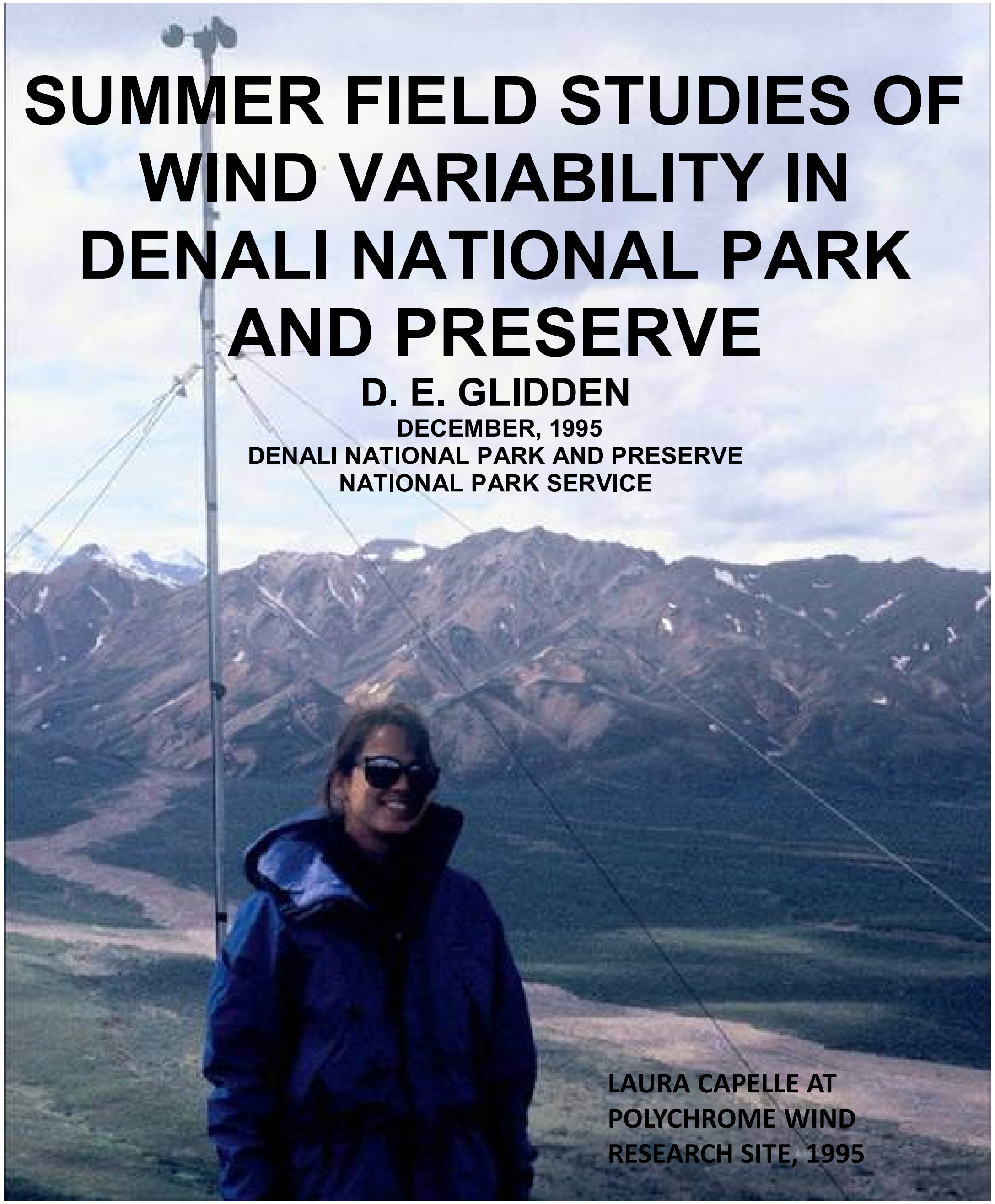
SUMMER FIELD STUDIES OF WIND VARIABILITY IN DENALI NATIONAL PARK AND PRESERVE

D. E. GLIDDEN

DECEMBER, 1995
DENALI NATIONAL PARK AND PRESERVE
NATIONAL PARK SERVICE



LAURA CAPELLE AT POLYCHROME WIND RESEARCH SITE, 1995

SUMMER FIELD STUDIES OF WIND VARIABILITY IN DENALI NATIONAL PARK AND PRESERVE

D. E. GLIDDEN

ORIGINALLY PRESENTED IN DECEMBER, 1995
DENALI NATIONAL PARK AND PRESERVE
DENALI PARK, ALASKA

Summer Field Studies of Wind Variability in Denali National Park and Preserve is made available in PDF format in the interests of scientific research and public information. It is reproduced from the original 1995 text.

Dave Glidden is a Field Specialist in Wind and Mountain Climatology, and has conducted wind studies for the National Park Service in Rocky Mountain National Park in Colorado. He has pursued field work on the variability of mountain winds and gust factors in Denali National Park in Alaska. A strong advocate of women in the sciences, he has been fortunate to have many women share in the excitement and rewards of field work. (Laura Capella, a former Observatory EduTrip ATL in mountain climatology during the early 1990's, assisted Dave during his 1995 field studies in Denali.) He specialized in Mountain Climatology at the University of Massachusetts/Amherst, where he directed a climatological research project in the White Mountains of New Hampshire, which included extensive field studies from the Presidential to the Franconia Ranges. Also while at UMASS, he investigated severe glacier winds in the early 1970s near the Icy Bay area of southeast Alaska. He has published studies and articles on mountain winds and climatology, and has been actively involved, through the Observatory, in trying to improve the participation of girls and women in the sciences. He has been associated with the Mount Washington Observatory since 1970, and has led winter EduTrips in mountain meteorology and climatology since their beginning some 14 years ago. When not in the field, Dave has been Head Coach of women's soccer at the collegiate level.

TOKLAT BLUFF WIND RESEARCH SITE, AT 3490 FT. (1064 M), JUNE 1995. THE ALASKA RANGE AND THE TOKLAT RIVER ARE VISIBLE TO THE SOUTH. DIVIDE MOUNTAIN BEGINS TO RISE ON THE RIGHT.

TOKLAT BLUFF WIND SITE. VIEW MORE TO THE SOUTHWEST

SUMMARY

Field studies of wind variability were conducted at three sites in Denali National Park and Preserve during June, 1995. Comparisons were made with 1994 data from the existing Upper Ridge (UR) Rock Creek wind site (part of the Inventory and Monitoring Program of the NPS), and with other mountain sites in Rocky Mountain National Park in Colorado (RMNP) and with Mount Washington, NH.

Data summarized include maximum winds, hourly pressure change, average gust factors and peak gust ratios, diurnal pressure and wind variations, and other supporting meteorological parameters.

The maximum winds recorded during the June, 1995 study period were 59 MPH (26 m/s) from the southeast at Polychrome, and were associated with rapidly rising pressure.

Peak gust ratios between sites were determined. Polychrome usually had higher winds, with one occurrence three times higher than that recorded at Eielson Bluff. On other occasions, maxima were quite close.

Comparing average winds and directions, Polychrome generally had higher values, but not always. During some hours, Eielson could have higher averages than either Polychrome or Toklat.

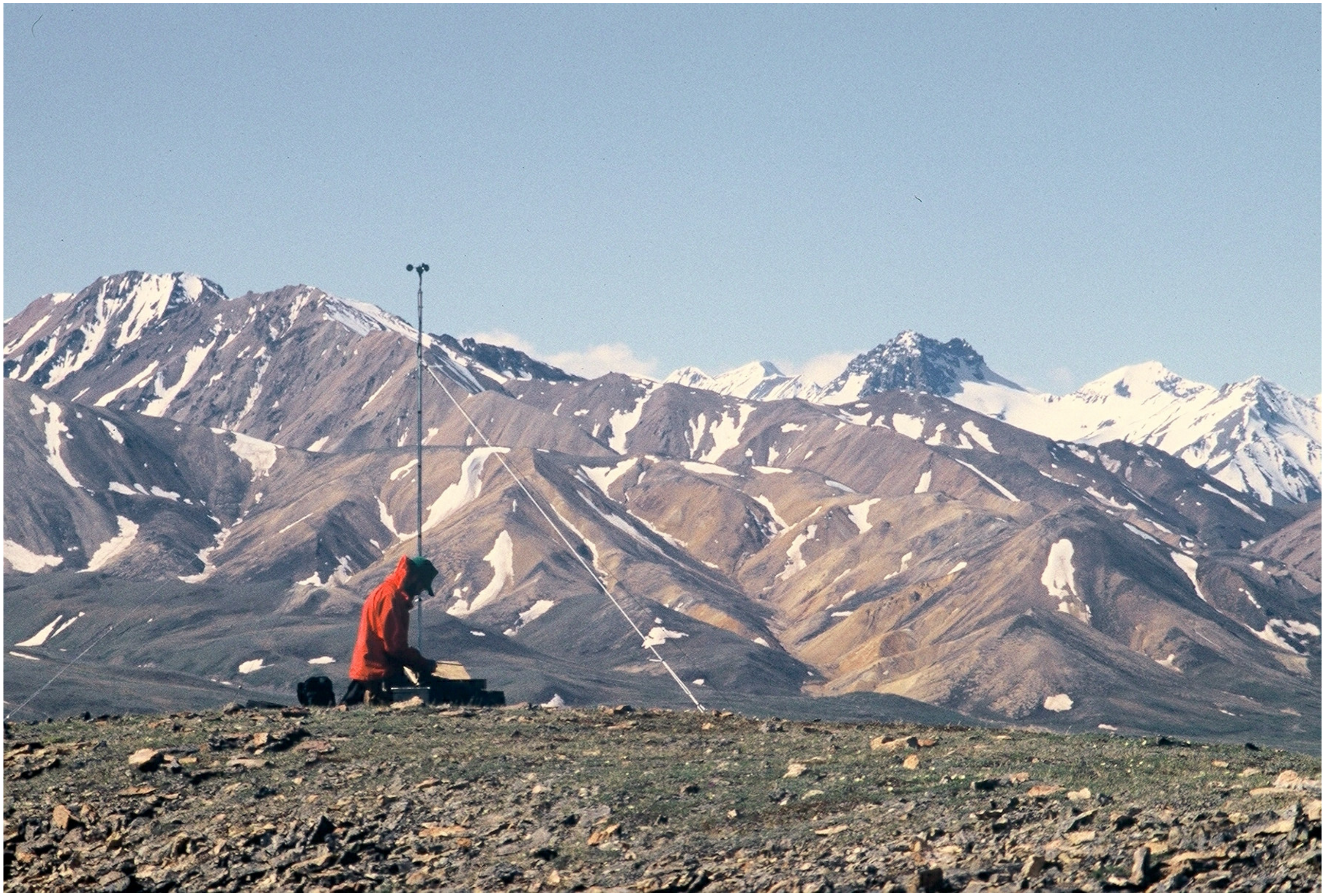
Diurnal pressure variations were identified at Polychrome. Average pressures begin to fall by 1400, with minima occurring between 1700-1900 hours. Pressure minima at Polychrome appear to correspond generally to average maximum winds at Eilson Bluff.

It is suggested that Denali National Park develop its own capability to identify and monitor all important climatic areas within its boundaries, and that this capability should be extended (where possible) to the higher reaches of the Alaska Range and the Mount McKinley massif, where the current data base is inadequate or non-existent.

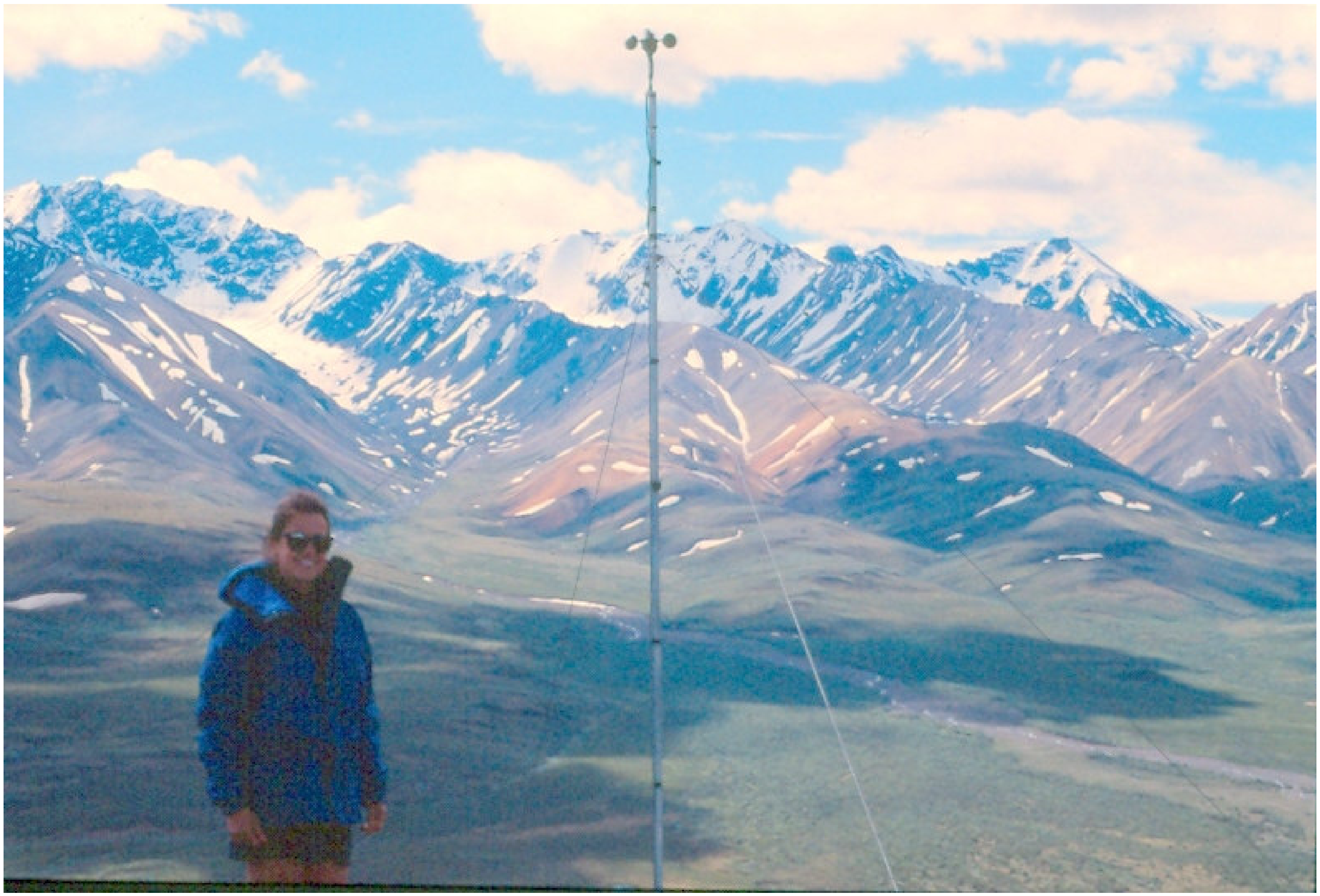
It is recommended that the NPS establish three wind research sites along a north-south transect, ranging from the Eielson area in the north, through a line above 12,000 ft (3658 m) on the Alaska Range, to the Petersville area in the south. This transect may help us to better correlate subsynoptic wind, pressure and weather conditions on Mount McKinley and the Alaska Range with synoptic or regional patterns. Through instrumenting these upper reaches, and by building a site-specific data base, we may improve our ability to anticipate and understand conditions peculiar to these areas. Visitor appreciation of extemes, and air rescue operations on Mount McKinley, may also be enhanced by this program.

NPS PERSONNEL JOE VAN HORN AND PAUL ATKINSON AT THE TOKLAT BLUFF WIND SITE, JUNE 1995

EIELSON BLUFF WIND RESEARCH SITE, DENALI NATIONAL PARK, JUNE 1995
VIEW IS TO THE SE, WITH MT. MCKINLEY IN THE BACKGROUND. THE MULDROW GLACIER TERMINUS IS JUST OUT OF SITE, BELOW TO THE LEFT.



POLYCHROME WIND RESEARCH SITE, AT 4217 FT. (1285 M). VIEW IS TO THE SOUTH, OVERLOOKING THE ALASKA RANGE. FULL 360 DEGREE EXPOSURE, WITH MOUNT MCKINLEY TO THE SE AND THE WYOMING MOUNTAINS TO THE NORTHEAST.



LAURA CAPELLE AT THE POLYCHROME WIND RESEARCH SITE, DENALI NATIONAL PARK, JUNE 1995

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SUMMER FIELD STUDIES OF WIND VARIABILITY IN DENALI NATIONAL PARK AND PRESERVE

DECEMBER 1995

D. E. GLIDDEN

Introduction

During the early 1980's, wind energy resource assessments were made for many stations in the United States, including Alaska. However, comparable data from field studies in some of the more rugged mountain areas of the world are rare in the realm of mountain climatology. Studies of actual wind behavior in the field, using calibration-tested instrumentation with similar response characteristics, are essential to the process of improving our understanding of mountain wind climatology. Topographically-induced airflow in mountains is a complex process influenced by many variables, and while some field research suggests that there may be similar mechanisms identifiable in different ranges and under varying prevailing conditions, the information is minimal.

Even the first introduction of modern Doppler weather radar, north of the Fairbanks area in the summer of 1993, yielded some surprising results while surveying complex terrain: "--foremost among them is the unanticipated complexity and small scale of meteorological processes during the winter in an Arctic region" (Fathauer, 1995). Thus, even with the aid of modern technology, many processes at work in mountains, on a scale significantly smaller than that which is found in Denali, remain unexplained, and the importance of quantifying what actually goes on in the field becomes clear.

Answering such questions, for example, as how gust factors range with increasing mean wind speeds in different areas--and how this may relate to subsynoptic changes in pressure--is important in establishing our ability to predict localized wind behavior in mountains under varying meteorological parameters.

During early June of 1995, with the encouragement of the Mount Washington Observatory of New Hampshire and Dave Stevens of the Alaska Regional Office of the National Park Service, and the enthusiastic support and help of the Resources and Preservation Staff at Denali, several temporary wind research sites with special instrumentation were established in Denali to monitor hourly wind speeds, peak gusts, and other related meteorological variables. Although of limited duration (several weeks) and scope, it was believed that this survey would help provide some valuable field data for comparison with similar exposures in Rocky Mountain National Park in Colorado (Glidden, 1981, 1982), the White Mountains of New Hampshire, (Glidden, 1974, 1976a, 1976b, 1986; Tattleman, 1975) and other mountain areas. The information would also be available for comparison with existing NPS monitoring equipment near Park Headquarters (Rock Creek) and elsewhere, and associated with the Inventory and Monitoring Program of the NPS and National Biological Service.

Field work of this nature may also help to resolve the larger questions of both identifying long-range climatological research in the Park and how this information may be evaluated and compared, and some of the more viable instrument site exposures for these purposes; and it may help us establish the reliability and compatibility of data acquired with different instrumentation.

Research Sites

Three main wind research sites, with excellent sensor exposure at 12 ft (3.6 m) A.G.L., were established from east to west along the Park Road corridor, and are described as follows:

1. Polychrome - 4217 ft (1285 m), full exposure on a north-south ridge well above the Polychrome rest area, and overlooking the Alaska Range to the south and Mt. McKinley to the southeast.

2. Toklat Bluff - 3490 ft (1064 m), located to the east of Divide Mountain on a bluff overlooking the Toklat River.

3. Eielson Bluff - 3360 ft (1024 m), several miles west of the Eielson Visitors' Center, this site is located on a bluff overlooking the McKinley River, the Muldrow Glacier, and Mt. McKinley.

4. Camp Toklat - 3000 ft (914 m), located 200 feet east of the NPS facility, on the edge of the Toklat River. (Temperature and relative humidity data only.)

Selected Data

Selected summary graphs were prepared from the June 1995 field data. General comments and observations are included with the following figures, but since the data base is limited, they should be considered as tentative in nature.

Figure 1

This compares the average monthly wind speed (MPH) for 1994 at the NPS Upper Ridge Site (4400 ft, 1341 m) to the 1950-93 averages for Mount Washington, New Hampshire (6290 ft, 1917 m). Data from the Upper Ridge Site (although there are slightly lower values found in the June-October period) do not appear to show the pronounced seasonal variation found on Mount Washington, which is more typical of mountain wind speed trends in lower latitudes of the United States.

Figure 2

The seasonal variability of maximum wind speeds for each month are compared at Denali Upper Ridge Site (1994), Mount Washington, New Hampshire (1935-93 averages), and at the TR 3 Site (11,600 ft, 3536 m) in Rocky Mountain National Park, Colorado (1974). With the exception of March and November, maxima at the Denali Upper Ridge Site also appear to lack definitive winter maxima. Although unexpected, this may reflect a normal pattern for this site in the Park, site topographic or exposure problems, an unusual flow pattern or year, or it may indicate limited data. Marcus (1970), during the Icefield Ranges Research Project summer studies on Mount Logan in 1968 and 1969, found that both field seasons were characterized by unusually stagnant pressure systems and low wind regimes, based on analysis of marine storm tracks and other station data.

Figures 3-4

The highest winds during the study period were recorded at Polychrome on June 24th under an active southeast flow. The hourly and peak gust wind speeds for June 23-24 (through 1400 hours) are presented in Figure 3. On the 24th, gusts to 59 MPH (26 m/s), with average 5-minute speeds of 46 mph (20.3 m/s), occurred around 0850, and gusts to 56 MPH (25 m/s) at 1408 hours. Figure 4 traces the hourly pressure change (in millibars) at Polychrome over the same period. Such modest winds were associated with a rapidly rising pressure regime. It should be noted that the indicated wind maximum of 59 MPH (26 m/s) for June 24, 1995 at Polychrome compares to a 60-second maximum of 51 MPH (22.5 m/s) at the Upper Ridge Site for the entire month of June 1994. The Upper Ridge Site is 56 meters higher than the Polychrome station.

Figures 5-7

The diurnal variability of maximum winds at Eielson Bluff (just across from the Muldrow Glacier), for June 12-16, 1995, may be found in Figure 5. Average maximum winds were found to occur between 1200 and 2200 hours, and average minima between 0700-1000. The average gust factors by hour of day for the period of June 12-22, 1995 are found in Figure

6. Minimum turbulence occurred at 2000 and 0700 hours, which (notwithstanding the long daylight hours in Denali) compares well in time with those values occurring in Rocky Mountain National Park. During non-advective and stable conditions, a certain periodic southeasterly flow off the Muldrow Glacier was identified in hourly stripchart data (not shown). A relative comparison of Eielson average daily gust factors to those at TR3 in Rocky Mountain National park (average for August 1980) may be found in Figure 7. The RMNP August 1980 average of 1.57 may be broadly compared to the June 12-22, 1995 average of 2.15 for Eielson, which is more within the RMNP average daily maxima range. One may expect that, with a longer data base for June, the average GFs at Eielson would fall. However, only data of this nature covering at least one summer period would allow any definitive comparison.

<u>Figures</u> <u>8-9</u>

Site comparison of average and maximum winds are found in Figures 8-11. Figure 8 shows daily peak gust ratios between Polychrome and Toklat Bluff, Polychrome and Eielson Bluff, and Toklat and Eielson Bluff for the period June 14-23, 1995. For example, on June 15th, the peak gust at Polychrome was three times greater than that occurring at Eielson. A ratio of 1.0 would indicate that the peak gusts were the same.

The actual daily peak gusts at the sites for June 14-24th are included in Figure 9, with maxima usually found at Polychrome. However, on June 18th, Polychrome and Toklat had the same maxima, with Eielson very close.

Figures 10-11

Figures 10 (Toklat/Eielson) and 11 (Polychrome/Eielson), comparing average winds and directions for the same days and times, describe a more interesting occurrence. Polychrome usually had higher average winds, and in some cases significantly higher winds (see June 15th). However, on June 17th, under airflow ranging from 240 degrees (at Polychrome) to 270 degrees (at Toklat), Eielson Bluff had higher averages than either Polychrome or Toklat at 1006 and 1127 hours, respectively. Unfortunately, the scope of this study did not include provisions for subsynoptic weather analysis, although this is recommended in any future work.

Figures 12-14

The average daily pressure at Polychrome (uncorrected, with absolute values not for comparison elsewhere) is contained in Figure 12. The diurnal pressure variation, by hour of day and for the period June 15-24, 1995 is plotted in Figure 13. Suggesting a diurnal pattern, average pressures begin to fall by 1400, with minima occurring between 1700-1900 hours. The time frame for pressure minima appears to generally agree with that for average maximum winds at Eielson (see Fig. 5). Figure 14 details the moderate southeast winds at Polychrome during the morning of June 24, 1995. Note the rapid changes in gustiness from around 0930-1000 hours.

Table 1

This table lists all peak gusts, times, and dates recorded at the Polychrome, Toklat, and Eielson sites.

Table 2

The State of Sky conditions (supplemental weather data) is listed at selected times for each site from June 14-23, 1995.

Comments on Existing and Future Mountain Climatological Research in Denali National Park

Denali National Park covers a large area, and we have to appreciate that it probably represents a number of subsynoptic, topographically-induced climatological zones which are influenced, but not strictly limited to elevation alone (see Fathauer, 1995). If some of our objectives are to monitor the various meteorological and mesoclimatological areas over the long-range, we may want to consider the possibility that current instrument location and type may be biased somewhat by proximity to Headquarters, low elevation, and the limitations of current systems. (Logistics and cost are usually a factor in locating research sites in areas as remote as those in Denali National Park.)

Concerning wind climatology, the current data base which potentially reflect conditions on the higher Alaska Range and Mount McKinley are probably inadequate or non-existing (although data collection efforts by the Japanese Alpine Club are recognized and certainly appreciated, with results which may be forthcoming). Research in Rocky Mountain National

Park (Glidden, 1981), particularly on Longs Peak (14,225 ft, 4345 m), demonstrated how different the wind regimes may be from site to site. Upper air probes or radar may or may not reflect conditions on Mt. McKinley or other Alaska Range sites.

It is suggested that Denali needs to develop its own capability to identify and monitor all important climatic areas within its confines, and that this capability need not involve great expense but would require a recognition of the need and a commitment to develop the monitoring program. In this light, the following recommendations are made for enhancing Denali climatological studies:

Establishing a north-south transect of three sites (same instruments at each location), during late Spring of 1996 to include the acquisition of more robust instrumentation for monitoring conditions on Mt. McKinley or an alternative lower, more serviceable Alaska Range site:

```
                     N
                     -
Site A (Wonder       X    wind speed, peak gust and direction
Lake/Eielson)          -    chart recorders, microbarographs,
                     -    hygrothermographs at all three sites
                     -    (NOT AWS units and not real-time data
                     -    acquisition during the early season
                    -    period of this summer study)
 Site B (Alaska      X
 Range > 12000 ft
or Mt. Mckinley massif)  -
                    -3
                    -
                    X    Site C (North of Petersville,
                    -          ca. 3000 ft.)
                    S
```

Once the sites are established, and depending on the instrumentation selected, the logistics and schedule to service them on a regular basis should be provided during the summer season portion of the study. Fostering a cooperative spirit and instrument training session with mountaineering Park Rangers, as well as occasional helicopter logistical support, would be important to conducting this research, particularly at the highest station.

This transect may help to provide us with the ability to correlate the aforementioned subsynoptic wind, pressure and weather conditions along the Alaska Range and Mount McKinley with synoptic or regional weather patterns. Only by instrumenting Mt. McKinley and/or the upper reaches of the Alaska Range, and by building a site-specific climatological data base, can we hope to improve our ability to anticipate and understand weather and wind conditions peculiar to these areas. Since this information involves mountaineering rescue and helicopter operations, it may have direct application to visitor safety, as well as public education about extreme environments within Denali and other science projects.

Until we are able to determine the value and relationship of data between these sites, an investment in the expense of real-time data is not recommended. Time and effort should focus on analyzing inter-site field data and any correlation to larger-scale weather systems, but at this stage it should not involve modelling or theoretical aspects of meteorology.

There is no substitute for accurate, comparable field data in mountain climatology.

In the future, establishing a representative climatological data base will help us to monitor and identify abnormal environmental changes within the Park, an important objective in resources management.

Acknowledgments

The author would like to express his appreciation to the entire Staff at Denali National Park. With the support of Gordon Olson in Research and Resource Preservation, Joe Van Horn and Paul Atkinson provided invaluable encouragement, field assistance, and logistical support for this project. In addition, I want to thank the many Camp Toklat personnel for their help. Laura Capelle, a veteran of Greenland and Antarctica, Assistant EduTrip Leader for the Mount Washington Observatory, and formerly associated with the Appalachian Mountain Club in Pinkham Notch, New Hampshire, also contributed hours of field work while operating out of Camp Denali.

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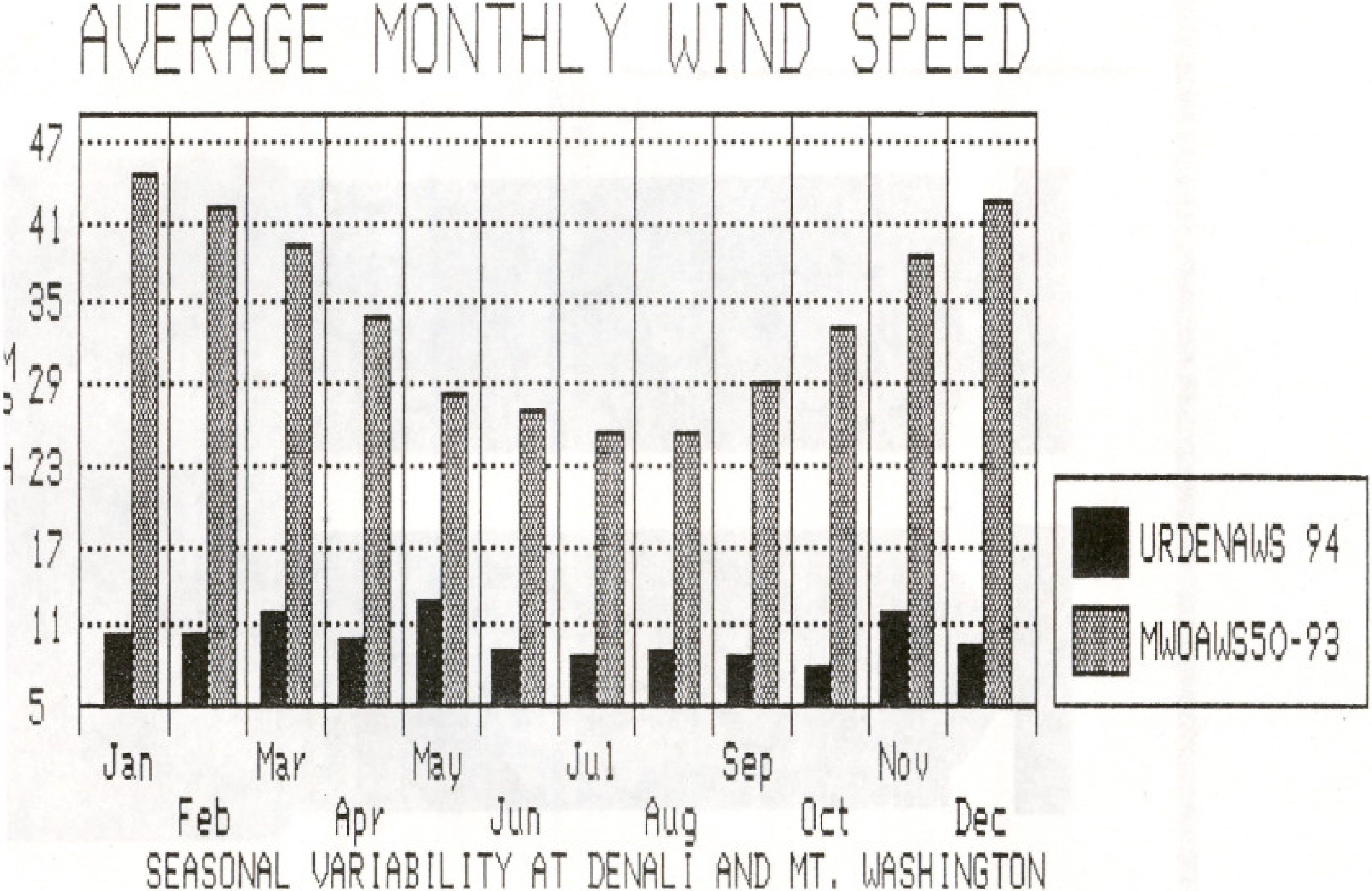

AVERAGE MONTHLY WIND SPEED
47
41
35
29
23
17
11
5
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
URDENAWS 94
MWOAWS50-93
SEASONAL VARIABILITY AT DENALI AND MT. WASHINGTON

FIG. 1

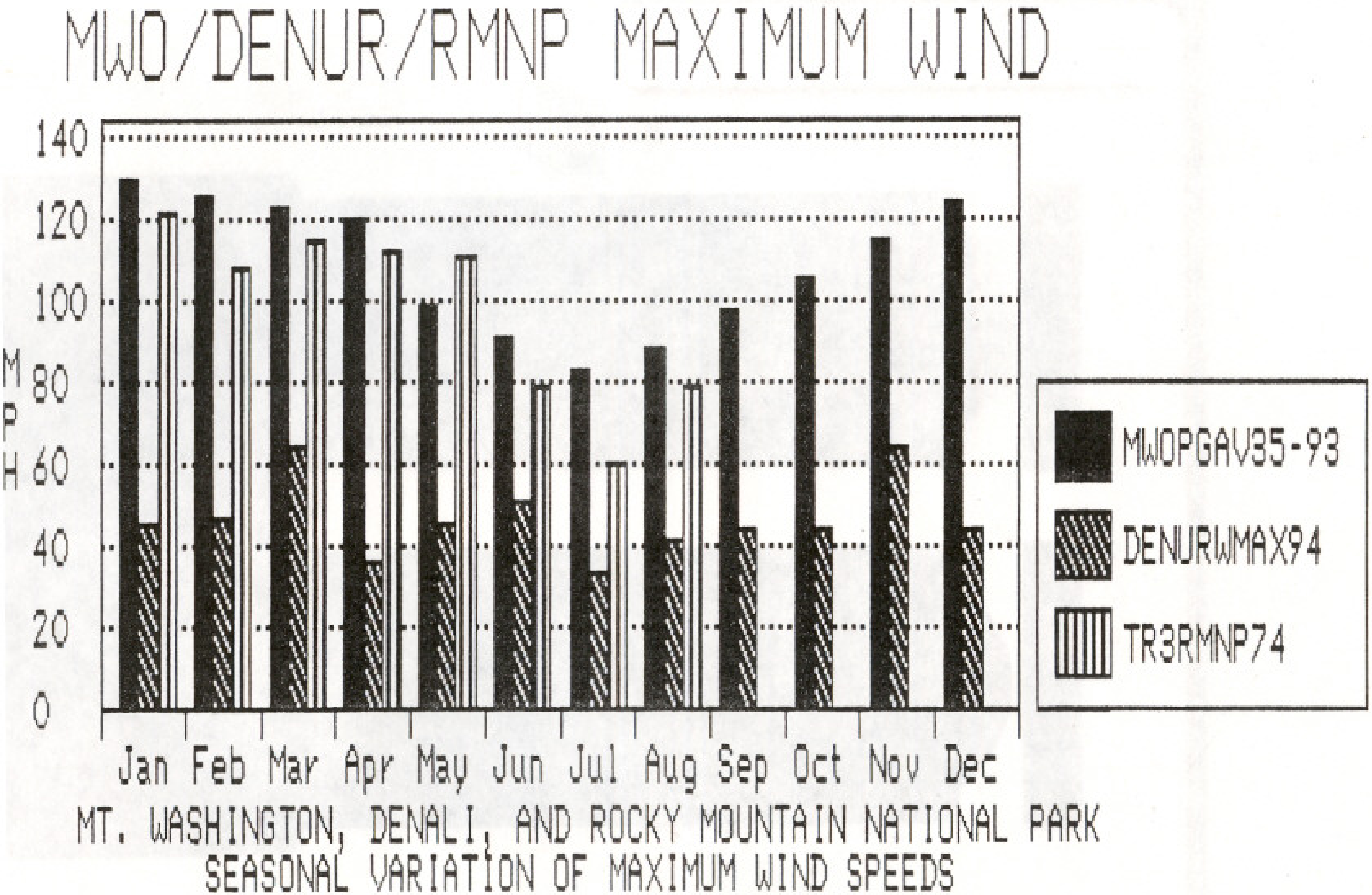

MWO/DENUR/RMNP MAXIMUM WIND
140
120
100
80
60
40
20
0
MPH
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
MWOPGAV35-93
DENURWMAX94
TR3RMNP74
MT. WASHINGTON, DENALI, AND ROCKY MOUNTAIN NATIONAL PARK
SEASONAL VARIATION OF MAXIMUM WIND SPEEDS

FIG. 2

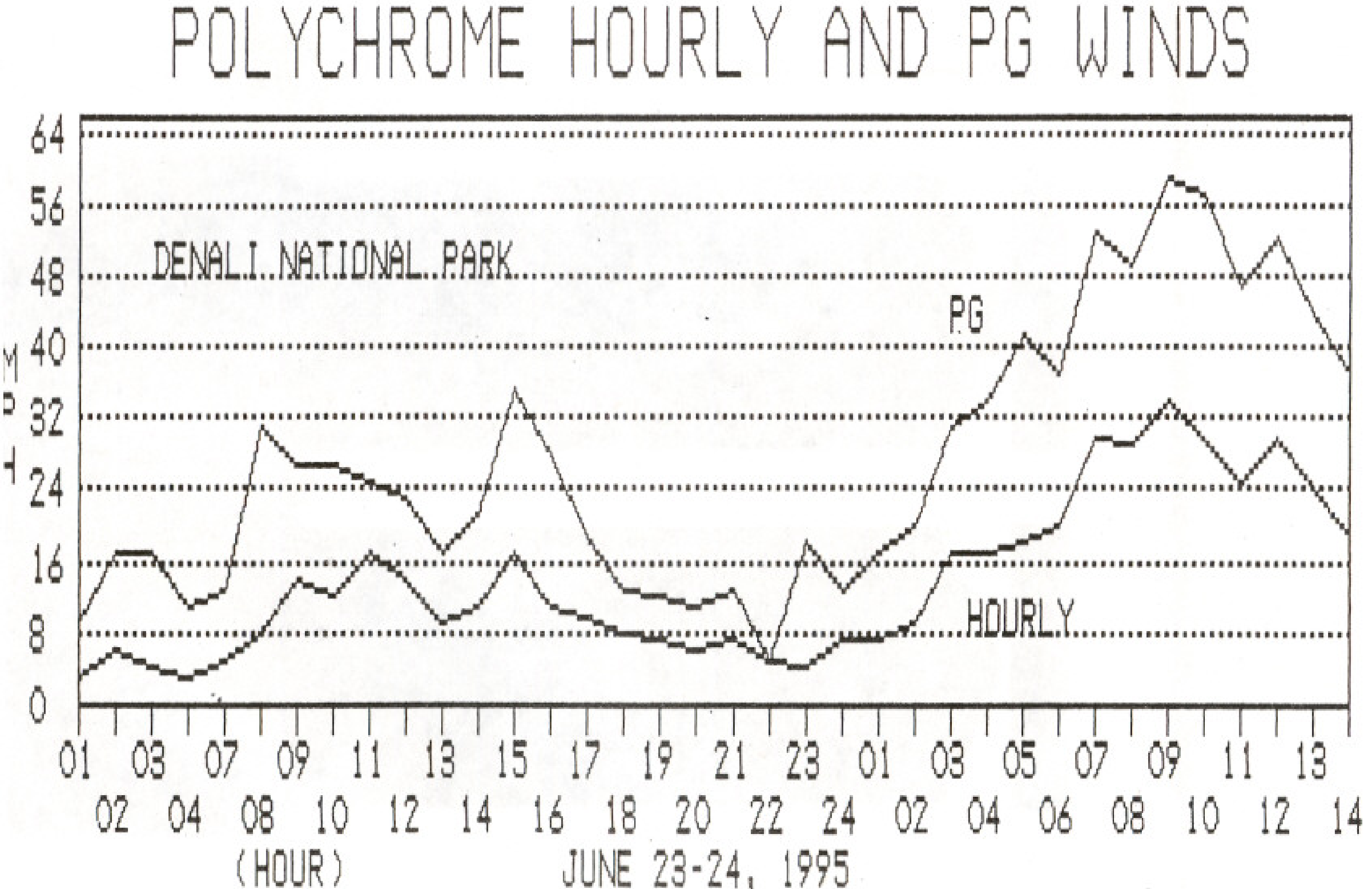

POLYCHROME HOURLY AND PG WINDS
DENALI NATIONAL PARK
PG
HOURLY
MPH
64
56
48
40
32
24
16
8
0
01 02 03 04 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 01 02 03 04 05 06 07 08 09 10 11 12 13 14
(HOUR)
JUNE 23-24, 1995

FIG. 3

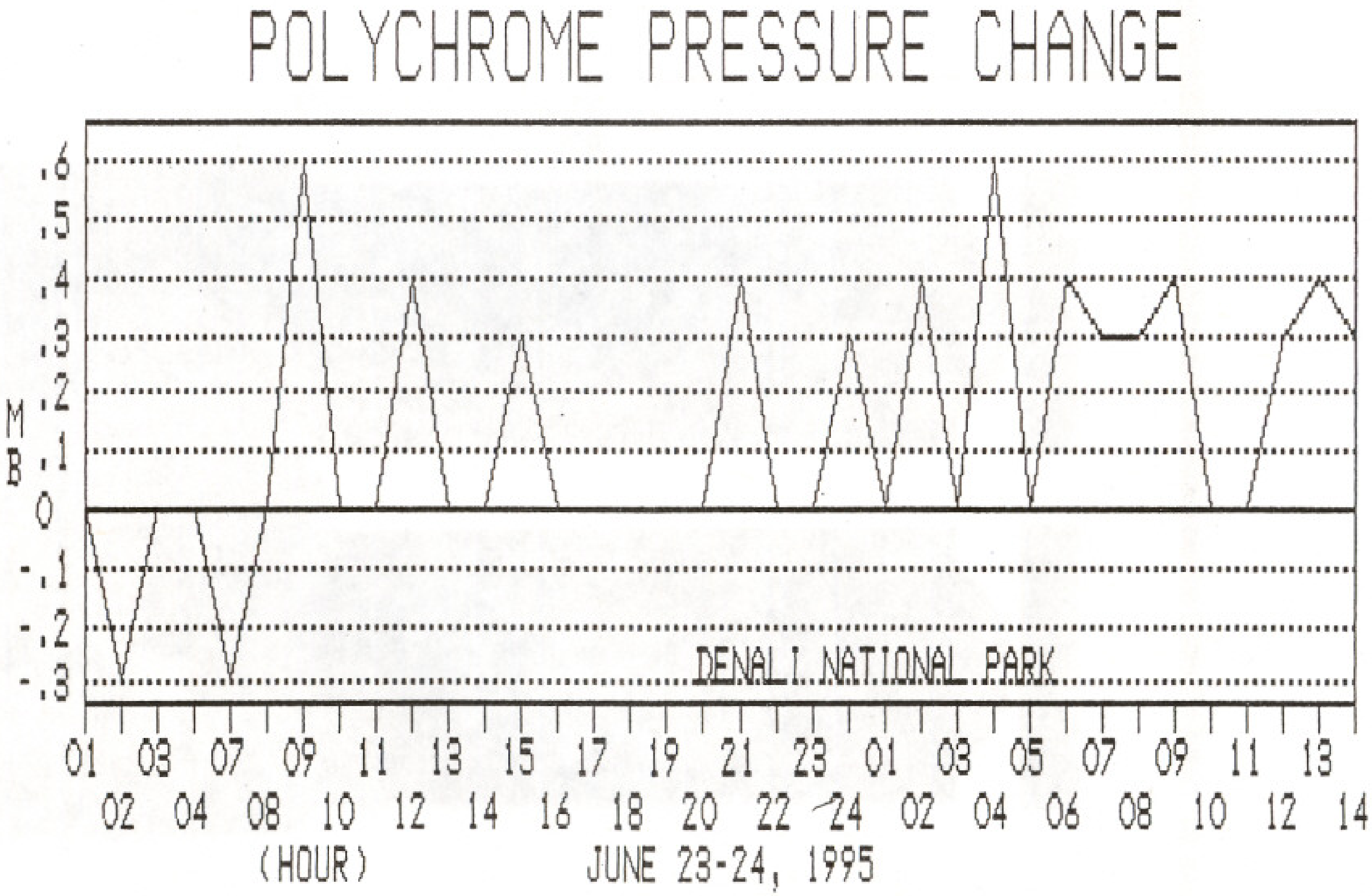

POLYCHROME PRESSURE CHANGE
MB
.6
.5
.4
.3
.2
.1
0
-.1
-.2
-.3
DENALI NATIONAL PARK
01 03 07 09 11 13 15 17 19 21 23 01 03 05 07 09 11 13
02 04 08 10 12 14 16 18 20 22 24 02 04 06 08 10 12 14
(HOUR)
JUNE 23-24, 1995

FIG. 4

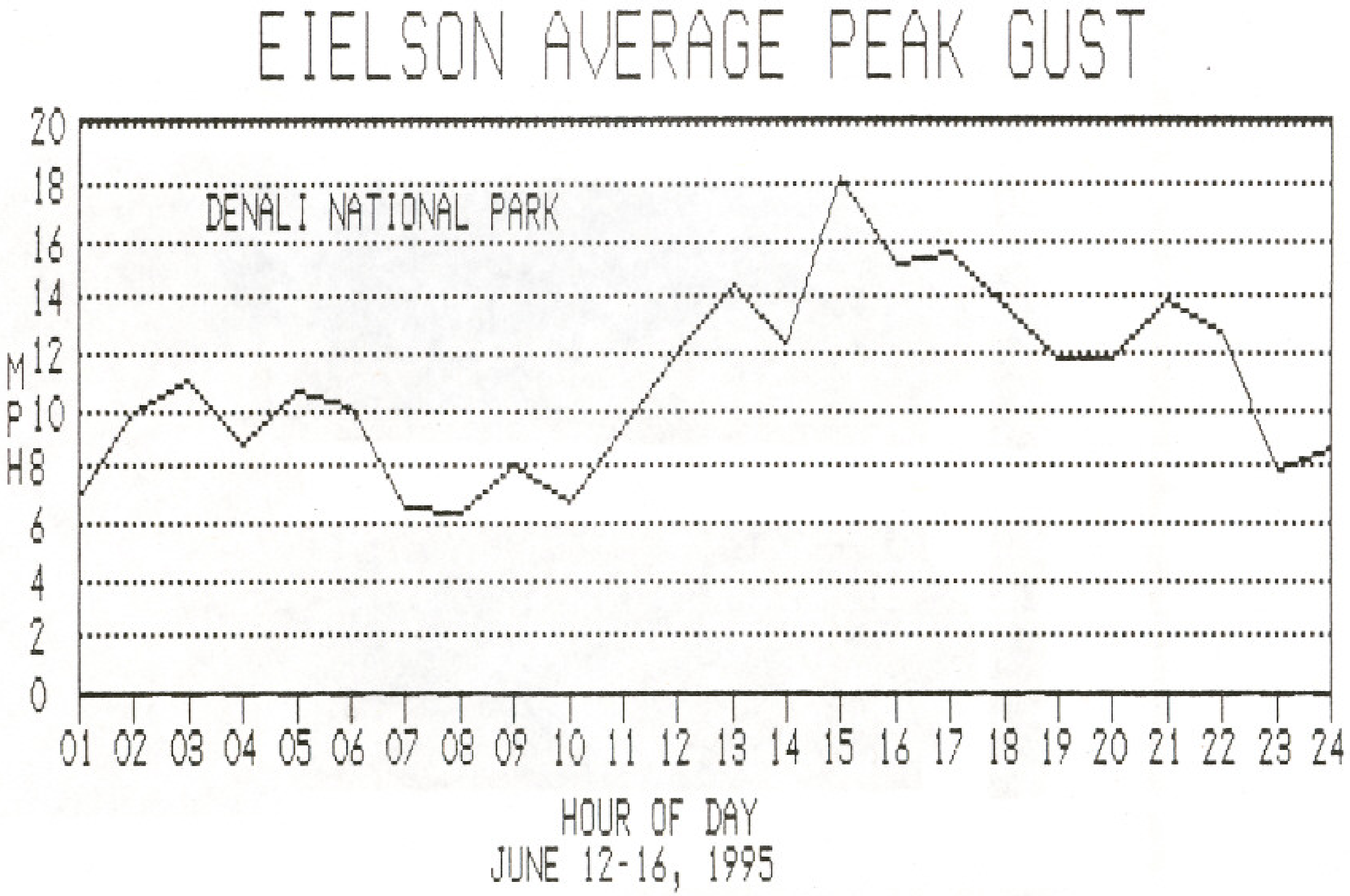

EIELSON AVERAGE PEAK GUST
DENALI NATIONAL PARK
MPH
20
18
16
14
12
10
8
6
4
2
0
01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
HOUR OF DAY
JUNE 12-16, 1995

FIG. 5

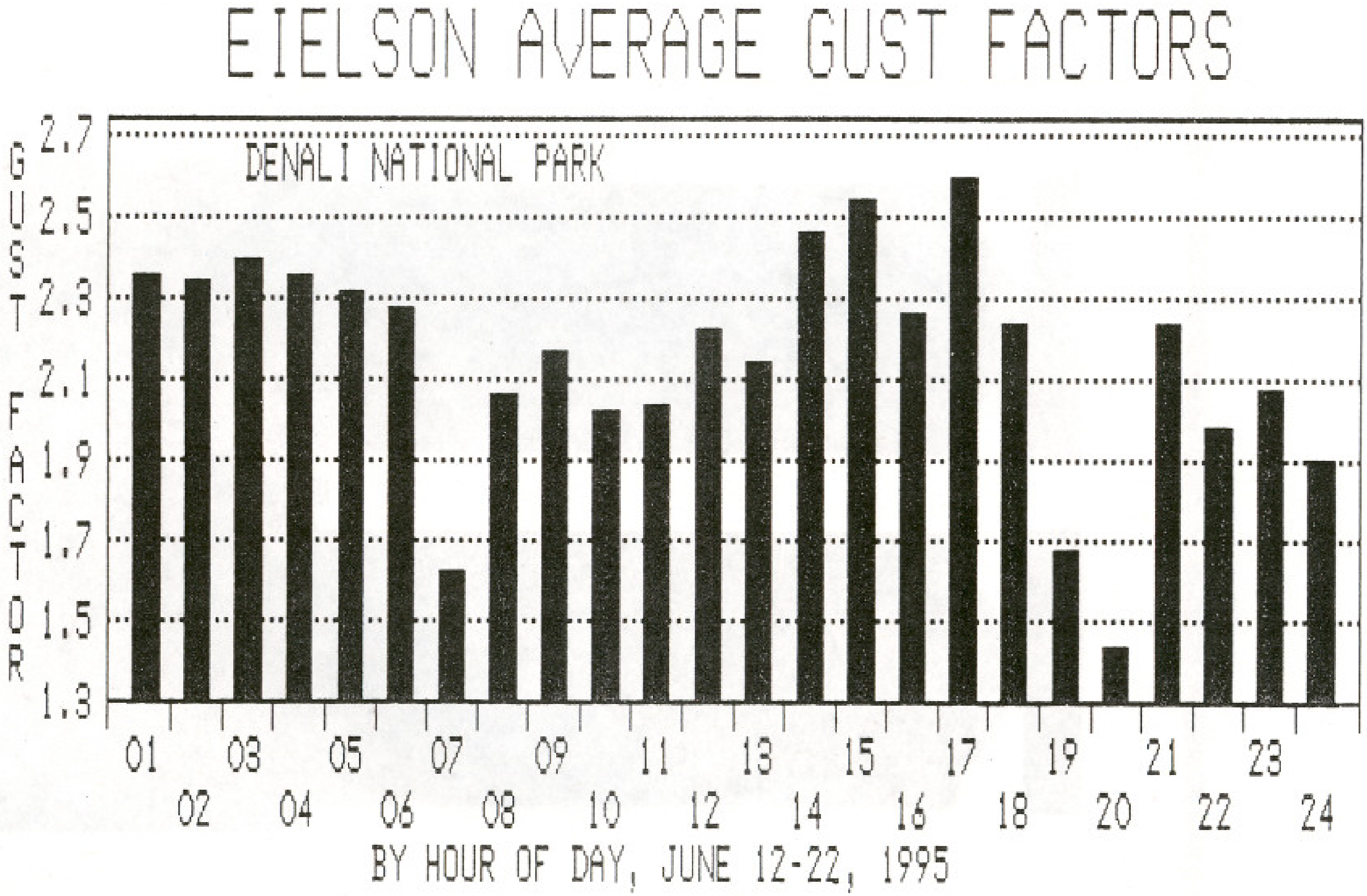

EIELSON AVERAGE GUST FACTORS
DENALI NATIONAL PARK
GUST FACTOR
2.7
2.5
2.3
2.1
1.9
1.7
1.5
1.3
01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
BY HOUR OF DAY, JUNE 12-22, 1995

FIG. 6

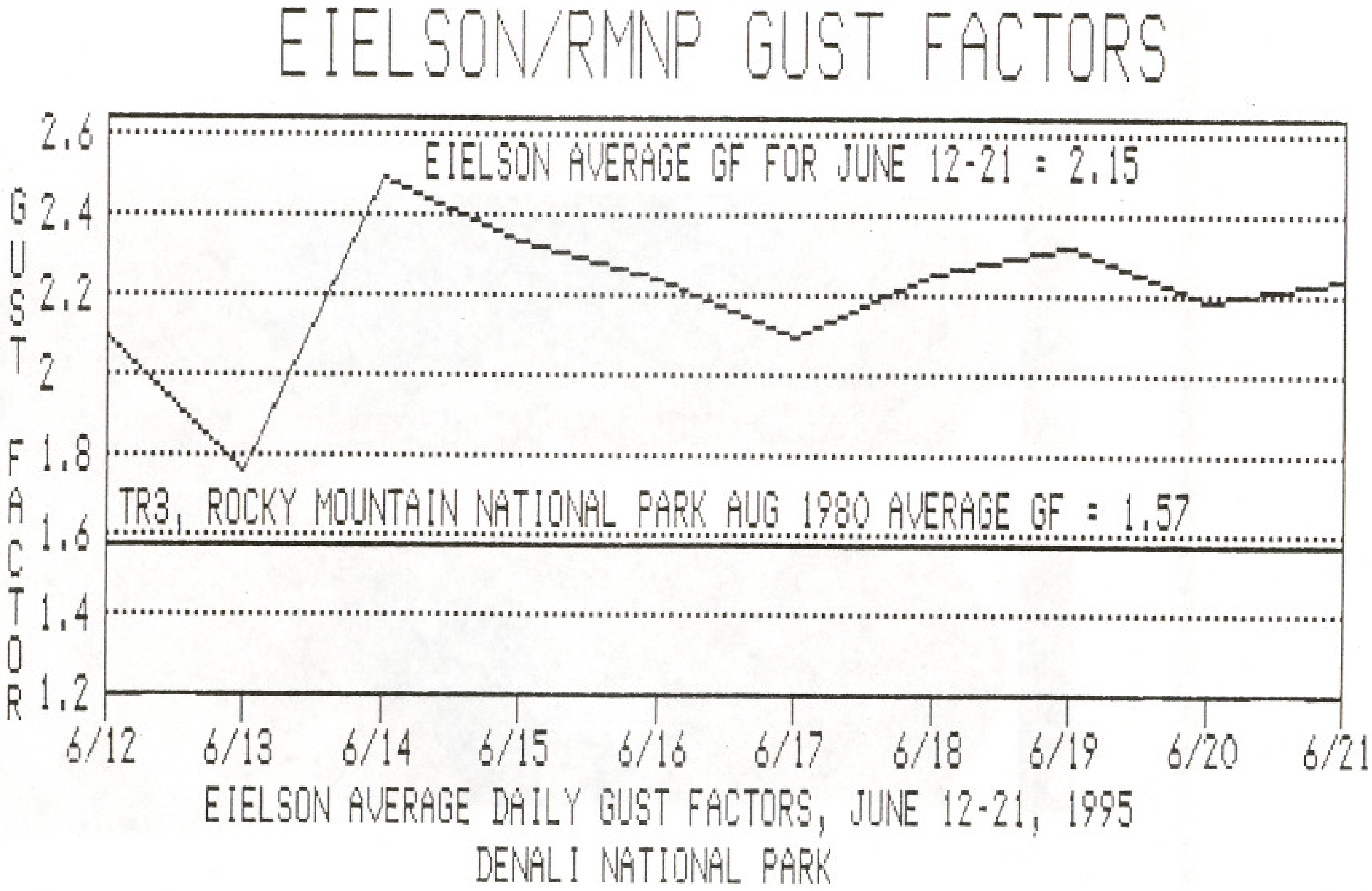

EIELSON/RMNP GUST FACTORS
EIELSON AVERAGE GF FOR JUNE 12-21 = 2.15
TR3, ROCKY MOUNTAIN NATIONAL PARK AUG 1980 AVERAGE GF = 1.57
GUST FACTOR
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
6/12
6/13
6/14
6/15
6/16
6/17
6/18
6/19
6/20
6/21
EIELSON AVERAGE DAILY GUST FACTORS, JUNE 12-21, 1995
DENALI NATIONAL PARK

FIG. 7

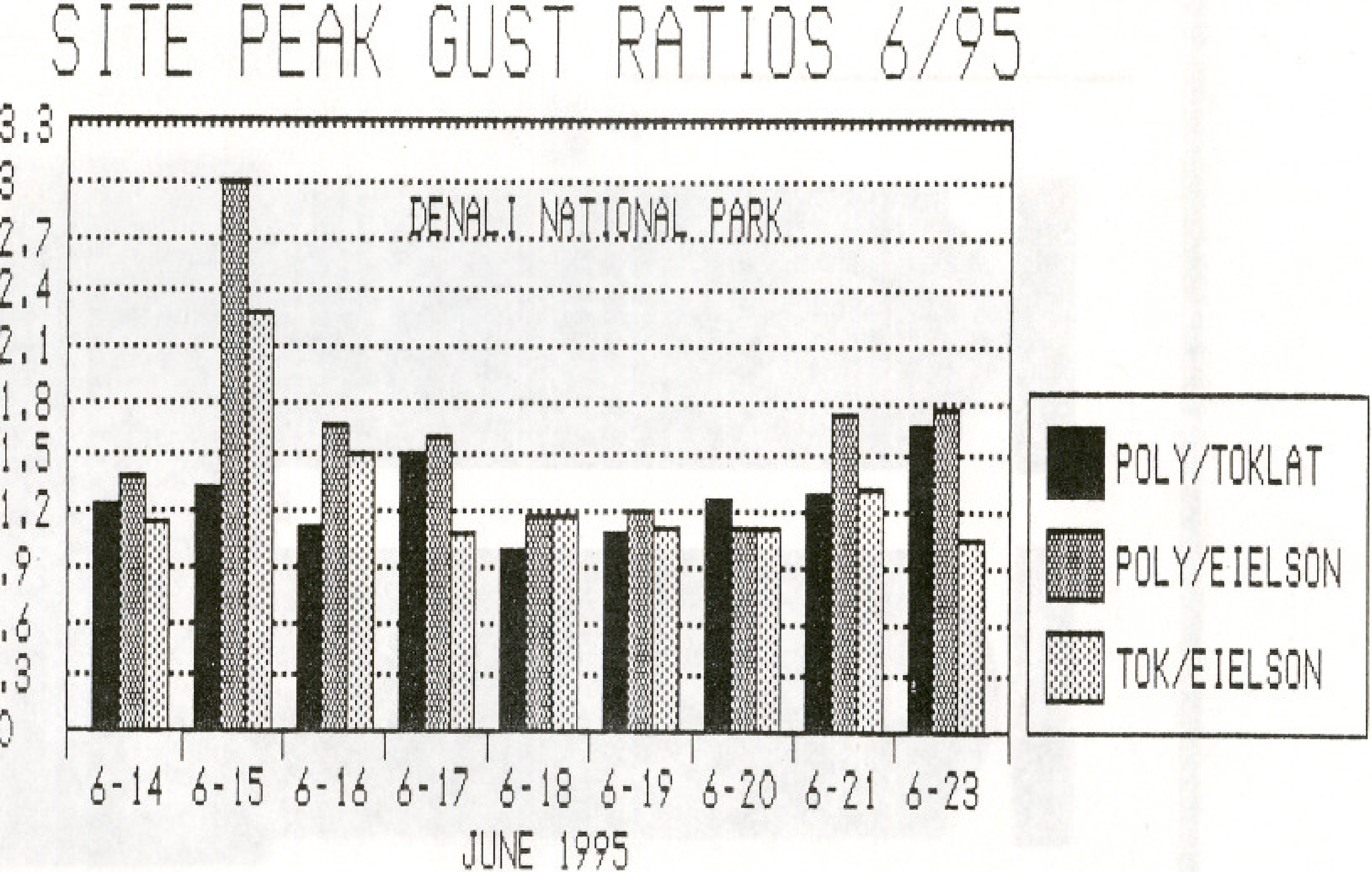
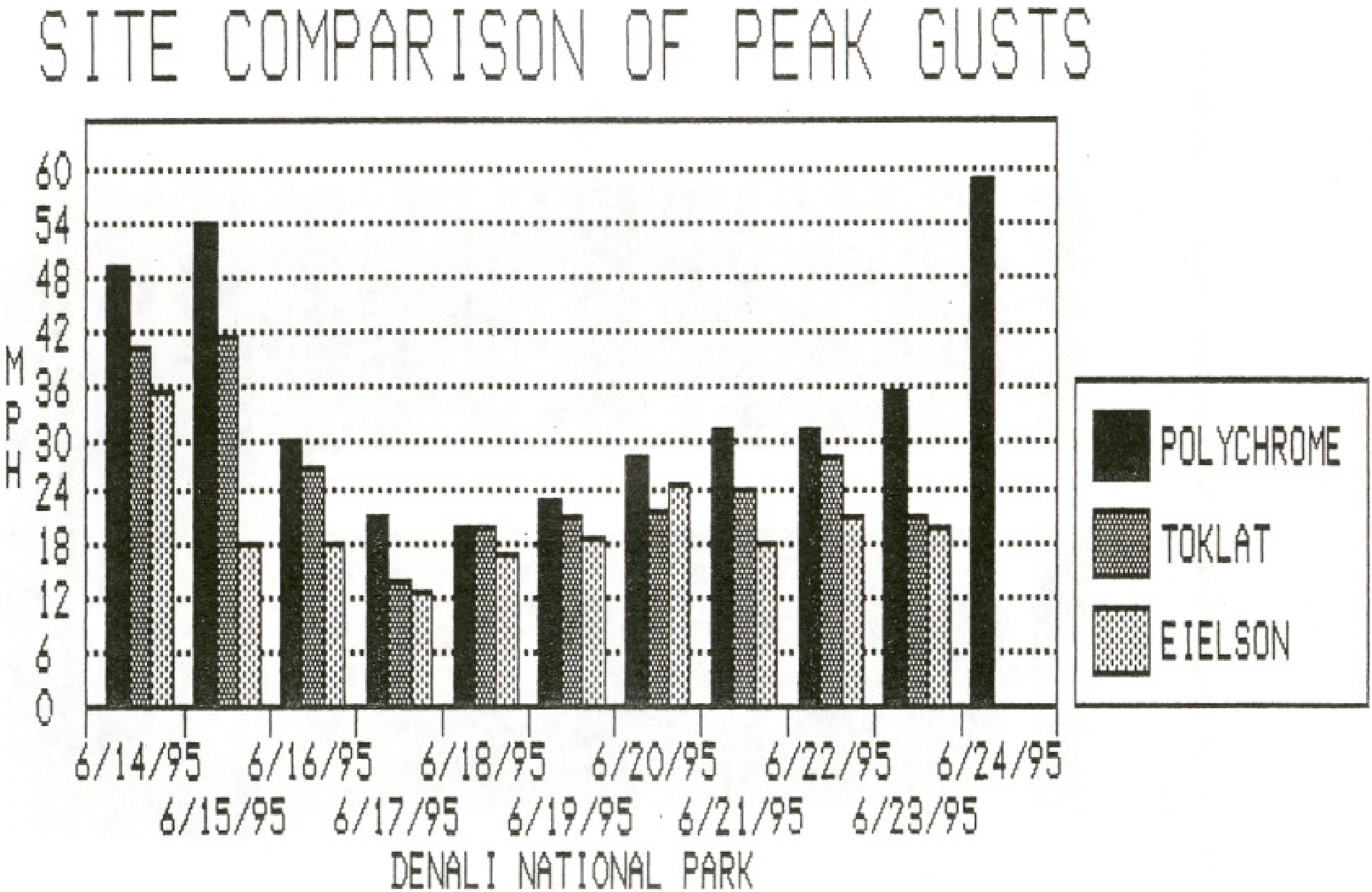

SITE PEAK GUST RATIOS 6/95
DENALI NATIONAL PARK
3.3
3
2.7
2.4
2.1
1.8
1.5
1.2
.9
.6
.3
0
6-14
6-15
6-16
6-17
6-18
6-19
6-20
6-21
6-23
JUNE 1995
POLY/TOKLAT
POLY/EIELSON
TOK/EIELSON

FIG. 8


SITE COMPARISON OF PEAK GUSTS
MPH
60
54
48
42
36
30
24
18
12
6
0
6/14/95
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6/16/95
6/17/95
6/18/95
6/19/95
6/20/95
6/21/95
6/22/95
6/23/95
6/24/95
DENALI NATIONAL PARK
POLYCHROME
TOKLAT
EIELSON

FIG. 9

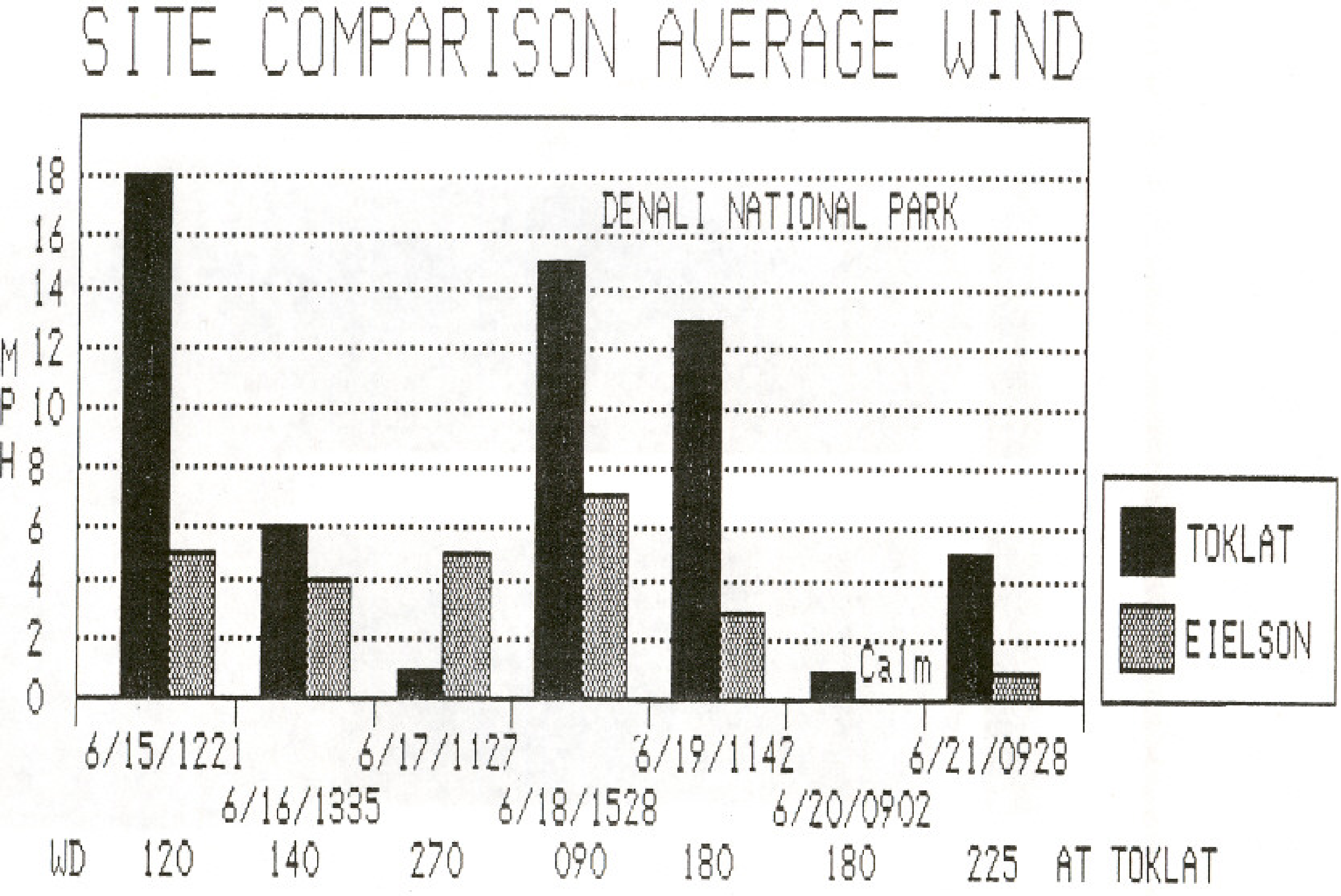

SITE COMPARISON AVERAGE WIND
DENALI NATIONAL PARK
MPH
18
16
14
12
10
8
6
4
2
0
Calm
TOKLAT
EIELSON
6/15/1221
6/16/1335
6/17/1127
6/18/1528
6/19/1142
6/20/0902
6/21/0928
WD 120 140 270 090 180 180 225 AT TOKLAT

FIG. 10

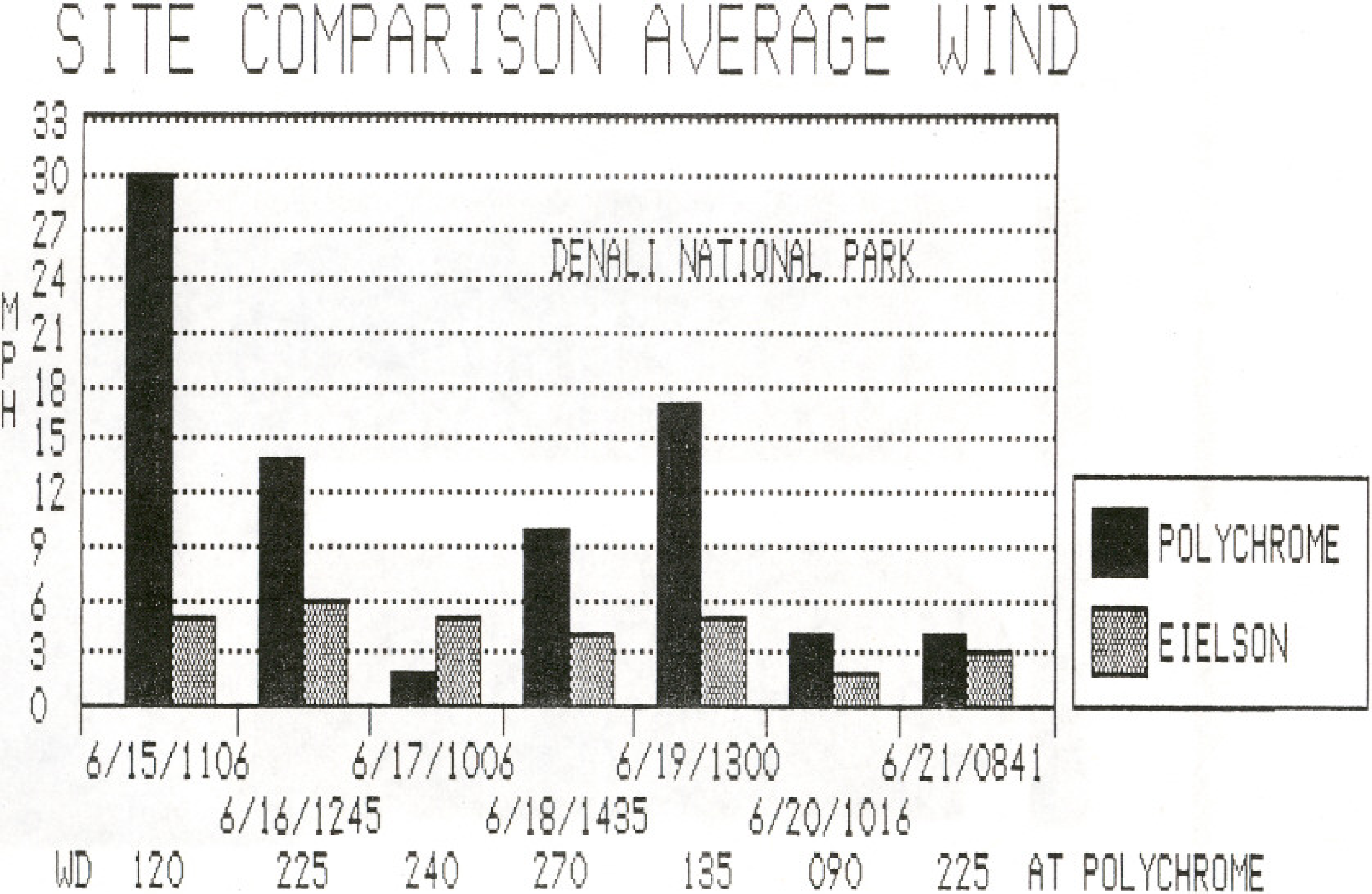

SITE COMPARISON AVERAGE WIND
DENALI NATIONAL PARK
M P H
33
30
27
24
21
18
15
12
9
6
3
0
POLYCHROME
EIELSON
6/15/1106
6/16/1245
6/17/1006
6/18/1435
6/19/1300
6/20/1016
6/21/0841
WD 120 225 240 270 135 090 225 AT POLYCHROME

FIG. 11

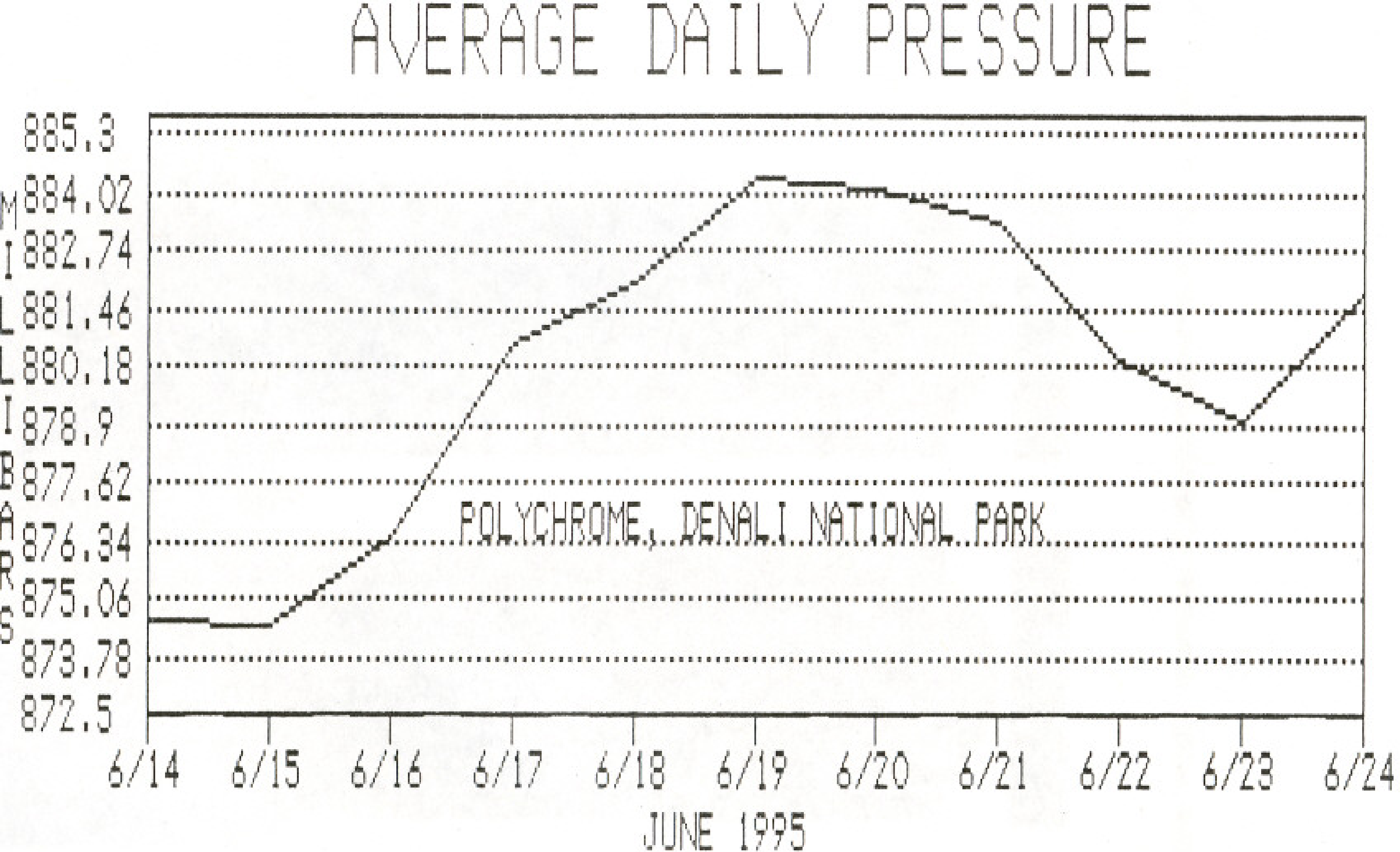
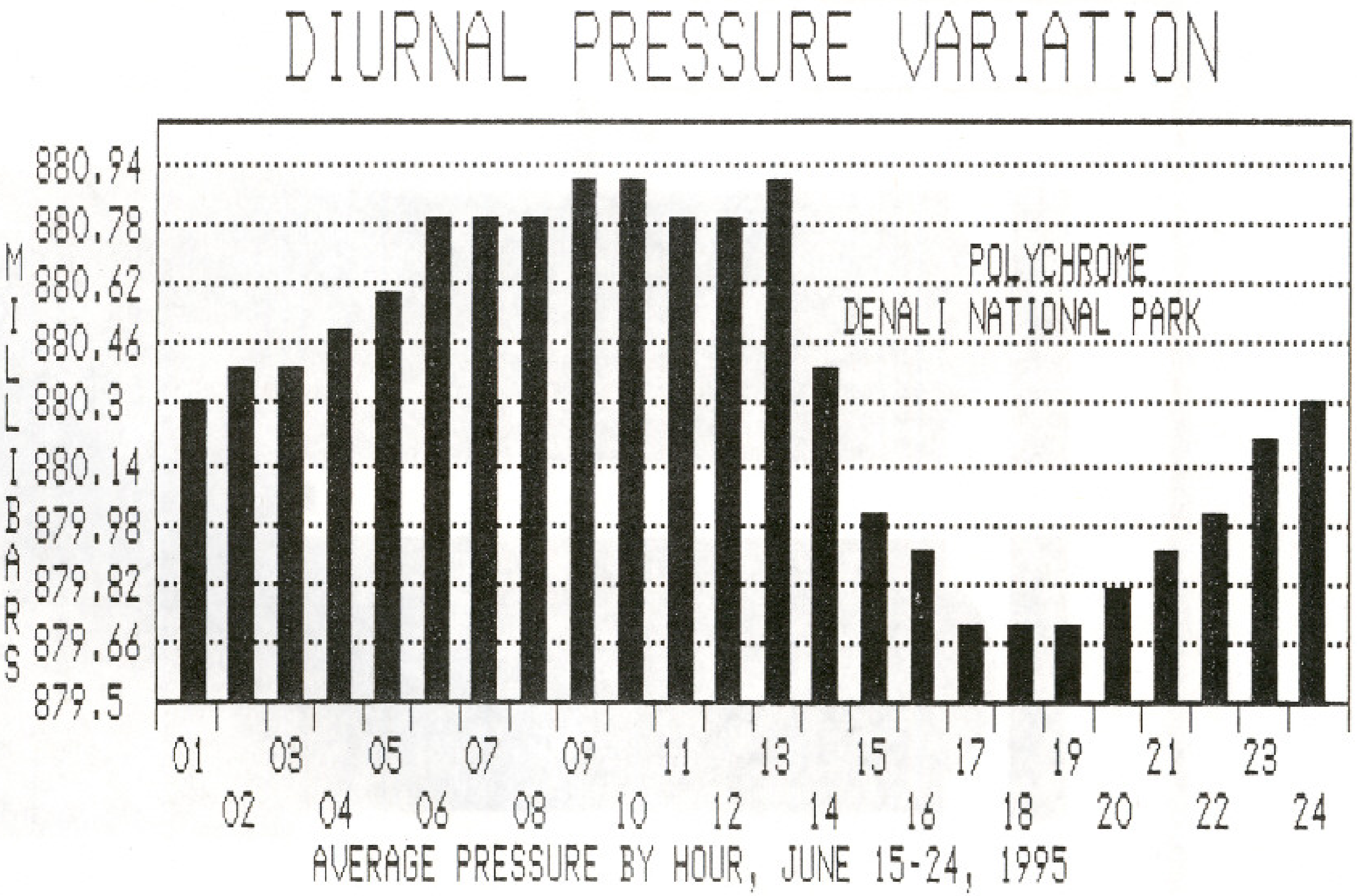

AVERAGE DAILY PRESSURE
MILLIBARS
885.3
884.02
882.74
881.46
880.18
878.9
877.62
876.34
875.06
873.78
872.5
POLYCHROME, DENALI NATIONAL PARK
6/14
6/15
6/16
6/17
6/18
6/19
6/20
6/21
6/22
6/23
6/24
JUNE 1995

FIG. 13



DIURNAL PRESSURE VARIATION
MILLIBARS
880.94
880.78
880.62
880.46
880.3
880.14
879.98
879.82
879.66
879.5
POLYCHROME
DENALI NATIONAL PARK
01
02
03
04
05
06
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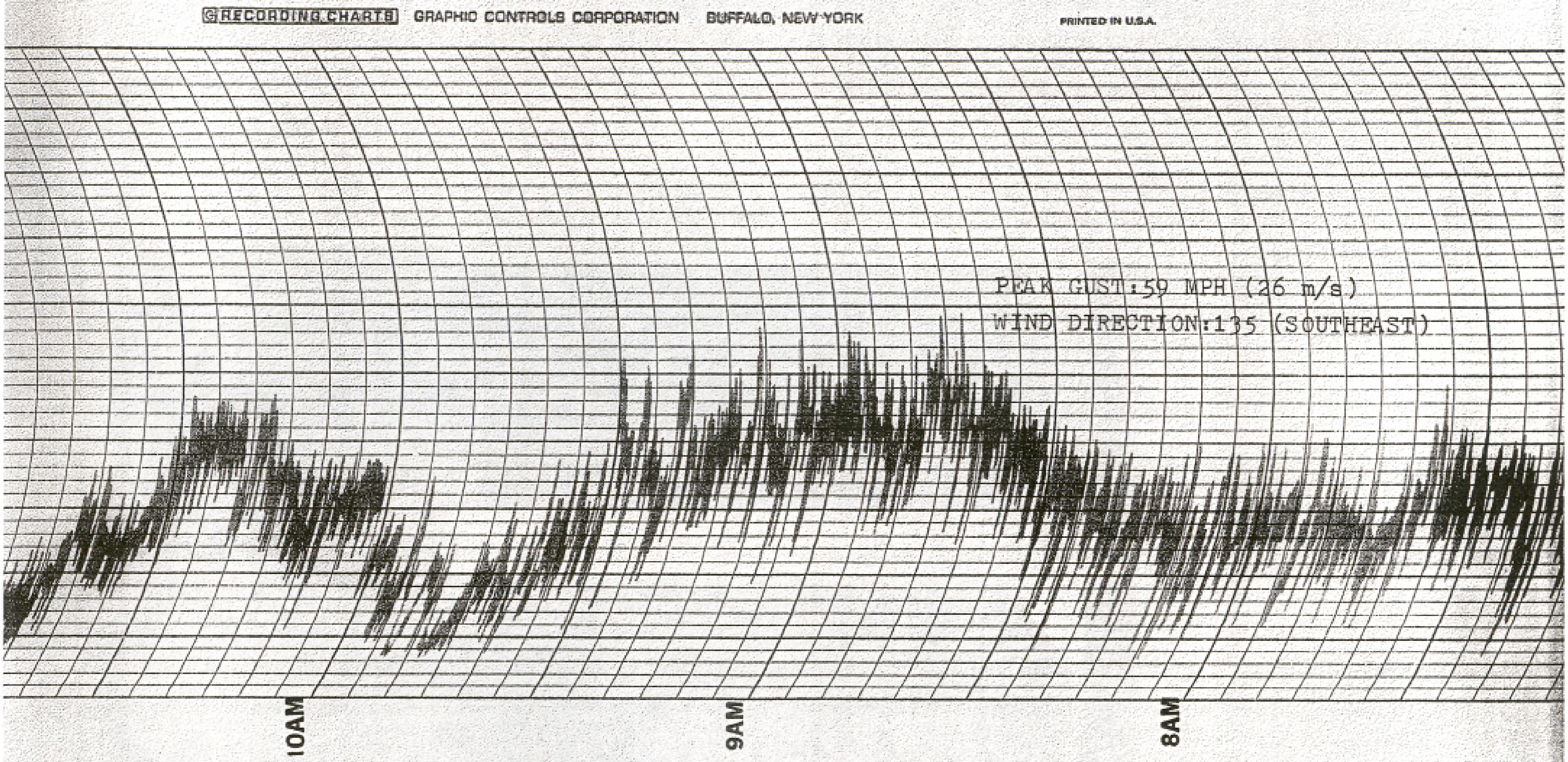
17
18
19
20
21
22
23
24
AVERAGE PRESSURE BY HOUR, JUNE 15-24, 1995

FIG. 13



POLYCHROME WIND RESEARCH SITE
DENALI NATIONAL PARK, ALASKA

ANEMOGRAPHIC TRACE FOR JUNE 24, 1995

SCALE: 0-100 MPH (0-44 m/s)

(SITE ELEVATION: 1285 m)

FIG. 14

PEAK WIND GUSTS, ALL SITES, DENALI NATIONAL PARK
JUNE 1995

PG	DPG	D	T	HE	S
59		95/06/24		09:00	POLYCHROME
57		95/06/24		10:00	POLYCHROME
56		95/06/24		15:00	POLYCHROME
54		95/06/15	11:06		POLYCHROME
53		95/06/24		07:00	POLYCHROME
52		95/06/24		12:00	POLYCHROME
49		95/06/14	14:00		POLYCHROME
		95/06/24		08:00	POLYCHROME
48		95/06/24		17:00	POLYCHROME
47		95/06/24		11:00	POLYCHROME
46		95/06/24		16:00	POLYCHROME
44		95/06/24		13:00	POLYCHROME
41		95/06/15	12:21		TOKLAT BLUFF
		95/06/24		05:00	POLYCHROME
40		95/06/14	15:50		TOKLAT BLUFF
37		95/06/24		06:00	POLYCHROME
		95/06/24		14:00	POLYCHROME
35		95/06/14		13:00	EIELSON BLUFF
		95/06/14	18:00		EIELSON BLUFF
		95/06/23		15:00	POLYCHROME
34		95/06/24		04:00	POLYCHROME
31		95/06/14		06:00	EIELSON BLUFF
		95/06/21	08:11		POLYCHROME
		95/06/22	11:52		POLYCHROME
		95/06/23		08:00	POLYCHROME
		95/06/24		03:00	POLYCHROME
30		95/06/16	12:45		POLYCHROME
29		95/06/14		14:00	EIELSON BLUFF
28		95/06/14		12:00	EIELSON BLUFF
		95/06/20	10:16		POLYCHROME
		95/06/22	19:05		TOKLAT BLUFF
		95/06/23		16:00	POLYCHROME
27		95/06/16	13:35		TOKLAT BLUFF
		95/06/22		16:00	POLYCHROME
		95/06/22		23:00	POLYCHROME
		95/06/23		09:00	POLYCHROME
		95/06/23		10:00	POLYCHROME
26		95/06/14		15:00	EIELSON BLUFF
25		95/06/13			TOKLAT BLUFF
		95/06/14		03:00	EIELSON BLUFF
		95/06/14		16:00	EIELSON BLUFF
		95/06/20		20:00	EIELSON BLUFF
		95/06/23		11:00	POLYCHROME
24		95/06/20		16:00	EIELSON BLUFF
		95/06/21	09:28		TOKLAT BLUFF
23		95/06/13		15:00	EIELSON BLUFF
		95/06/13		16:00	EIELSON BLUFF
		95/06/13		17:00	EIELSON BLUFF
		95/06/14		02:00	EIELSON BLUFF
		95/06/14		05:00	EIELSON BLUFF
		95/06/14		11:00	EIELSON BLUFF
		95/06/14		17:00	EIELSON BLUFF
		95/06/19	13:00		POLYCHROME

TABLE 1

PEAK WIND GUSTS, ALL SITES, DENALI NATIONAL PARK
JUNE 1995

PG	DPG	D	T	HE	S
23		95/06/23		12:00	POLYCHROME
22		95/06/18		21:00	EIELSON BLUFF
		95/06/20		21:00	EIELSON BLUFF
		95/06/20	09:02		TOKLAT BLUFF
21		95/06/13		20:00	EIELSON BLUFF
		95/06/13		22:00	EIELSON BLUFF
		95/06/17	10:06		POLYCHROME
		95/06/19	11:42		TOKLAT BLUFF
		95/06/22		14:00	POLYCHROME
		95/06/22		17:00	POLYCHROME
		95/06/23		14:00	POLYCHROME
		95/06/23	08:00		TOKLAT BLUFF
20		95/06/13		21:00	EIELSON BLUFF
		95/06/14		18:00	EIELSON BLUFF
		95/06/18	14:35		POLYCHROME
		95/06/18	15:28		TOKLAT BLUFF
		95/06/22		15:00	POLYCHROME
		95/06/23	10:25		EIELSON BLUFF
		95/06/24		02:00	POLYCHROME
19		95/06/13		19:00	EIELSON BLUFF
		95/06/19		17:00	EIELSON BLUFF
		95/06/19	08:20		EIELSON BLUFF
		95/06/23		17:00	POLYCHROME
18		95/06/13		18:00	EIELSON BLUFF
		95/06/14		19:00	EIELSON BLUFF
		95/06/15		21:00	EIELSON BLUFF
		95/06/15	16:00		EIELSON BLUFF
		95/06/16	10:00		EIELSON BLUFF
		95/06/21		18:00	EIELSON BLUFF
		95/06/23		23:00	POLYCHROME
17		95/06/15		22:00	EIELSON BLUFF
		95/06/17		22:00	EIELSON BLUFF
		95/06/18	08:30		EIELSON BLUFF
		95/06/19		20:00	EIELSON BLUFF
		95/06/19		21:00	EIELSON BLUFF
		95/06/23		02:00	POLYCHROME
		95/06/23		03:00	POLYCHROME
		95/06/23		13:00	POLYCHROME
		95/06/24		01:00	POLYCHROME
16		95/06/15		15:00	EIELSON BLUFF
		95/06/17		15:00	EIELSON BLUFF
		95/06/19		18:00	EIELSON BLUFF
		95/06/21		21:00	EIELSON BLUFF
15		95/06/14		21:00	EIELSON BLUFF
		95/06/17		16:00	EIELSON BLUFF
		95/06/17		21:00	EIELSON BLUFF
		95/06/19		14:00	EIELSON BLUFF
		95/06/19		15:00	EIELSON BLUFF
		95/06/20		17:00	EIELSON BLUFF
		95/06/21		19:00	EIELSON BLUFF
		95/06/22		20:00	POLYCHROME
14		95/06/14		20:00	EIELSON BLUFF
		95/06/15		16:00	EIELSON BLUFF

PEAK WIND GUSTS, ALL SITES, DENALI NATIONAL PARK
JUNE 1995

PG	DPG	D	T	HE	S
14		95/06/17		13:00	EIELSON BLUFF
		95/06/17		13:00	EIELSON BLUFF
		95/06/17	11:27		TOKLAT BLUFF
		95/06/18		19:00	EIELSON BLUFF
		95/06/22		21:00	POLYCHROME
		95/06/22		24:00	POLYCHROME
13		95/06/14		04:00	EIELSON BLUFF
		95/06/14		07:00	EIELSON BLUFF
		95/06/15		03:00	EIELSON BLUFF
		95/06/15		17:00	EIELSON BLUFF
		95/06/15		18:00	EIELSON BLUFF
		95/06/16		01:00	EIELSON BLUFF
		95/06/16		02:00	EIELSON BLUFF
		95/06/16		11:00	EIELSON BLUFF
		95/06/17		23:00	EIELSON BLUFF
		95/06/17	08:00		EIELSON BLUFF
		95/06/18		01:00	EIELSON BLUFF
		95/06/18		16:00	EIELSON BLUFF
		95/06/18		20:00	EIELSON BLUFF
		95/06/19		23:00	EIELSON BLUFF
		95/06/20		06:00	EIELSON BLUFF
		95/06/22		18:00	POLYCHROME
		95/06/23		07:00	POLYCHROME
		95/06/23		18:00	POLYCHROME
		95/06/23		21:00	POLYCHROME
		95/06/23		24:00	POLYCHROME
12		95/06/12		17:00	EIELSON BLUFF
		95/06/13		23:00	EIELSON BLUFF
		95/06/14		01:00	EIELSON BLUFF
		95/06/15		14:00	EIELSON BLUFF
		95/06/15		19:00	EIELSON BLUFF
		95/06/15		20:00	EIELSON BLUFF
		95/06/16		09:00	EIELSON BLUFF
		95/06/16		10:00	EIELSON BLUFF
		95/06/16		12:00	EIELSON BLUFF
		95/06/17		17:00	EIELSON BLUFF
		95/06/19		16:00	EIELSON BLUFF
		95/06/22		19:00	POLYCHROME
		95/06/23		19:00	POLYCHROME
11		95/06/15		13:00	EIELSON BLUFF
		95/06/16		13:00	EIELSON BLUFF
		95/06/16		14:00	EIELSON BLUFF
		95/06/17		04:00	EIELSON BLUFF
		95/06/17		12:00	EIELSON BLUFF
		95/06/17		24:00	EIELSON BLUFF
		95/06/18		10:00	EIELSON BLUFF
		95/06/18		11:00	EIELSON BLUFF
		95/06/18		14:00	EIELSON BLUFF
		95/06/19		02:00	EIELSON BLUFF
		95/06/19		05:00	EIELSON BLUFF
		95/06/19		13:00	EIELSON BLUFF
		95/06/19		19:00	EIELSON BLUFF
		95/06/20		07:00	EIELSON BLUFF

PEAK WIND GUSTS, ALL SITES, DENALI NATIONAL PARK
JUNE 1995

PG	DPG	D	T	HE	S
11		95/06/20		12:00	EIELSON BLUFF
		95/06/20		18:00	EIELSON BLUFF
		95/06/20		19:00	EIELSON BLUFF
		95/06/21		05:00	EIELSON BLUFF
		95/06/21		15:00	EIELSON BLUFF
		95/06/22		01:00	EIELSON BLUFF
		95/06/23		04:00	POLYCHROME
		95/06/23		20:00	POLYCHROME
10		95/06/12		18:00	EIELSON BLUFF
		95/06/12		19:00	EIELSON BLUFF
		95/06/15		11:00	EIELSON BLUFF
		95/06/16		04:00	EIELSON BLUFF
		95/06/16		07:00	EIELSON BLUFF
		95/06/16		08:00	EIELSON BLUFF
		95/06/16		15:00	EIELSON BLUFF
		95/06/16		17:00	EIELSON BLUFF
		95/06/17		11:00	EIELSON BLUFF
		95/06/17		18:00	EIELSON BLUFF
		95/06/18		12:00	EIELSON BLUFF
		95/06/18		15:00	EIELSON BLUFF
		95/06/19		03:00	EIELSON BLUFF
		95/06/19		06:00	EIELSON BLUFF
		95/06/19		22:00	EIELSON BLUFF
		95/06/20		01:00	EIELSON BLUFF
		95/06/21		20:00	EIELSON BLUFF
		95/06/21		24:00	EIELSON BLUFF
9		95/06/12		16:00	EIELSON BLUFF
		95/06/12		20:00	EIELSON BLUFF
		95/06/13		07:00	EIELSON BLUFF
		95/06/14		09:00	EIELSON BLUFF
		95/06/14		22:00	EIELSON BLUFF
		95/06/15		10:00	EIELSON BLUFF
		95/06/15		23:00	EIELSON BLUFF
		95/06/15		24:00	EIELSON BLUFF
		95/06/17		05:00	EIELSON BLUFF
		95/06/17		14:00	EIELSON BLUFF
		95/06/17		19:00	EIELSON BLUFF
		95/06/18		13:00	EIELSON BLUFF
		95/06/18		17:00	EIELSON BLUFF
		95/06/18		22:00	EIELSON BLUFF
		95/06/19		01:00	EIELSON BLUFF
		95/06/19		12:00	EIELSON BLUFF
		95/06/19		24:00	EIELSON BLUFF
		95/06/21		06:00	EIELSON BLUFF
		95/06/21		17:00	EIELSON BLUFF
		95/06/23		01:00	POLYCHROME
8		95/06/13		05:00	EIELSON BLUFF
		95/06/13		06:00	EIELSON BLUFF
		95/06/14		08:00	EIELSON BLUFF
		95/06/15		09:00	EIELSON BLUFF
		95/06/15		12:00	EIELSON BLUFF
		95/06/17		03:00	EIELSON BLUFF
		95/06/17		10:00	EIELSON BLUFF

PEAK WIND GUSTS, ALL SITES, DENALI NATIONAL PARK
JUNE 1995

PG	DPG	D	T	HE	S
8		95/06/17		20:00	EIELSON BLUFF
		95/06/18		02:00	EIELSON BLUFF
		95/06/18		23:00	EIELSON BLUFF
		95/06/19		04:00	EIELSON BLUFF
		95/06/19		11:00	EIELSON BLUFF
		95/06/20		04:00	EIELSON BLUFF
		95/06/20		11:00	EIELSON BLUFF
		95/06/20		13:00	EIELSON BLUFF
		95/06/21		16:00	EIELSON BLUFF
		95/06/21		22:00	EIELSON BLUFF
		95/06/21		23:00	EIELSON BLUFF
7		95/06/12		21:00	EIELSON BLUFF
		95/06/12		24:00	EIELSON BLUFF
		95/06/13		01:00	EIELSON BLUFF
		95/06/13		02:00	EIELSON BLUFF
		95/06/13		03:00	EIELSON BLUFF
		95/06/14		10:00	EIELSON BLUFF
		95/06/14		24:00	EIELSON BLUFF
		95/06/15		04:00	EIELSON BLUFF
		95/06/16		05:00	EIELSON BLUFF
		95/06/16		18:00	EIELSON BLUFF
		95/06/16		20:00	EIELSON BLUFF
		95/06/16		22:00	EIELSON BLUFF
		95/06/16		23:00	EIELSON BLUFF
		95/06/18		03:00	EIELSON BLUFF
		95/06/18		04:00	EIELSON BLUFF
		95/06/18		06:00	EIELSON BLUFF
		95/06/18		18:00	EIELSON BLUFF
		95/06/19		07:00	EIELSON BLUFF
		95/06/19		10:00	EIELSON BLUFF
		95/06/20		02:00	EIELSON BLUFF
		95/06/20		03:00	EIELSON BLUFF
		95/06/20		05:00	EIELSON BLUFF
		95/06/20		08:00	EIELSON BLUFF
		95/06/20		14:00	EIELSON BLUFF
		95/06/20		15:00	EIELSON BLUFF
		95/06/20		23:00	EIELSON BLUFF
		95/06/21		01:00	EIELSON BLUFF
		95/06/21		07:00	EIELSON BLUFF
		95/06/21		08:00	EIELSON BLUFF
		95/06/21		12:00	EIELSON BLUFF
		95/06/21		14:00	EIELSON BLUFF
		95/06/22		08:00	EIELSON BLUFF
6		95/06/13		08:00	EIELSON BLUFF
		95/06/13		24:00	EIELSON BLUFF
		95/06/15		05:00	EIELSON BLUFF
		95/06/16		21:00	EIELSON BLUFF
		95/06/17		09:00	EIELSON BLUFF
		95/06/18		05:00	EIELSON BLUFF
		95/06/18		24:00	EIELSON BLUFF
		95/06/20		22:00	EIELSON BLUFF
		95/06/21		02:00	EIELSON BLUFF
		95/06/21		03:00	EIELSON BLUFF

PEAK WIND GUSTS, ALL SITES, DENALI NATIONAL PARK
JUNE 1995

PG	DPG	D	T	HE	S
6		95/06/21		11:00	EIELSON BLUFF
		95/06/21		13:00	EIELSON BLUFF
5		95/06/12		22:00	EIELSON BLUFF
		95/06/13		09:00	EIELSON BLUFF
		95/06/15		01:00	EIELSON BLUFF
		95/06/15		02:00	EIELSON BLUFF
		95/06/15		08:00	EIELSON BLUFF
		95/06/16		06:00	EIELSON BLUFF
		95/06/16		16:00	EIELSON BLUFF
		95/06/17		06:00	EIELSON BLUFF
		95/06/18		09:00	EIELSON BLUFF
		95/06/19		08:00	EIELSON BLUFF
		95/06/20		09:00	EIELSON BLUFF
		95/06/20		10:00	EIELSON BLUFF
		95/06/22		22:00	POLYCHROME
		95/06/23		22:00	POLYCHROME
4		95/06/18		07:00	EIELSON BLUFF
		95/06/20		24:00	EIELSON BLUFF
		95/06/21		09:00	EIELSON BLUFF
		95/06/22		03:00	EIELSON BLUFF
3		95/06/12		23:00	EIELSON BLUFF
		95/06/13		04:00	EIELSON BLUFF
		95/06/14		23:00	EIELSON BLUFF
		95/06/16		03:00	EIELSON BLUFF
		95/06/16		19:00	EIELSON BLUFF
		95/06/17		01:00	EIELSON BLUFF
		95/06/17		08:00	EIELSON BLUFF
		95/06/21		04:00	EIELSON BLUFF
		95/06/22		05:00	EIELSON BLUFF
		95/06/22		06:00	EIELSON BLUFF
2		95/06/15		06:00	EIELSON BLUFF
		95/06/16		24:00	EIELSON BLUFF
		95/06/17		02:00	EIELSON BLUFF
		95/06/19		09:00	EIELSON BLUFF
		95/06/21		10:00	EIELSON BLUFF
1		95/06/13		10:00	EIELSON BLUFF
		95/06/13		11:00	EIELSON BLUFF
		95/06/13		12:00	EIELSON BLUFF
		95/06/13		13:00	EIELSON BLUFF
		95/06/13		14:00	EIELSON BLUFF
		95/06/17		07:00	EIELSON BLUFF
		95/06/18		08:00	EIELSON BLUFF
		95/06/22		02:00	EIELSON BLUFF
0		95/06/15		07:00	EIELSON BLUFF
		95/06/22		04:00	EIELSON BLUFF
		95/06/22		07:00	EIELSON BLUFF
		95/06/23		05:00	POLYCHROME
		95/06/23		06:00	POLYCHROME

PEAK WIND GUSTS, ALL SITES, DENALI NATIONAL PARK
JUNE 1995

	PG	DPG	D	T	HE	S
Count:	48	0				
Minimum:	0					
Maximum:	59					
Total:	1,248					
Average:	26					

STATE OF SKY OBSERVATIONS, DENALI NATIONAL PARK
JUNE 1995

D	S	T	SOK
95/06/14	EIELSON BLUFF	18:00	PC
	POLYCHROME	14:00	MOV
	TOKLAT BLUFF	15:50	MOV
95/06/15	EIELSON BLUFF	16:00	PC
	POLYCHROME	11:06	MOV
	TOKLAT BLUFF	12:21	PC
95/06/16	EIELSON BLUFF	10:00	RW
	POLYCHROME	12:45	RW-
	TOKLAT BLUFF	13:35	RW-
95/06/17	EIELSON BLUFF	08:00	MOV
	POLYCHROME	10:06	PC
	TOKLAT BLUFF	11:27	PC
95/06/18	EIELSON BLUFF	08:30	PC
	POLYCHROME	14:35	RW-
	TOKLAT BLUFF	15:28	PC
95/06/19	EIELSON BLUFF	08:20	CLR
	POLYCHROME	13:00	PC
	TOKLAT BLUFF	11:42	PC
95/06/20	POLYCHROME	10:16	OV-
	TOKLAT BLUFF	09:02	PC
95/06/21	POLYCHROME	08:11	MOV
	TOKLAT BLUFF	09:28	PC
95/06/22	POLYCHROME	11:52	PC
	TOKLAT BLUFF	19:05	SW-
95/06/23	EIELSON BLUFF	10:25	RW
	POLYCHROME	08:00	RW
	TOKLAT BLUFF	08:00	SW-
95/06/24	EIELSON BLUFF	07:50	OV+
	TOKLAT BLUFF		OV

TABLE 2

TOKLAT TEMPERATURE DATA FOR JUNE 1995 WIND STUDY
DENALI NATIONAL PARK

D	HE	TMEAN	RH
95/06/17			
	01:00	43	84
	02:00	43	84
	03:00	42	84
	04:00	42	84
	05:00	42	84
	06:00	41	84
	07:00	42	86
	08:00	44	78
	09:00	46	68
	10:00	48	60
	11:00	49	56
	12:00	52	53
	13:00	52	54
	14:00	52	53
	15:00	53	53
	16:00	54	53
	17:00	53	54
	18:00	53	54
	19:00	53	54
	20:00	52	56
	21:00	52	59
	22:00	51	65
	23:00	49	64
	24:00	47	68
95/06/18			
	01:00	47	73
	02:00	41	47
	03:00	38	82
	04:00	38	84
	05:00	40	82
	06:00	42	81
	07:00	45	75
	08:00	48	72
	09:00	53	61
	10:00	53	59
	11:00	55	56
	12:00	53	70
	13:00	52	72
	14:00	56	64
	15:00	55	69
	16:00	56	64
	17:00	55	66
	18:00	56	64
	19:00	55	64
	20:00	57	66
	21:00	52	72
	22:00	50	73
	23:00	46	77
	24:00	45	79
95/06/19			
	01:00	43	83
	02:00	42	84

TOKLAT TEMPERATURE DATA FOR JUNE 1995 WIND STUDY
DENALI NATIONAL PARK

D	HE	TMEAN	RH
95/06/19	03:00	42	83
	04:00	40	84
	05:00	39	84
	06:00	41	83
	07:00	45	78
	08:00	50	68
	09:00	54	60
	10:00	59	49
	11:00	63	43
	12:00	64	45
	13:00	65	43
	14:00	65	42
	15:00	67	40
	16:00	67	40
	17:00	67	39
	18:00	67	39
	19:00	65	39
	20:00	68	38
	21:00	61	45
	22:00	66	59
	23:00	52	63
	24:00	48	65
95/06/20			
	01:00	49	67
	02:00	49	65
	03:00	48	69
	04:00	45	70
	05:00	45	70
	06:00	47	69
	07:00	50	68
	08:00	53	61
	09:00	62	55
	10:00	62	61
	11:00	65	47
	12:00	64	47
	13:00	63	50
	14:00	61	50
	15:00	63	51
	16:00	59	55
	17:00	64	51
	18:00	65	65
	19:00	59	63
	20:00	63	52
	21:00	58	63
	22:00	56	65
	23:00	55	70
	24:00	51	77
95/06/21			
	01:00	49	78
	02:00	47	79
	03:00	44	81
	04:00	45	83
	05:00	47	82

TOKLAT TEMPERATURE DATA FOR JUNE 1995 WIND STUDY
DENALI NATIONAL PARK

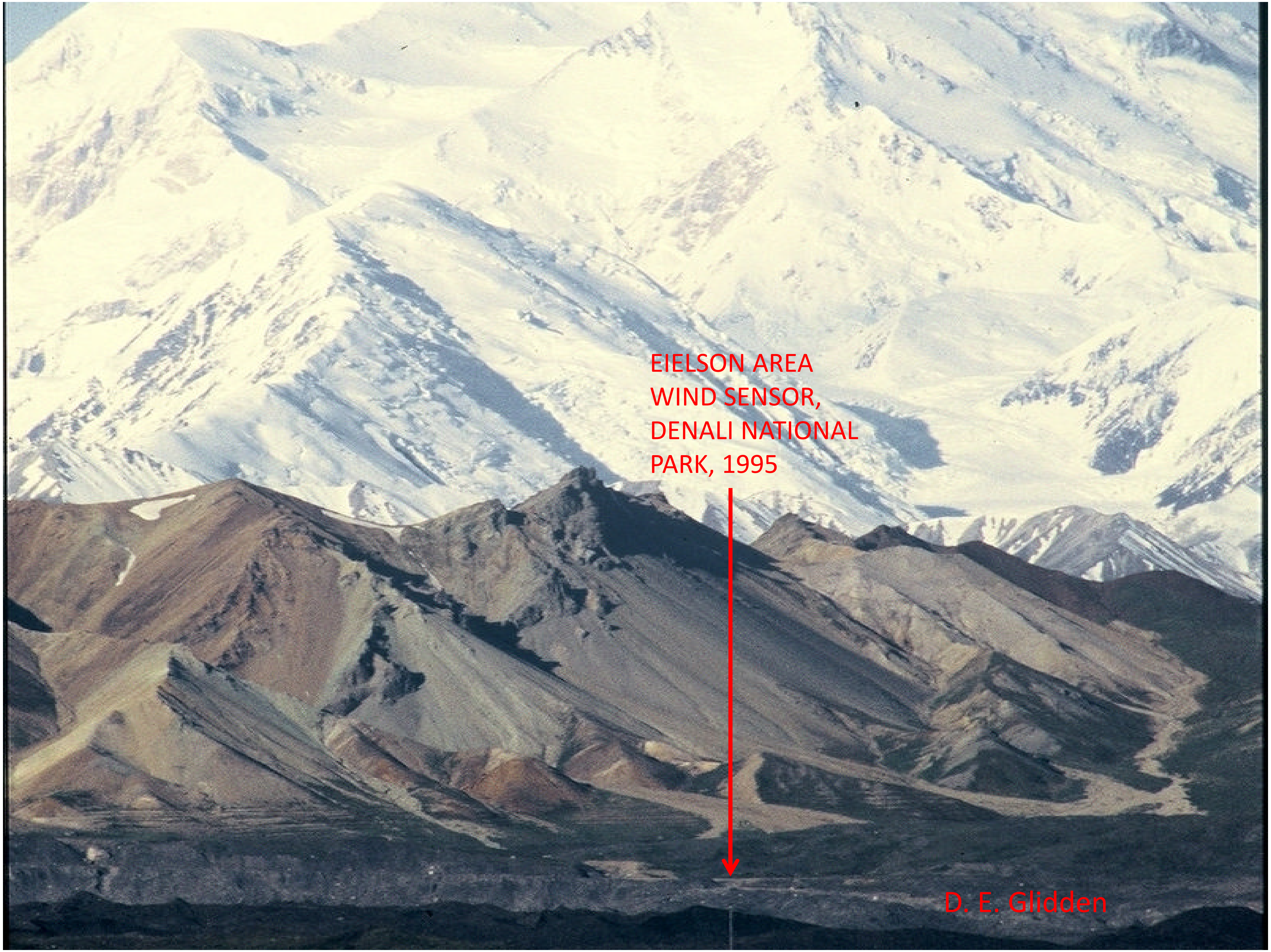
D	HE	TMEAN	RH
95/06/21	06:00	47	81
	07:00	49	79
	08:00	50	77
	09:00	51	73
	10:00	55	67
	11:00	55	64
	12:00	56	64
	13:00	57	63
	14:00	57	67
	15:00	50	77
	16:00	50	77
	17:00	56	64
	18:00	55	65
	19:00	55	71
	20:00	54	72
	21:00	55	72
	22:00	52	75
	23:00	51	75
	24:00	50	76
95/06/22			
	01:00	47	78
	02:00	43	82
	03:00	42	83
	04:00	42	83
	05:00	42	83
	06:00	43	81
	07:00	46	73
	08:00	50	71
	09:00	53	66
	10:00	56	61
	11:00	58	57
	12:00	60	55
	13:00	57	63
	14:00	59	59
	15:00	59	59
	16:00	59	60
	17:00	59	61
	18:00	57	62
	19:00	57	63
	20:00	57	63
	21:00	57	66
	22:00	53	76
	23:00	51	77

TOKLAT TEMPERATURE DATA FOR JUNE 1995 WIND STUDY
DENALI NATIONAL PARK

D	HE	TMEAN	RH
95/06/22	24:00		
		50	78
95/06/23			
	01:00		
		49	85
	02:00		
		49	83
	03:00		
		49	84
	04:00		
		49	82
	05:00		
		49	83
	06:00		
		48	84
	07:00		
		47	84
	08:00		
		47	85
	09:00		
		47	84
	10:00		
		47	81
	11:00		
		46	78
	12:00		
		46	74
	13:00		
		47	75
	14:00		
		47	77
	15:00		
		45	78
	16:00		
		46	78
	17:00		
		43	78
	18:00		
		43	77
	19:00		
		42	79
	20:00		
		41	79
	21:00		
		40	81
	22:00		
		41	82
	23:00		
		41	83
	24:00		
		41	83
95/06/24			
	01:00		

TOKLAT TEMPERATURE DATA FOR JUNE 1995 WIND STUDY
DENALI NATIONAL PARK

D	HE	TMEAN	RH
95/06/24	01:00	42	83
	02:00		
		43	82
	03:00		
		44	77
	04:00		
		43	76
	05:00		
		43	73
	06:00		
		43	72
	07:00		
		44	72
	08:00		
		44	82
	09:00		
		43	72
	10:00		
		45	67
	11:00		
		46	65
	12:00		
		48	73
	13:00		
		45	72
	14:00		
		45	75
	15:00		
	16:00		
	17:00		
	Count:	182	182
	Minimum:	38	38
	Maximum:	68	86
	Total:	9,241	12,521
	Average:	51	69


EIELSON AREA
WIND SENSOR,
DENALI NATIONAL
PARK, 1995
D. E. Glidden