.93	-34.44
53	0.36	0.36	0.25	17	11	12	0	0	20	0	0	72 01 54.347	38 27 17.380	3223.20	3174.73	-18.55	-29.06
63	0.33	0.31	0.19	30	18	19	0	0	0	30	15	71 49 00.078	38 17 40.876	3219.29	3170.20	-13.11	-53.10
73	0.33	0.30	0.18	27	23	23	0	0	0	15	32	71 36 07.868	38 08 29.413	3214.41	3164.70	-7.78	-77.07

Fixed point shift (m):

	Del Lat	Del Long	Del Height
Summit	0.43	-0.40	0.01
Sondrestrom	0.31	-0.46	0.09
Angmagssalik	0.37	-0.36	-0.02

NORTHWEST QUAD

		Sigma				Number of Simultaneous Passes								Height	Height		
Site	Lat	Long	Ht	Sm	Sfj	Ang	31	32	33	23	13	Latitude	Longitude	WGS72	(m asl)	X	Y
31	0.33	0.33	0.20	25	1	16	25	19	0	0	0	72 20 54.946	40 12 49.625	3150.50	3104.16	-78.68	7.78
32	0.33	0.31	0.18	27	4	22	19	32	0	0	0	72 24 16.550	39 30 42.677	3192.00	3145.18	-54.38	13.20
33	0.34	0.32	0.21	24	14	16	0	0	25	0	0	72 27 30.977	38 48 10.407	3229.90	3182.69	-30.00	18.70
23	0.33	0.31	0.19	28	20	17	0	0	0	31	16	72 40 21.885	38 58 43.674	3225.31	3178.72	-35.59	42.70
13	0.34	0.34	0.20	18	16	11	0	0	0	16	21	72 53 11.060	39 09 24.609	3205.25	3159.29	-41.07	66.64

Fixed point shift (m):

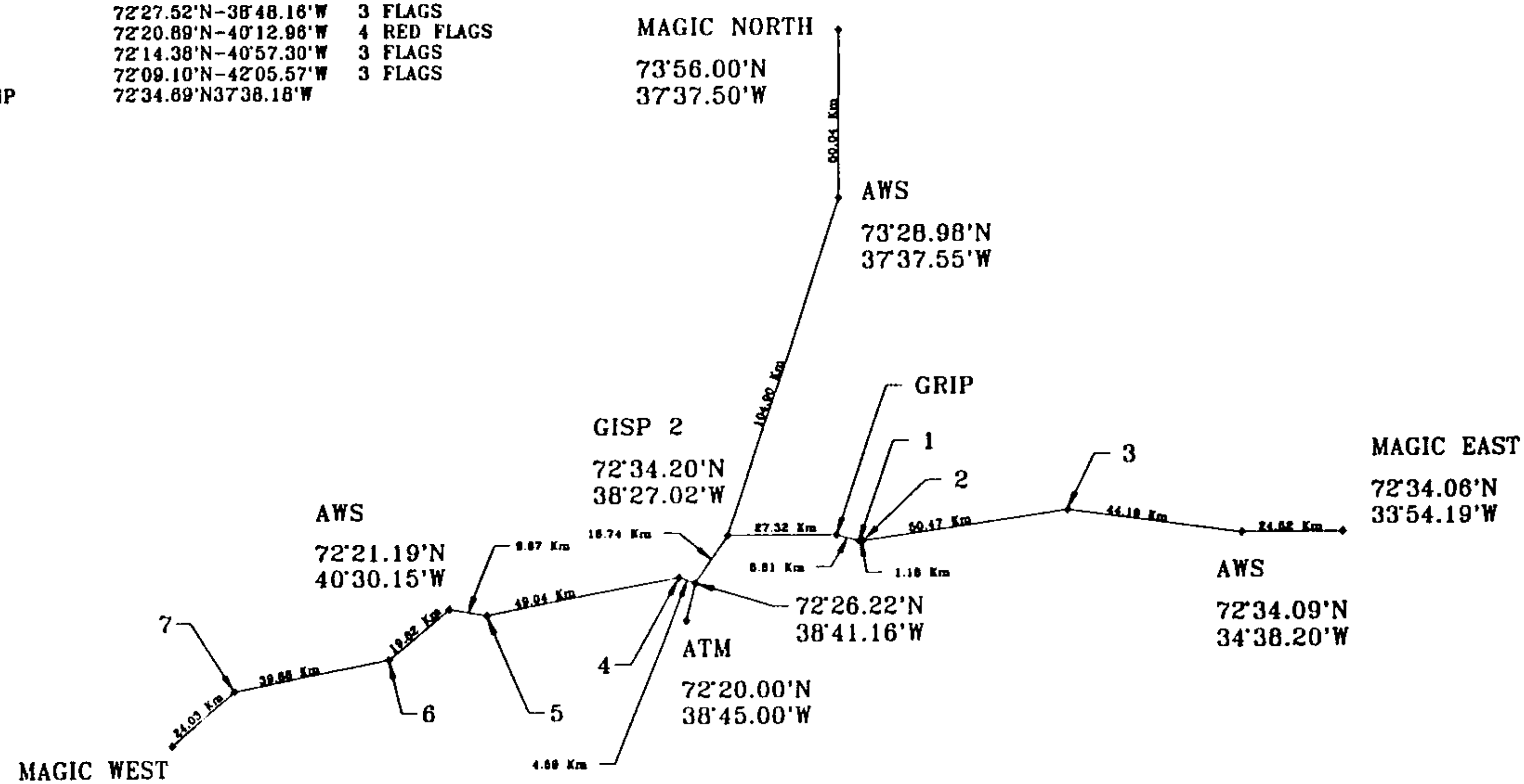
	Del Lat	Del Long	Del Height
Summit	0.31	0.00	0.00
Sondrestrom	0.30	-0.08	0.02
Angmagssalik	0.27	0.02	-0.02

Notes

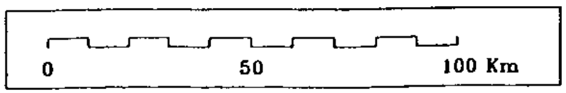
- Height WGS72 refers to the WGS72 ellipsoid. Height above sea level was obtained using the MX1502 processor, certain versions of which enable the transformation from the WGS72 ellipsoid to the corresponding geoid to be made.
- Sigma refers to the standard deviation resulting from the iterative position adjustment by the MAGNET software. The absolute uncertainty in a given coordinate is related to the absolute uncertainty in the TRANSIT satellite positions. Since these positions were calculated using the broadcast ephemeris, absolute positions could be uncertain by more than 10 m.

GISP0295

STATION	LOCATION	MARKER
1	72°33.36'N-37°27.99'W	3 FLAGS
2	72°33.08'N-37°25.90'W	GREEN FLAG
3	72°38.46'N-35°56.60'W	2 GREEN, 6 RED FLAGS
4	72°27.52'N-38°48.16'W	3 FLAGS
5	72°20.89'N-40°12.96'W	4 RED FLAGS
6	72°14.38'N-40°57.30'W	3 FLAGS
7	72°09.10'N-42°05.57'W	3 FLAGS
GRIP	72°34.69'N37°38.18'W	



Distances between stations are approximate

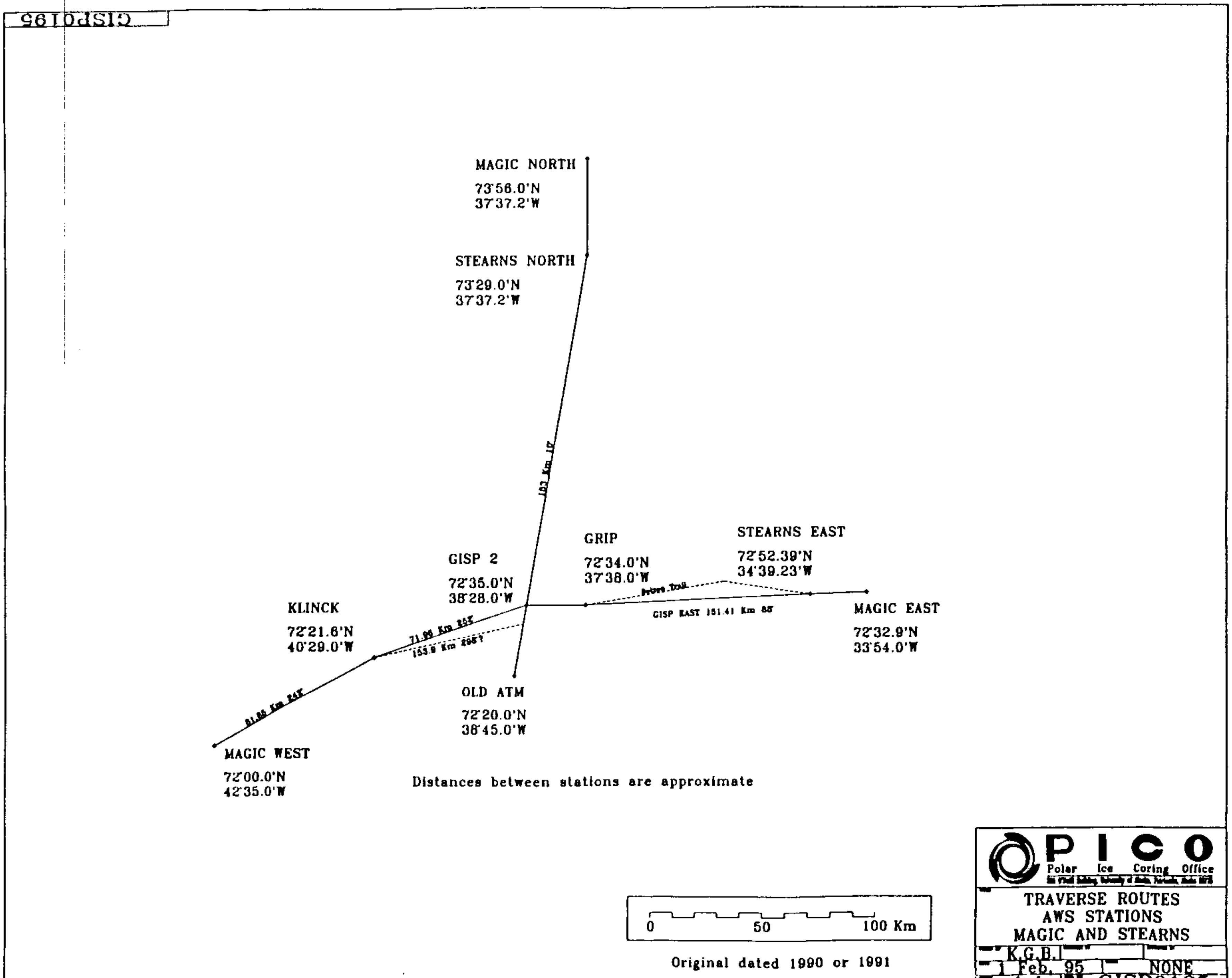


Original dated 6/93

PICO Polar Ice Coring Office

TRAVERSE ROUTES
MAGIC AWS STATIONS

K.G.B. | 1 Feb. 95 | NONE | GISP0295


GISP0195
MAGIC NORTH
73°56.0'N
37°37.2'W
STEARNS NORTH
73°29.0'N
37°37.2'W
103 Km 10°
GISP 2
72°35.0'N
38°28.0'W
GRIP
72°34.0'N
37°38.0'W
STEARNS EAST
72°52.39'N
34°39.23'W
GISP EAST 151.41 Km 88°
MAGIC EAST
72°32.9'N
33°54.0'W
KLINCK
72°21.6'N
40°29.0'W
71.96 Km 252°
155.9 Km 256°
OLD ATM
72°20.0'N
38°45.0'W
81.88 Km 24°
MAGIC WEST
72°00.0'N
42°35.0'W
Distances between stations are approximate
0
50
100 Km
Original dated 1990 or 1991
PICO
Polar Ice Coring Office
TRAVERSE ROUTES
AWS STATIONS
MAGIC AND STEARNS
K.G.B.
1 Feb. 95
NONE

GPS READINGS FOR THE AWS SITES

The following are the positions for the AWS sites:

Site	ARGOS I.D.	Lat.	Long.	Alt. (m)	Date	Location
GISP2	8936	72.58°N	38.46°W	3205	Aug 91	
GRIP		72.57°N	37.62°W	3230	Jun 89	
Kenton	8922	72.21°N	38.48°W	3185	Jun 89	ATM
Klinck	8938	72.31°N	40.48°W	3105	Aug 90	West
Barber	8939	71.67°N	38.17°W	3170	Jul 90	South
Julie	8928	72.57°N	34.64°W	3100	Aug 91	East
Matt	8929	73.48°N	37.62°W	3100	Aug 91	North

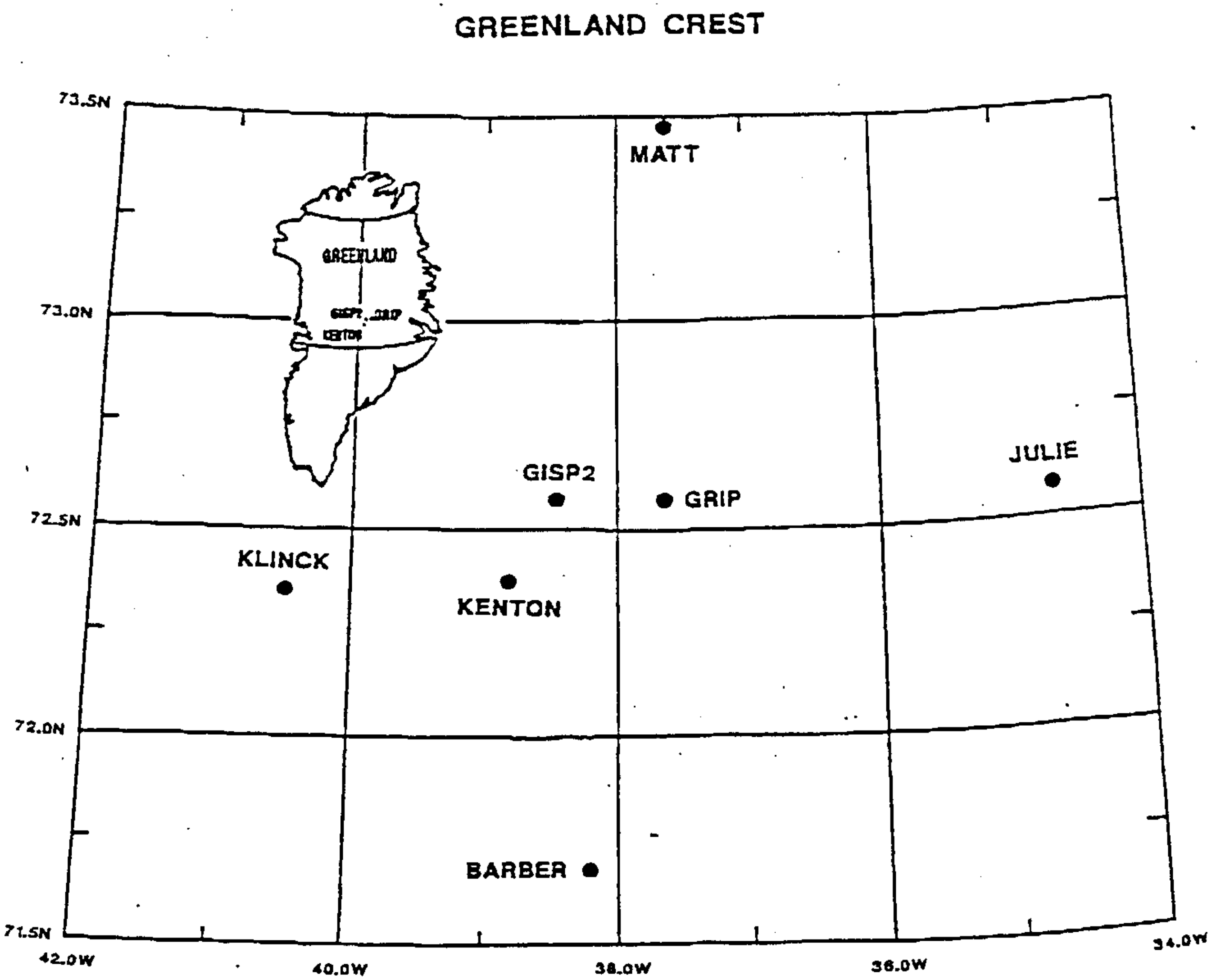


Figure 1. Map showing the locations of the AWS units on the Greenland Crest starting in August 1991.

Introduction and Objectives

During the previous summer (1991) field season, we established 3 autonomous, remote, magnetic data collection stations in an array around the GISP II ice drilling camp. These stations utilize a combination of lead-acid gel cell batteries and solar panels to power a system which measures variations in the Earth's magnetic field. These variations are produced by electrical currents flowing in the ionosphere above the stations. The measurements are stored in electronic memory, along with an accurate measure of time obtained from Omega navigation broadcasts. The locations of these stations are given in Table 1 and are shown on Figure 1. In addition to the three stations deployed during the 1991 field season, one additional station was deployed during the 1992 field season and is also listed in Table 1 and shown on Figure 1.

Table 1

Station Name	Geographic Latitude	Geographic Longitude	Deployment Date
MAGIC Gisp	72° 34.2' N	38° 27.0' W	July 28, 1991
MAGIC East	72° 34.2' N	33° 54.0' W	Aug. 1, 1991
MAGIC North	73° 56.0' N	37° 37.2' W	Aug. 7, 1991
MAGIC West	72° 00.0' N	42° 35.45' W	July 16, 1992

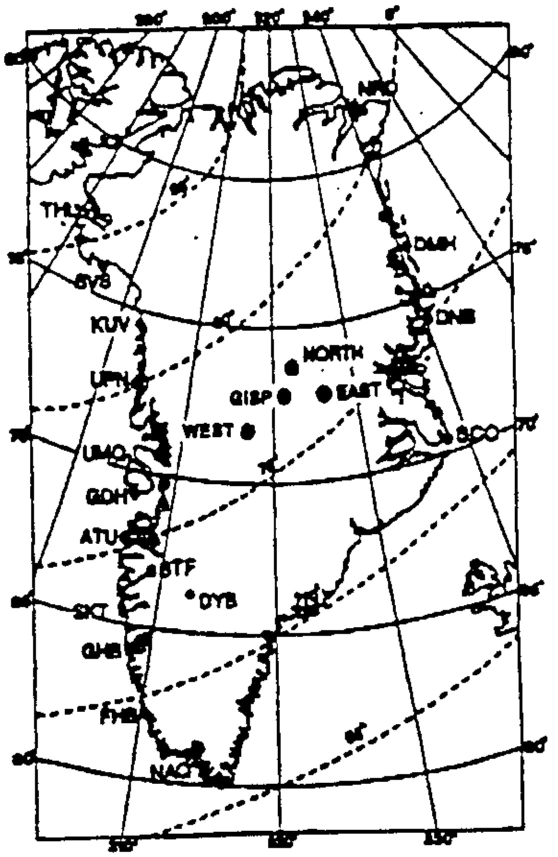


Figure 1: Map of Greenland showing the coastal magnetometer stations and the interior MAGIC array of magnetometer stations. Solid lines show geographic coordinates, dashes lines show invariant magnetic latitude lines.

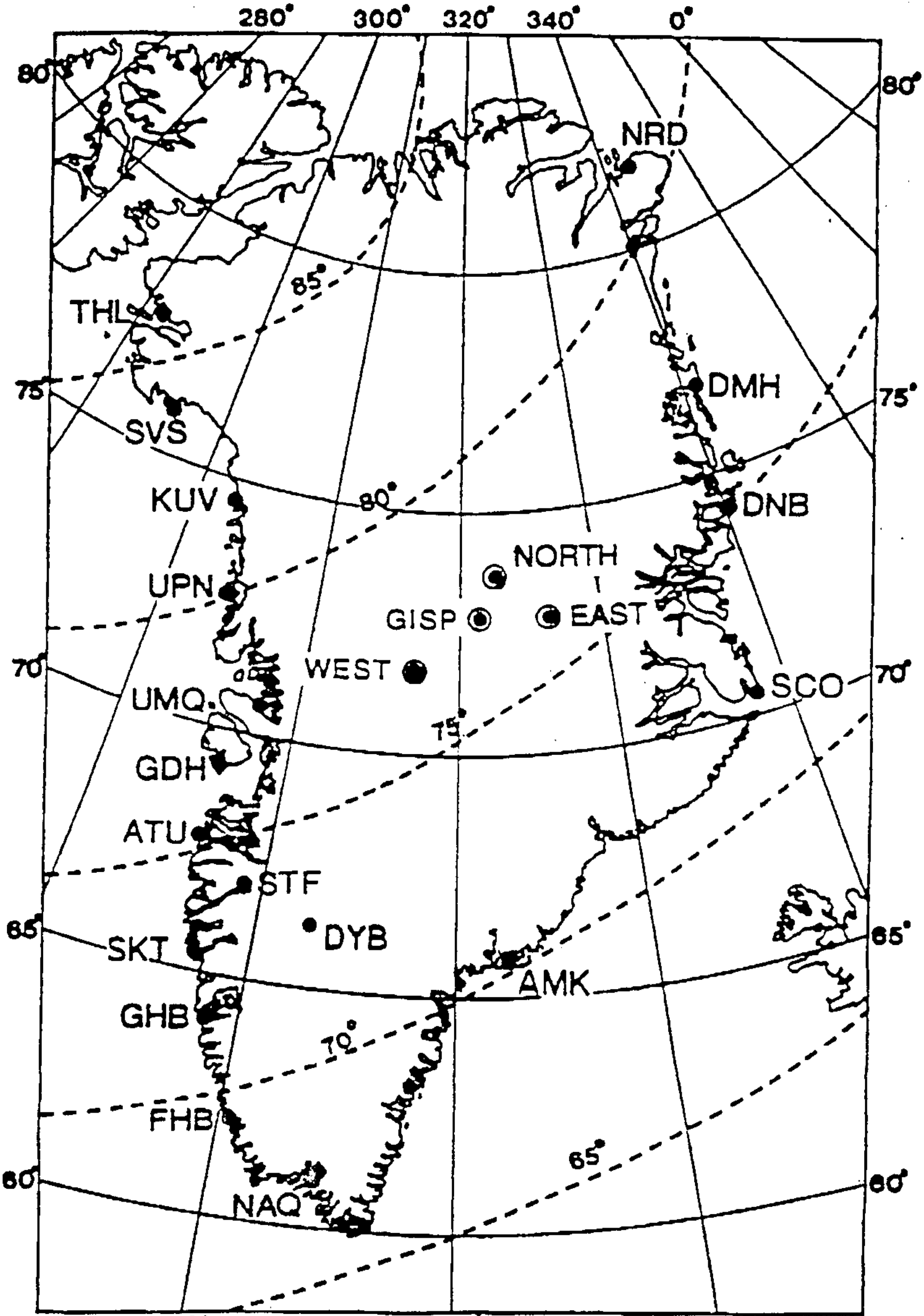

280°
300°
320°
340°
0°
80°
80°
85°
75°
75°
80°
70°
70°
75°
65°
65°
70°
60°
60°
65°
310°
320°
330°
NRD
THL
DMH
SVS
KUV
DNB
NORTH
UPN
GISP
EAST
WEST
SCO
UMQ
GDH
ATU
STF
DYB
SKT
AMK
GHB
FHB
NAQ

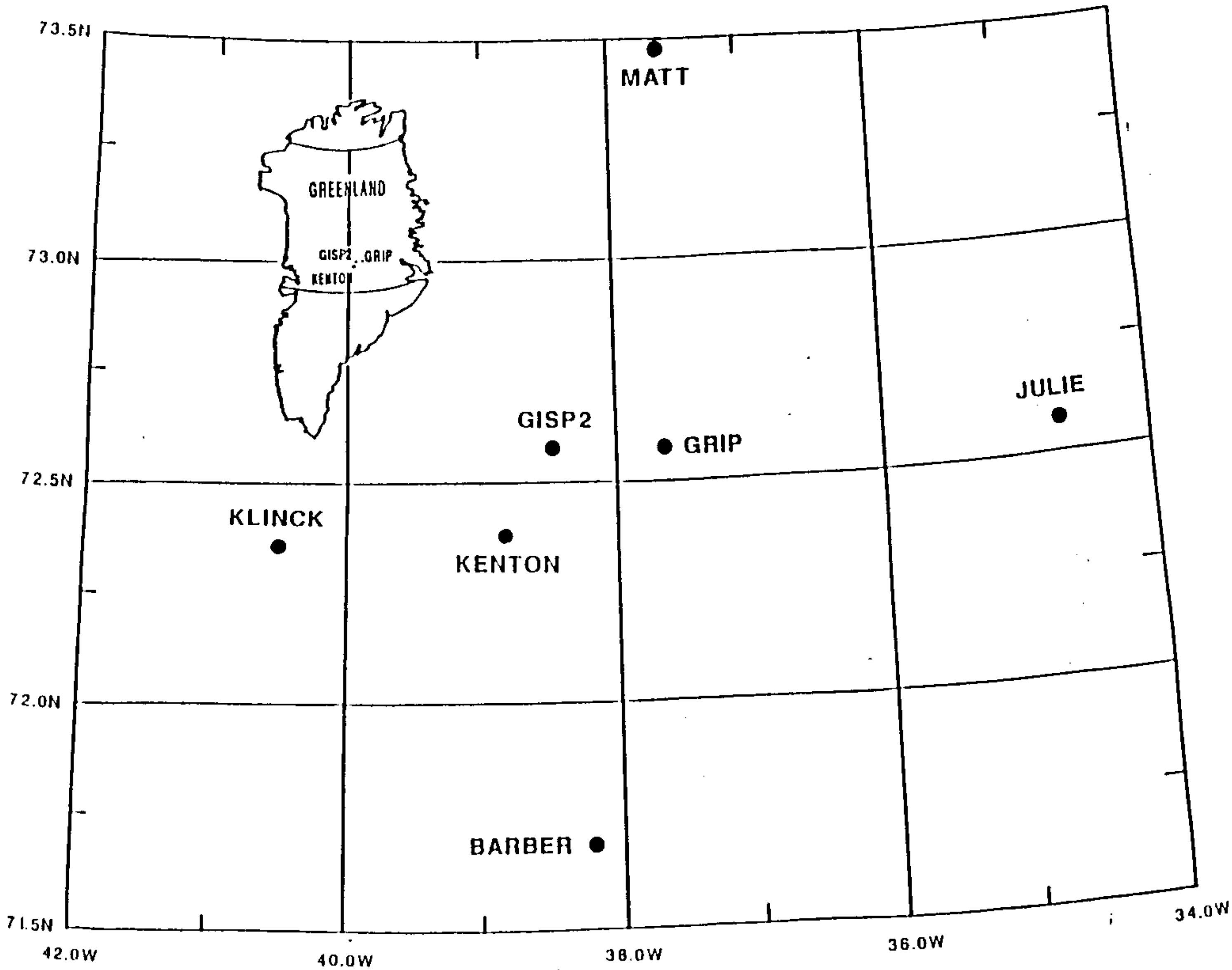
Table 2.1. Automatic weather station locations on Greenland as of August 1991. The ARGOS ID and WMO# are for 1991. Cathy site is not used and GRIP site is not active.

Site Name	ARGOS ID	Lat. (deg)	Long. (deg)	Alt. (m)	Date Start	Stop	WMO#
Cathy		72.3 °N	38.0 °W	3210	May 87	May 89	
GISP2	8936	72.58°N	38.46°W	3205	Jun 89	Aug 91	04115
	8925				Aug 91		
GRIP		72.57°N	37.62°W	3230	Jun 89		
Kenton	8922	72.28°N	38.82°W	3185	Jun 89		04110
Klinck	8938	72.31°N	40.48°W	3105	Aug 90		
Barber	8939	71.67°N	38.17°W	3170	Jul 90		
Julie	8929	72.57°N	34.63°W	3100	Aug 91		
Matt	8928	73.48°N	37.62°W	3100	Aug 91		

Table 2. Monthly means of air temperature, wind speed, resultant wind speed and direction and maximum wind speed and direction for four months in 1991 on the Greenland Crest.

Site	August	September	October	November	Mean
		Monthly Mean Air Temperature, °C			
GISP2	−14.7	−27.8	−33.7	−29.8	−26.5
Kenton	−14.0	−27.4	−32.8	−27.8	−25.5
Barber	−13.7	−26.9	−31.9	−28.5	−25.3
Klinck	−15.9	−26.9	−31.5	−28.1	−25.6
Mean	−14.6	−27.3	−32.5	−28.6	−25.7
		Monthly Mean Wind Speed, m s^{-1}			
GISP2	3.7	4.3	3.9	5.1	4.3
Kenton	4.4	5.0	4.2	5.2	4.7
Barber	5.2	5.5	4.5	8.6	6.0
Klinck	4.8	5.2	5.2	5.6	5.2
Mean	4.5	5.0	4.5	6.1	5.0
		Resultant Wind Speed and Direction, m s^{-1}/°			
GISP2	1.8/115	1.0/ 99	3.2/182	4.6/213	1.99/179
Kenton	2.5/112	1.7/ 96	3.5/164	4.5/199	2.36/158
Barber	2.9/ 90	1.7/ 71	3.2/160	7.5/197	2.56/160
Klinck	3.8/110	2.6/115	4.6/158	4.9/188	3.36/148
		Max Wind Speed and Direction, m s^{-1}/°			
GISP2	14.6/ 74	15.4/ 9	13.4/171	19.2/219	
Kenton	12.9/ 84	19.7/105	15.6/154	22.4/219	
Barber	19.8/ 80	21.1/196	15.7/143	23.6/203	
Klinck	12.4/ 50	17.8/181	15.5/178	21.6/202	

GREENLA..D CREST



August, 1991

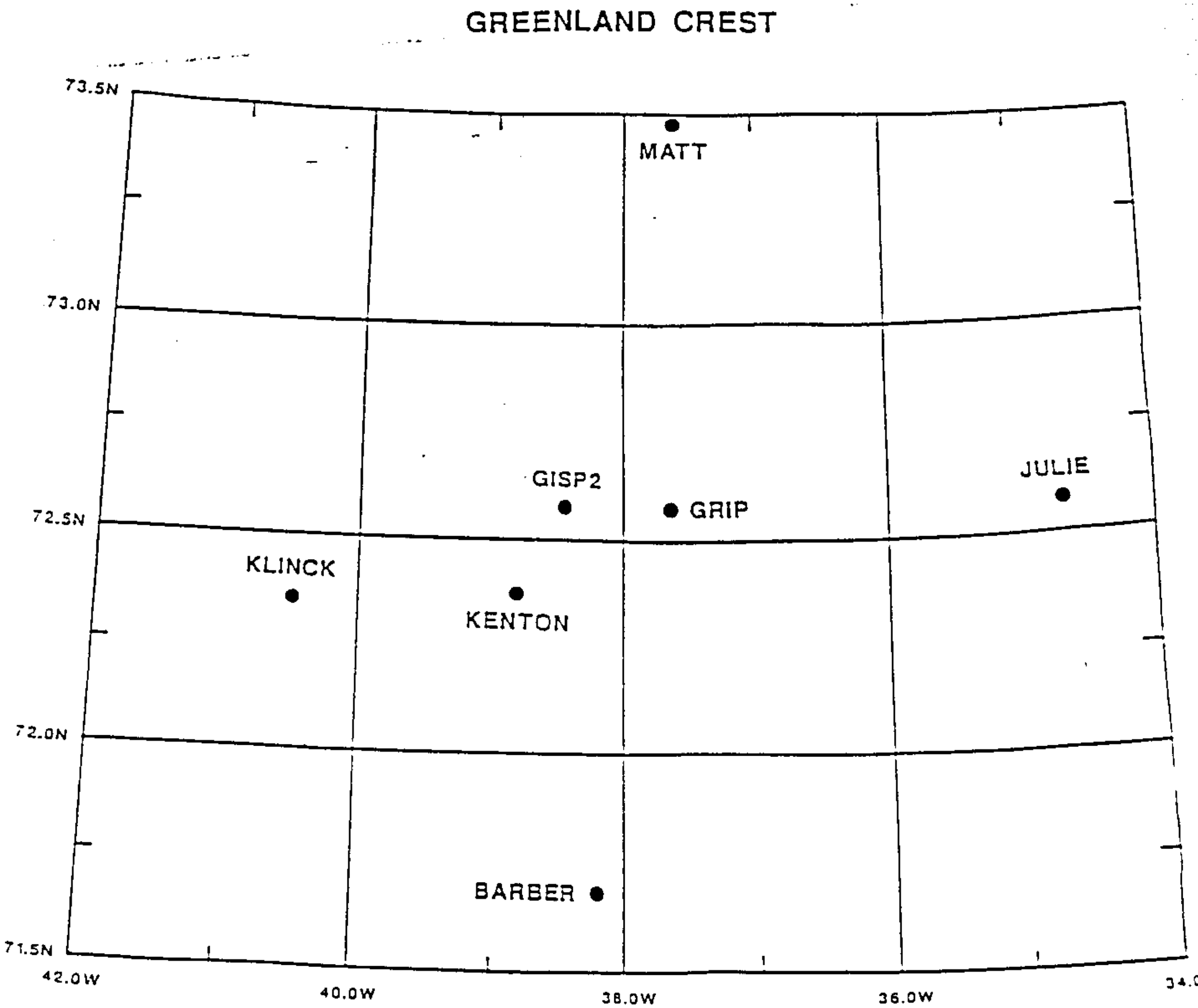
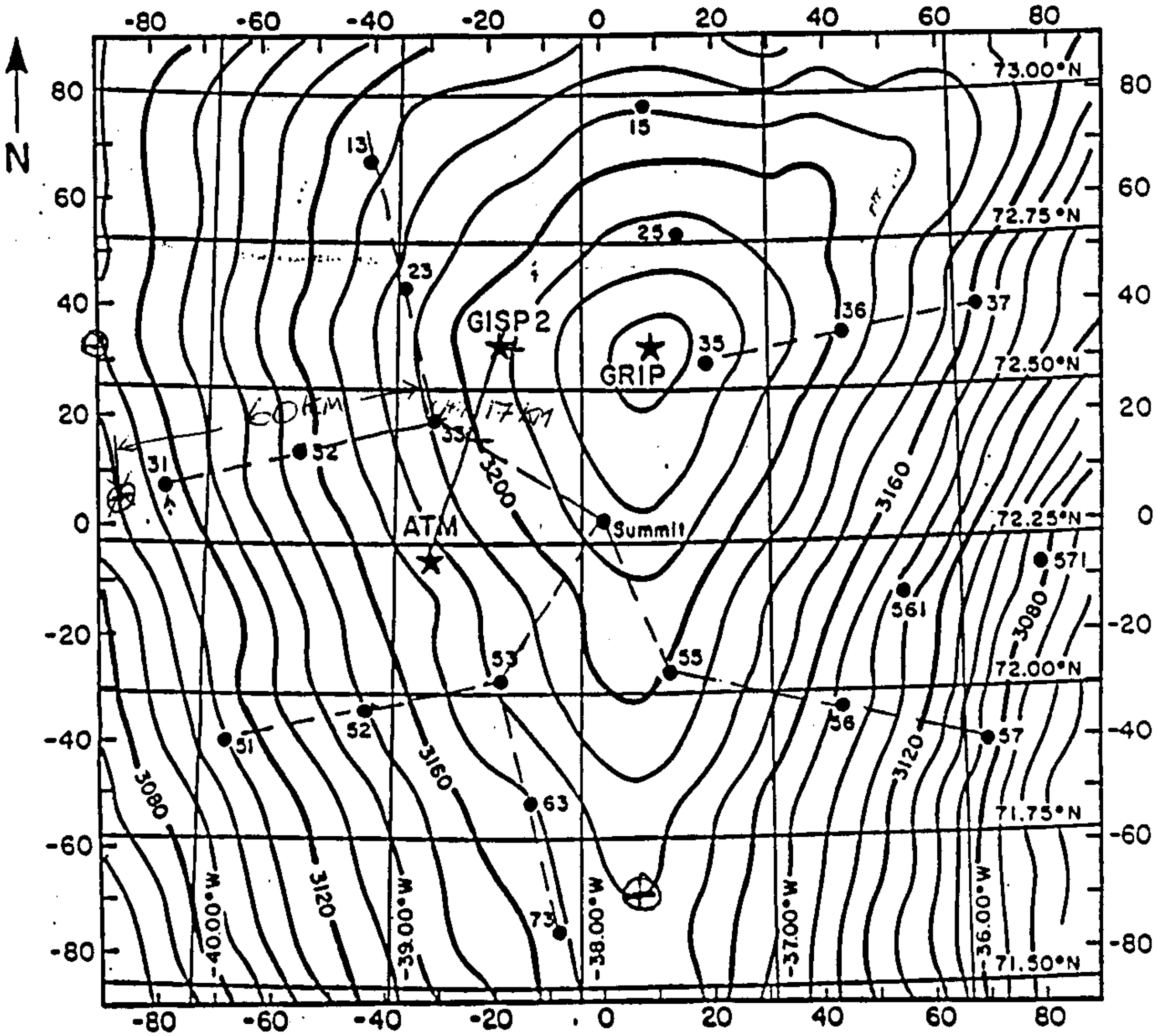


Figure 1. Map of the Greenland Crest showing the locations of the AWS sites starting in August 1991. The AWS unit at Grip is not installed.



GISP2:	72° 35' N 38° 28' W (-18.4, 31.7)	ATM:	72° 20' N 38° 45' W (-31, -7)	GRIP:	72° 34' N 37° 38' W (9.4, 31.2)	Grid coordinates are in km: (0, 0) is the site of the original strain net "Summit Camp".

Surface Contour Map. Map of the Summit region of the Greenland Ice Cap showing surface contours. The contour interval is 10 m. (This 180 km x 180 km grid was surveyed by Dr. Steven Hodge *et. al.* of the U.S.G.S. in Puget Sound, Washington. This map is based on the map recently published by Hodge *et. al.* in the Journal of Glaciology, Vol. 36, No. 122, 1990, pp. 17 - 30). Also shown (solid circles) are the stations used in the strain net study of Dr. John Bolzan at the Byrd Polar Research Center in Columbus, Ohio.