U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL WEATHER SERVICE
NATIONAL METEOROLOGICAL CENTER

OFFICE NOTE 227

Skill of Medium Range Forecast Group

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This is an unreviewed manuscript, primarily intended for informal exchange of information among NMC staff members.

Purpose

This paper depicts in a graphical manner the skill of the Medium Range (3-10 day) Forecast Group (MRFG) man and machine (numerical model guidance) forecasts. It will be updated each February in order to present the latest calendar year versus long term mean score in each forecast category. Only scores with at least a 5 year period of record will be presented. Hence, this paper contains only the standardized and unstandardized mean sea level pressure correlation, the Gilman precipitation skill, the Hughes precipitation skill and the minimum/maximum absolute error temperature scores for days 3, 4, and 5. Subsequent updates to this note also will include the experimental precipitation scores for days 3, 4, and 5, the mean temperature and precipitation skill scores for the 6 to 10 day forecast, and the mean 500mb correlation score for the 6 to 10 day forecast.

Numerical Model Guidance (Past to Present)

1. Acronyms

   a. Baro - Reed Barotropic Advection Model

   b. 6L PE - 6-Layer Primitive Equation Model

   c. CM - Course Mesh 380km

   d. FM - Fine Mesh 190km

   e. SMH2C - Spectral Model Hemispheric
      24 modes 12-layers

   f. SMG3C - Spectral Model Global 30 modes 12-layers

   g. SMG26 - Spectral Model Global 24 modes 6-layers

2. 00Z Guidance

   a. To 84-hours

      (1) From 1970 through 1977: 6L PE CM

      (2) From 1978 through 1979: 7L PE FM

      (3) From January 1980 to August 15, 1980: 7L PE FM to 60-hours then 7L PE CM with Fourth Order Differencing to 84-hours.

      (4) From August 15, 1980, through December 31, 1980: SMG3C to 48-hours then SMH2C to 84-hours.

      (5) From April 15, 1981, through December 31, 1981: SMG3C to 48-hours then SMG2C to 84-hours.

   b. Greater than 84-hours to 144-hours

      (1) From 1970 through 1979: Baro (Mesh 1977-1979)

      (2) From January 1980 to August 15, 1980: 7L PE CM with Fourth Order Differencing.

      (3) From August 15, 1980, to April 15, 1981: SMH2C

      (4) From April 15, 1981, through December 31, 1981: SMG26

3. 12Z Guidance

a. To 60-hours

(1) From 1970 through 1977: 6L PE CM

b. Greater than 60-hours to 96-hours (500mb only):

(1) From 1970 through 1977: Baro (Mesh in 1977)

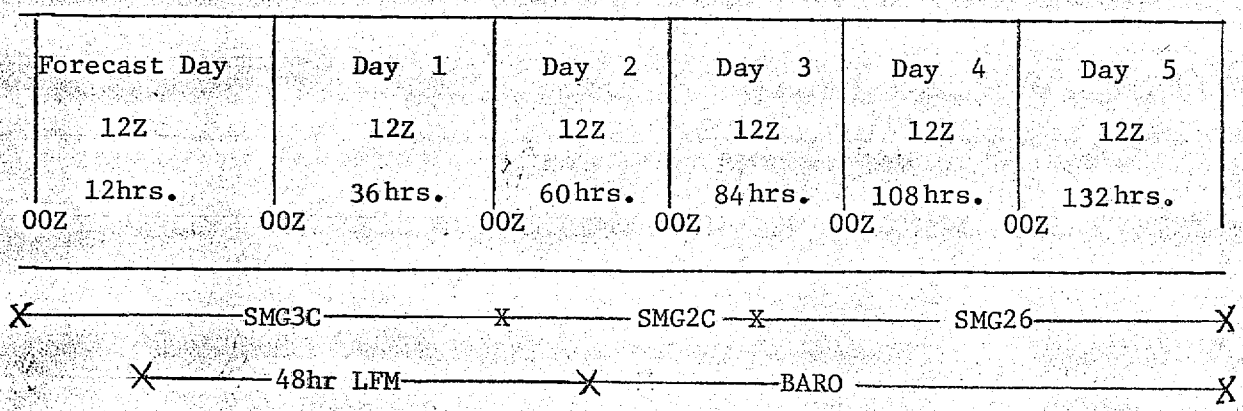
c. To 48 hours

(1) From October 1971 through August 1977: 7L PE FM (old LFM)

(2) From September 1977 through 1981: 7L PE LFM (127km)

d. Greater than 48-hours to 120-hours (500mb only)

(1) From 1978 through 1981: Baro run from the 48-hour LFM inserted into the 60-hour SMG2C from 00Z.



Figures

Figure 1 depicts the North American (130 grid points) and the United States (86 grid points) mean sea level pressure correlation verification areas.

Figures 2 through 4 are plots of the North American calendar year 1981 and 14 year average (1968 through 1981) monthly mean standardized mean sea level pressure correlation scores for the man forecasts verifying on days 3, 4, and 5 after forecast day. (See Appendix A for an explanation of this score).

Figures 5 through 7 are similar to Figures 2 through 4 except that the forecasts are machine made and are for a 12 year average (1970 through 1981).

Figures 8 through 10 are similar to Figures 2 through 4 except the average is for the 6 years (1976 through 1981) and the area is the United States.

Figures 11 through 13 are similar to Figures 8 through 10 except that the forecasts are machine made.

Figures 14 through 16 are plots of the North American calendar year 1981 and 5 year (1977 through 1981) monthly mean unstandardized mean sea level pressure correlation scores for the man forecasts verifying on days 3, 4, and 5 after forecast day. (See Appendix A for an explanation of this score.)

Figures 17 through 19 are similar to Figures 14 through 16 except that the forecasts are machine made.

Figures 20 through 22 are similar to Figures 14 through 16 except that the area is the United States.

Figures 23 through 25 are similar to Figures 20 through 22 except that the forecasts are machine made.

Figures 26 through 29 are plots of the man and machine North American seasonal mean sea level pressure correlation scores ((standardized + unstandardized) ÷2) for the man and machine for the years 1977 through 1981.

Figure 30 is a plot of the machine ((North American + United States) ÷2) 500mb standardized correlation scores for the years 1979 through 1981.

Figure 31 is a plot of the United States December 1981 mean sea level correlation score for the machine for days 1 through 7.

Figure 32 is similar to Figure 31 except that the level is 500mb.

Figures 33, 43, 53, and 63 are average SMG mean sea level pressure errors for January, April, July, and October respectively.

Figures 34, 44, 54, and 64 are average SMG mean sea level pressure positive errors for January, April, July, and October respectively.

Figures 35, 45, 55, and 65 are the total number of times an SMG positive error occurred during January, April, July and October respectively.

Figures 36, 46, 56, and 66 are average SMG mean sea level pressure negative errors for January, April, July, and October respectively.

Figures 37, 47, 57, and 67 are the total number of times an SMG negative error occurred during January, April, July, and October respectively.

Figures 38, 48, 58, and 68 are similar to Figures 32, 42, 52, and 62 except that the level is 500mb.

Figures 39, 49, 59, and 69 are similar to Figures 33, 43, 53, and 63 except that the level is 500mb.

Figures 40, 50, 60, and 70 are similar to Figures 34, 44, 54, and 64 except that the level is 500mb.

Figures 41, 51, 61, and 71 are similar to Figures 35, 45, 55, and 65 except that the level is 500mb.

Figures 42, 52, 62, and 72 are similar to Figures 36, 46, 56, and 66 except that the level is 500mb.

Figures 73 depicts the 100 stations in the United States where the precipitation forecasts are verified.

Figure 74 is an example of a day 3, 4, or 5 precipitation forecast. The dashed lines are the 24-hour departure from normal probability of precipitation (DN POP) forecast for January 3. The solid lines are the 24-hour climatological (normal) probability of precipitation (NPOP) for the first 15 days of January. A total of (DN POP + NPOP)$\geq$30 is considered a yes forecast of precipitation ($\geq$.01 inch). All stations with an (NPOP)$\geq$30 are considered as a yes climatological forecast of precipitation.

Figures 75 through 77 are plots of the calendar year 1981 and 12-year average monthly mean Gilman precipitation skill scores for the man forecasts verifying on days 3, 4, and 5 after forecast day. See Appendix B for an explanation of this score.

Figures 78 through 80 are plots of the calendar year 1981 and 5-year average monthly mean Hughes precipitation skill scores for the man forecasts verifying oin days 3, 4, and 5 after forecast day. See Appendix C for an explanation of this score.

Figure 81 depicts the 41 stations used to verify the days 3, 4, and 5 minimum/maximum departures from normal temperature forecasts.

Figures 82 through 87 are plots of the calendar year 1980, 10-year average (1972 through 1981) and normal (climat) monthly mean minimum/maximum departure from normal temperature absolute error for the man forecasts verifying on days 3, 4, and 5 after forecast day.

Figures 88 through 93 are similar to Figures 82 through 87 except that the forecasts are machine (Klein-Lewis (KL) regression) made.

Figure 94 is a plot of the average combined days 3, 4, and 5 minimum/maximum departure from normal temperature absolute errors for the man, machine (KL) and climat for the years 1972 through 1981.

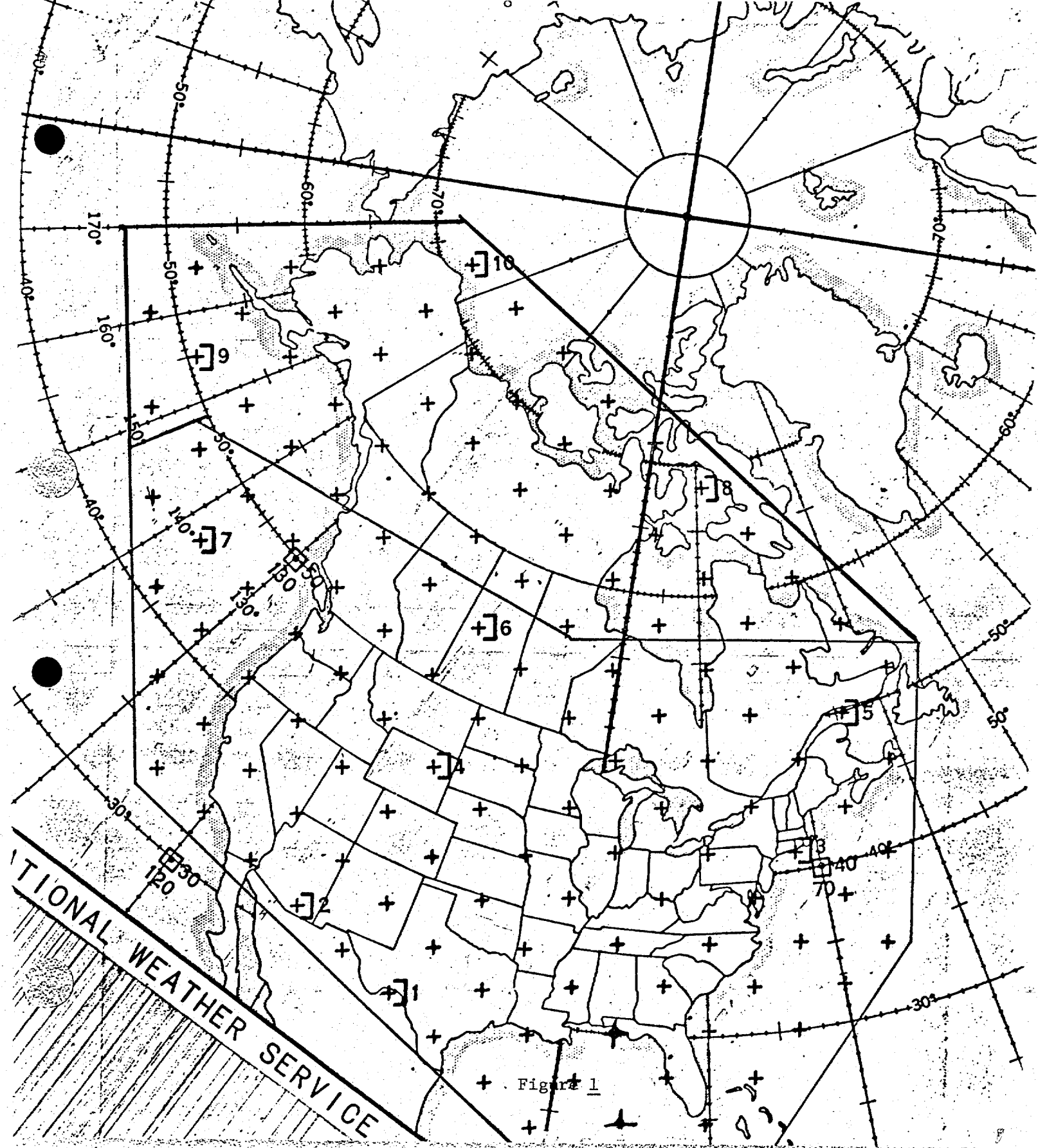

TIONAL WEATHER SERVICE
170°
160°
150°
140°
130°
120°
80°
70°
60°
50°
40°
30°
1
2
3
4
5
6
7
8
9
10
30
120
50
130
40
70

Figure 1

DAY 3 MAN NA MSLP STANDARDIZED CORRELATION SCORES

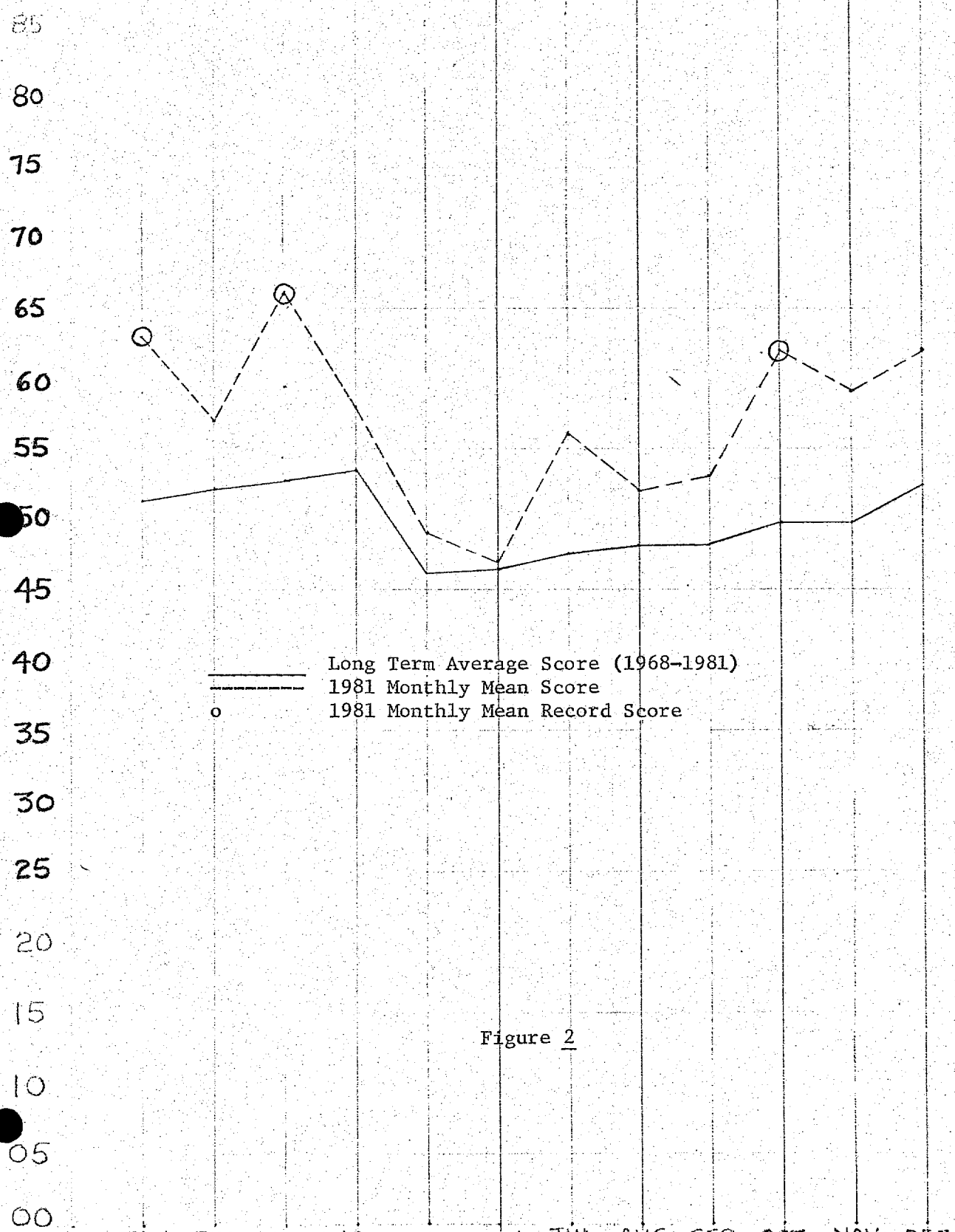


Figure 2

DAY 4 MAN NA MSLP STANDARDIZED CORRELATION SCORES

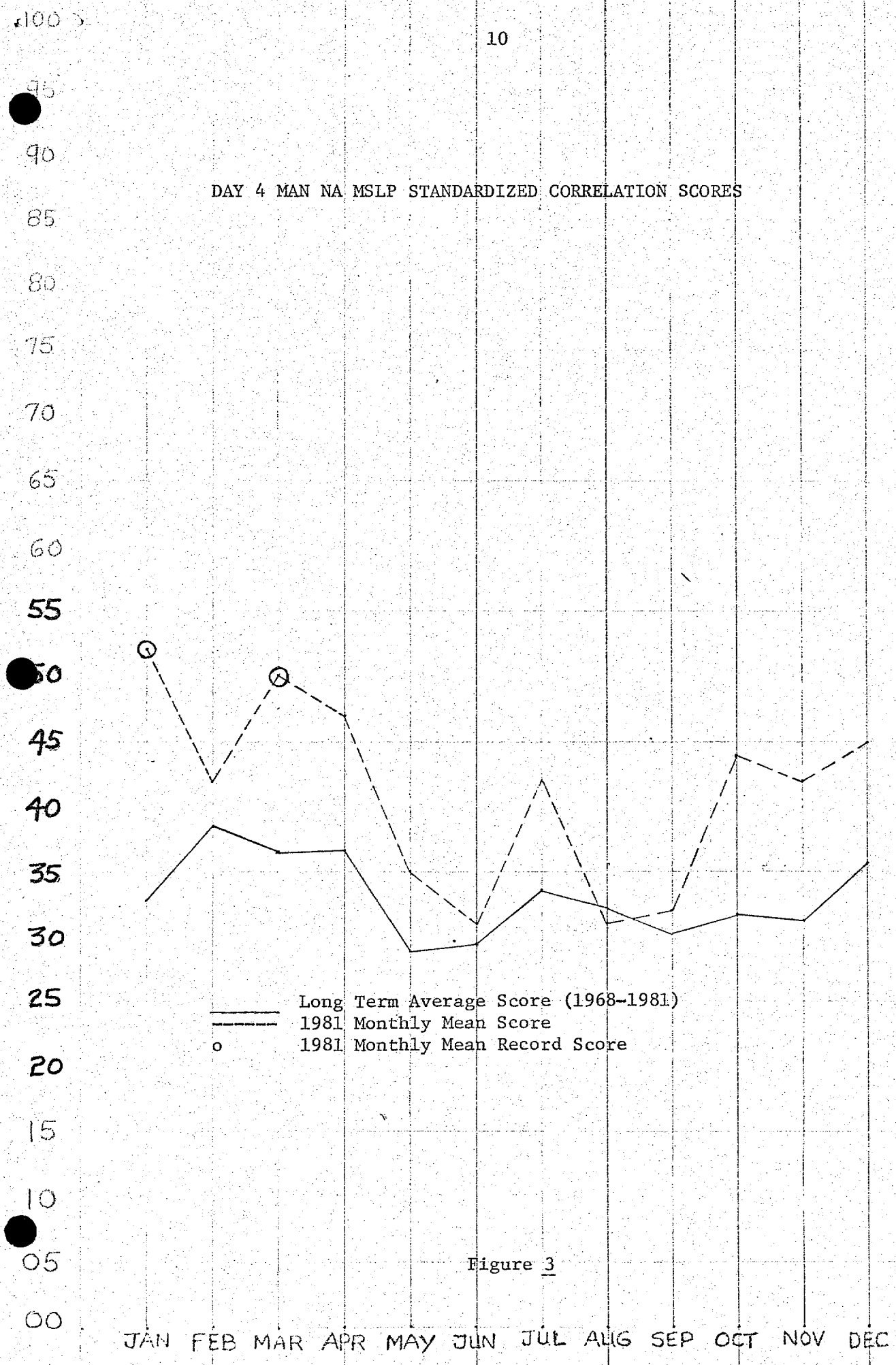


Figure 3

DAY 5 MAN NA MSLP STANDARDIZED CORRELATION SCORES

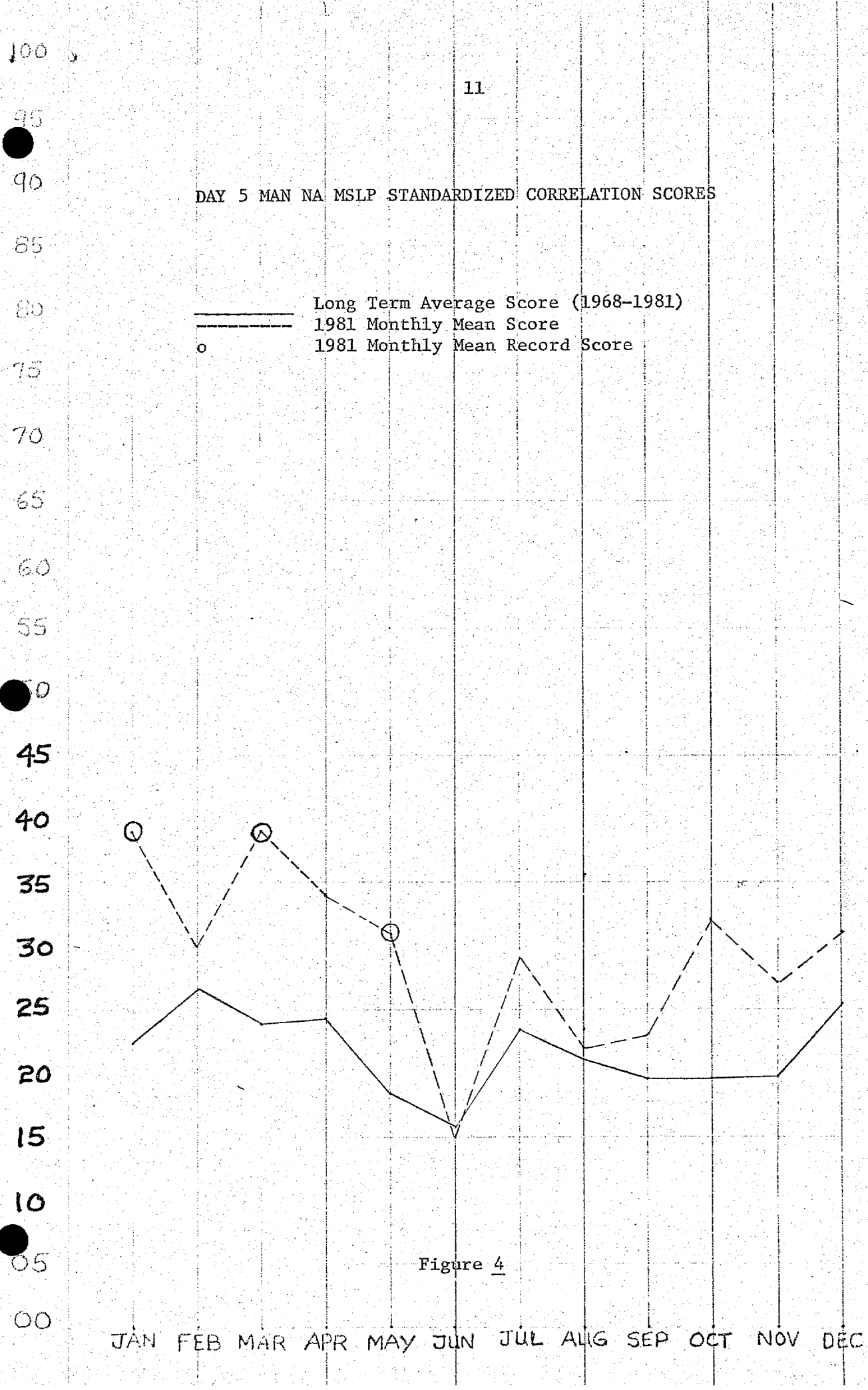


Figure 4

DAY 3 SMG2C NA MSLP STANDARDIZED CORRELATION SCORES

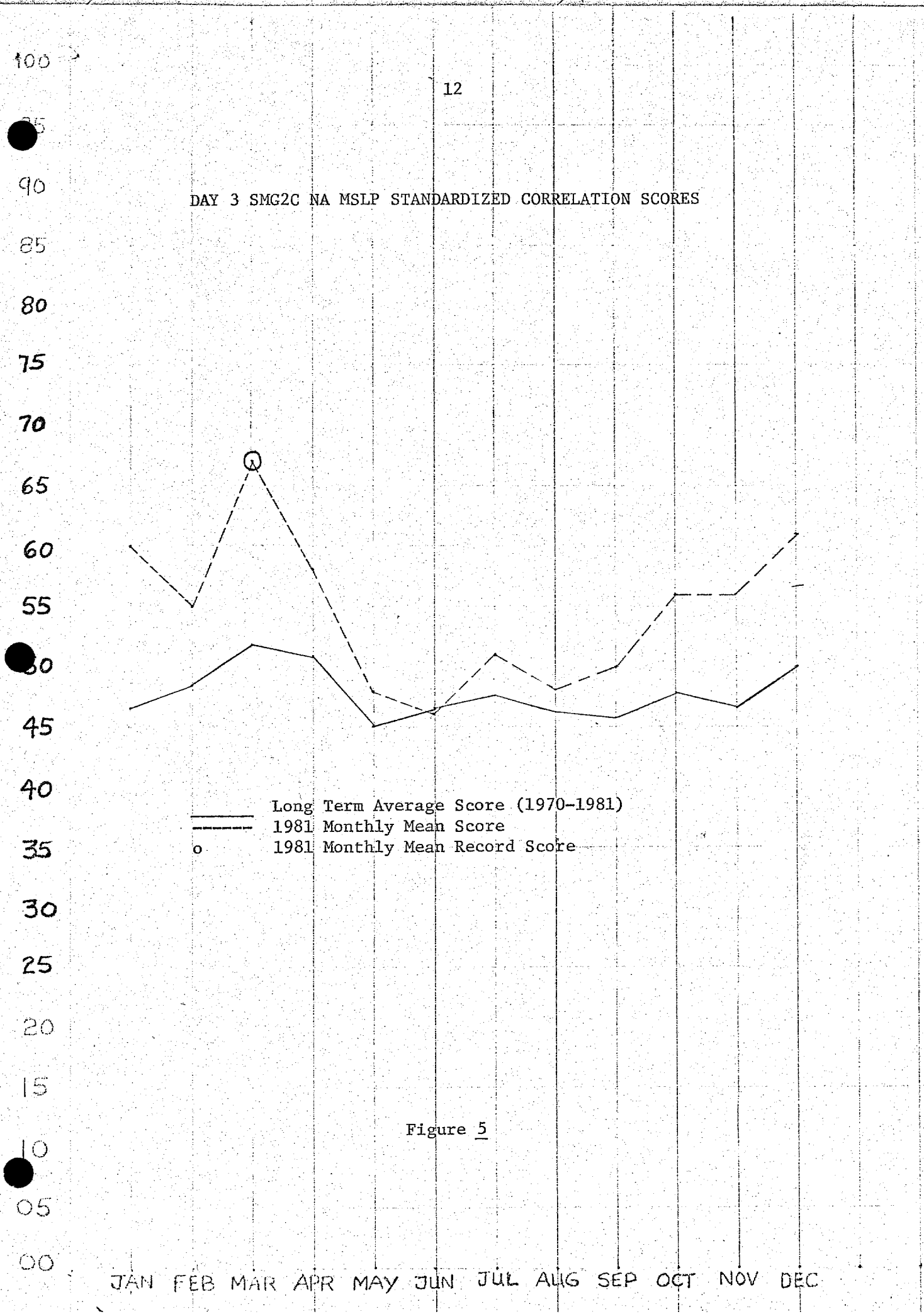


Figure 5

DAY 4 SMG26 NA MSLP STANDARDIZED CORRELATION SCORES

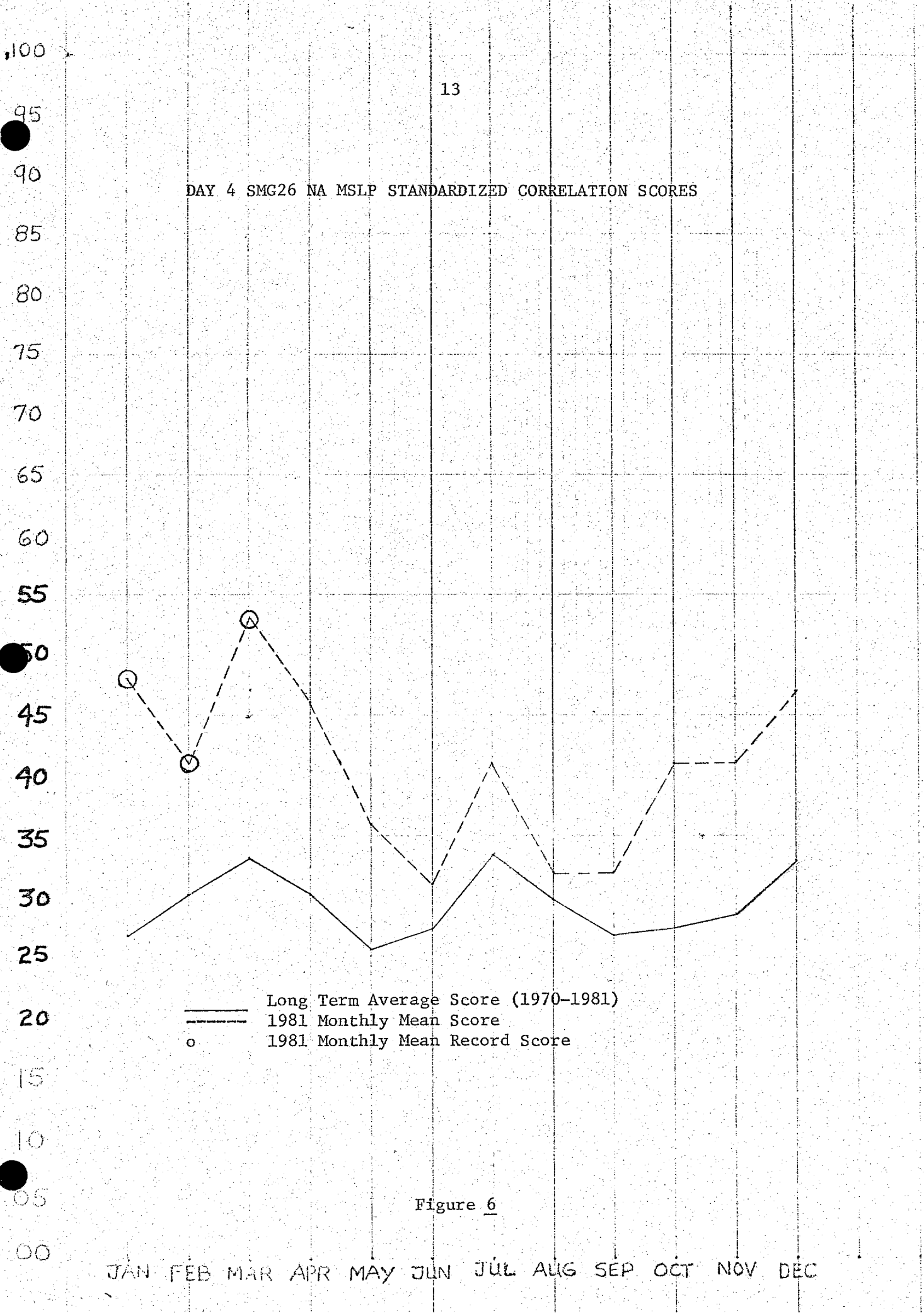


Figure 6

DAY 5 SMG26 NA MSLP STANDARDIZED CORRELATION SCORES

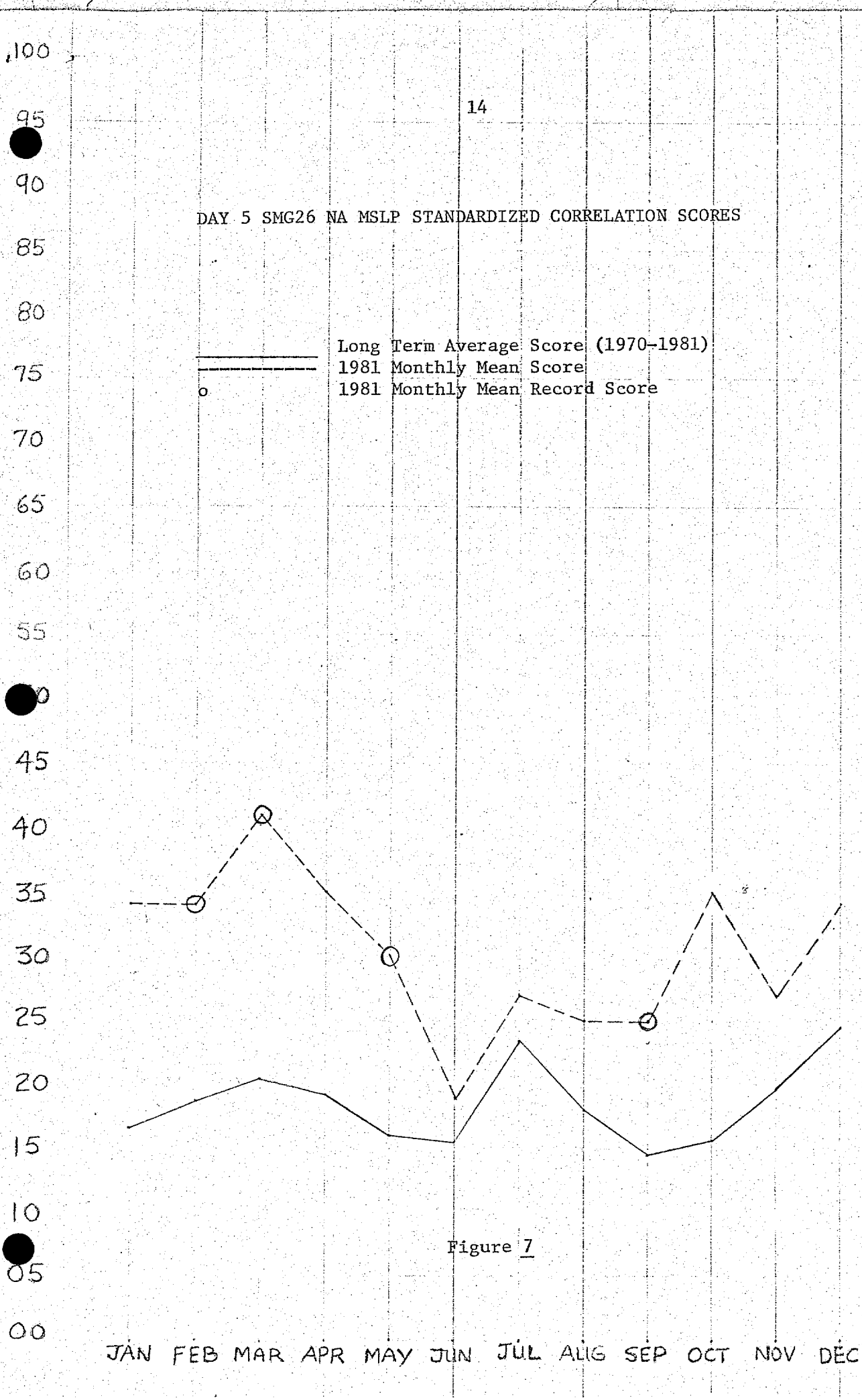
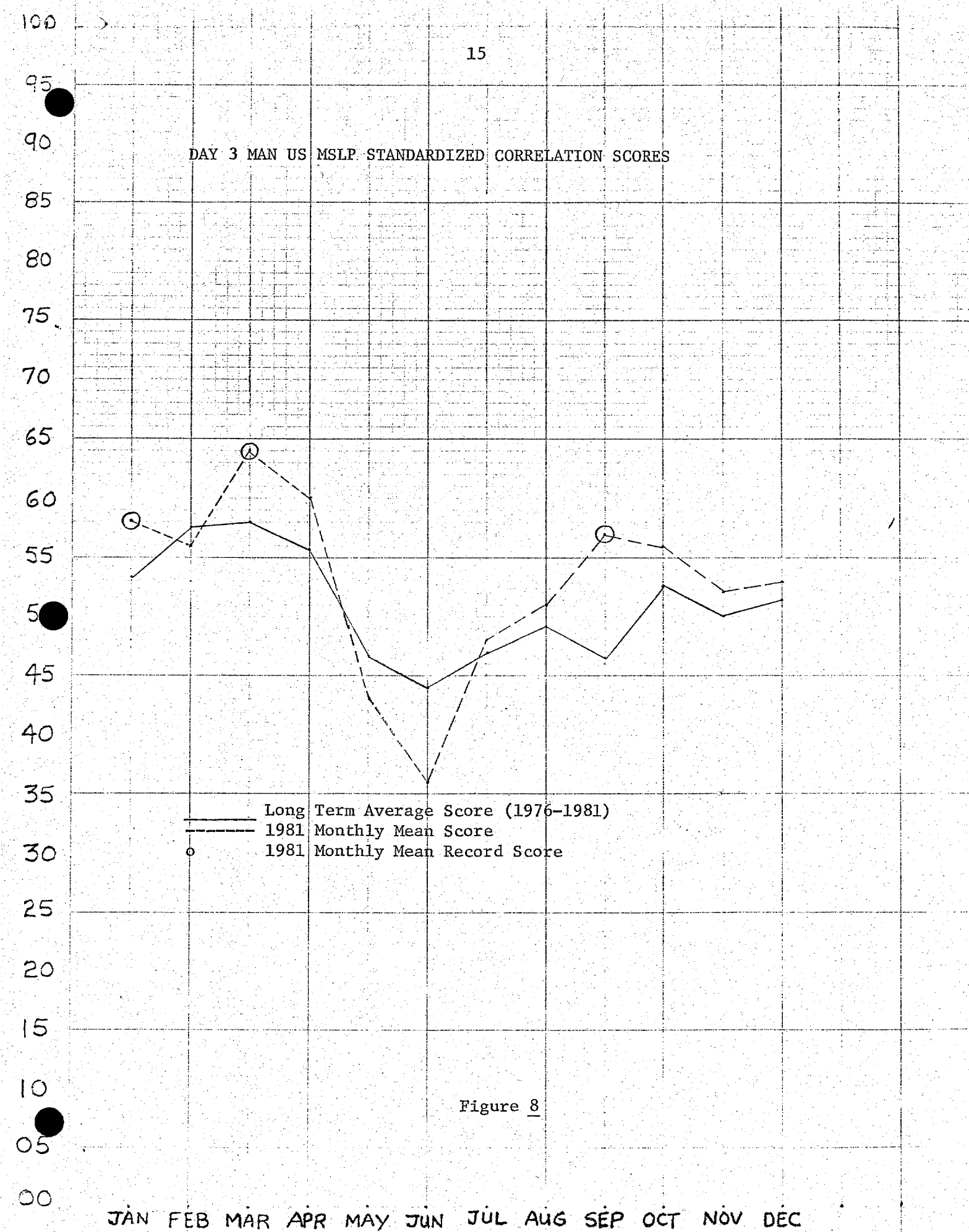


Figure 7


DAY 3 MAN US MSLP STANDARDIZED CORRELATION SCORES
100
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05
00
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
Long Term Average Score (1976-1981)
1981 Monthly Mean Score
1981 Monthly Mean Record Score

Figure 8

DAY 4 MAN US MSLP STANDARDIZED CORRELATION SCORES

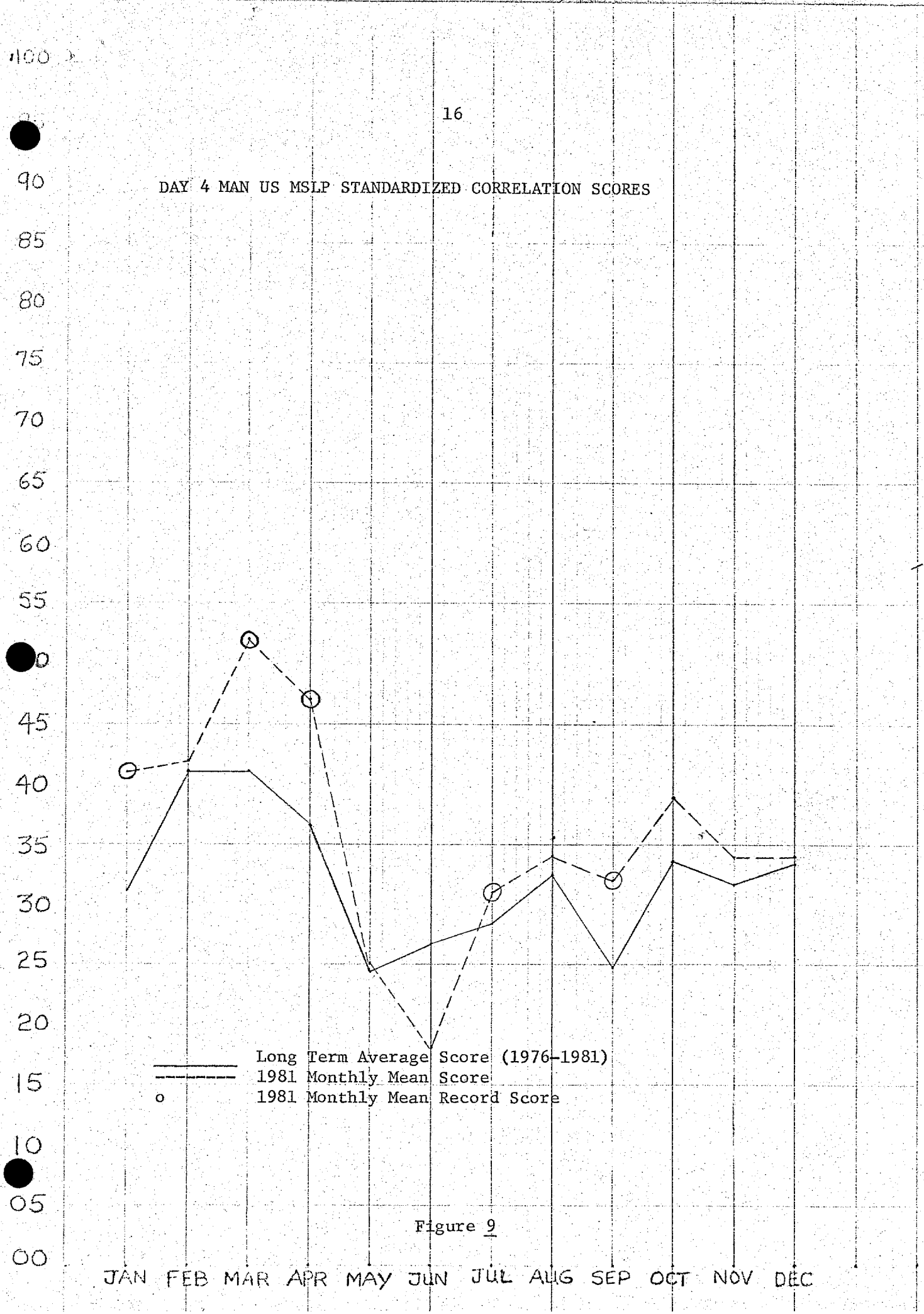


Figure 9

DAY 5 MAN US MSLP STANDARDIZED CORRELATION SCORES

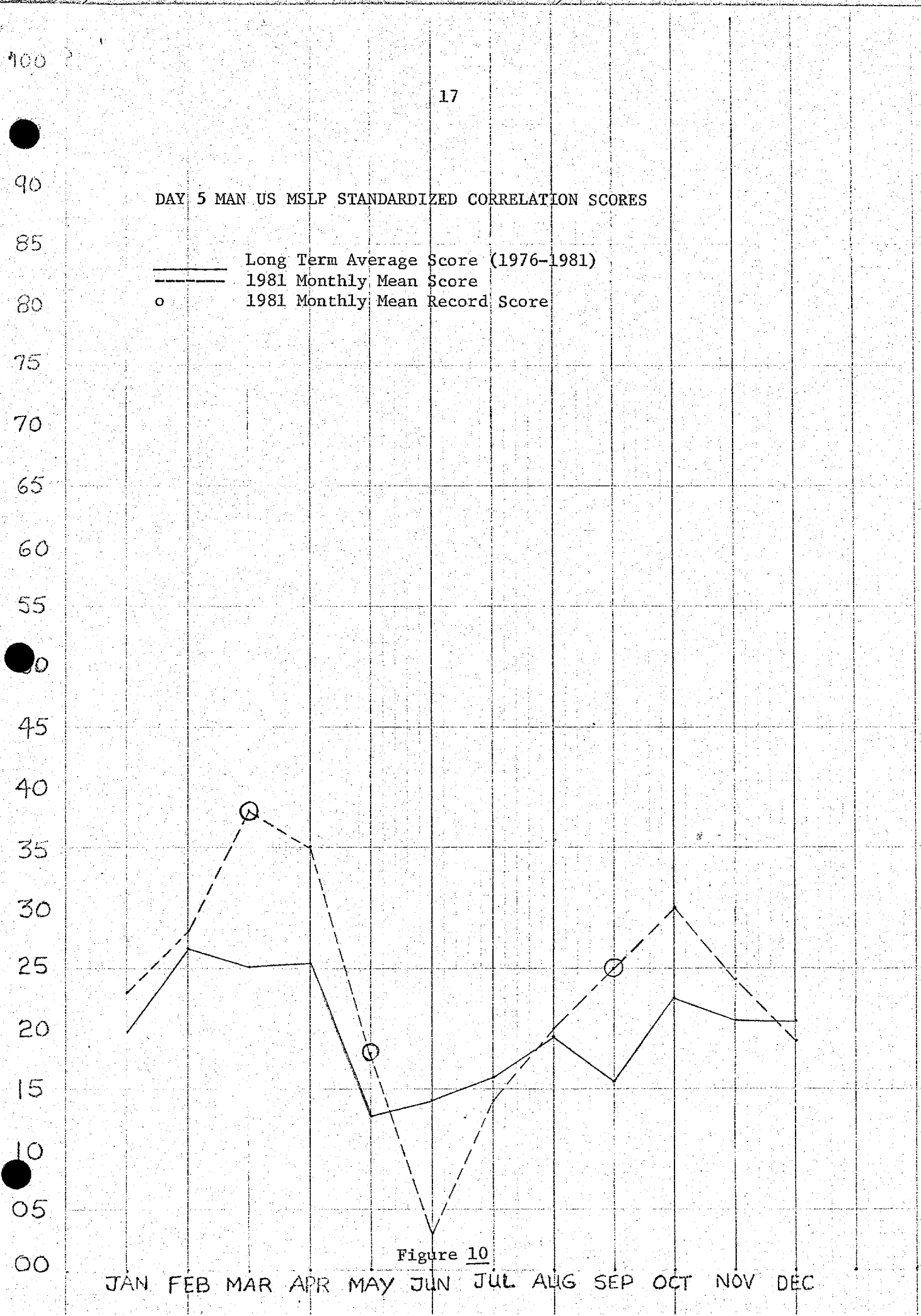


Figure 10

DAY 3 SMG2C US MSLP STANDARDIZED CORRELATION SCORES

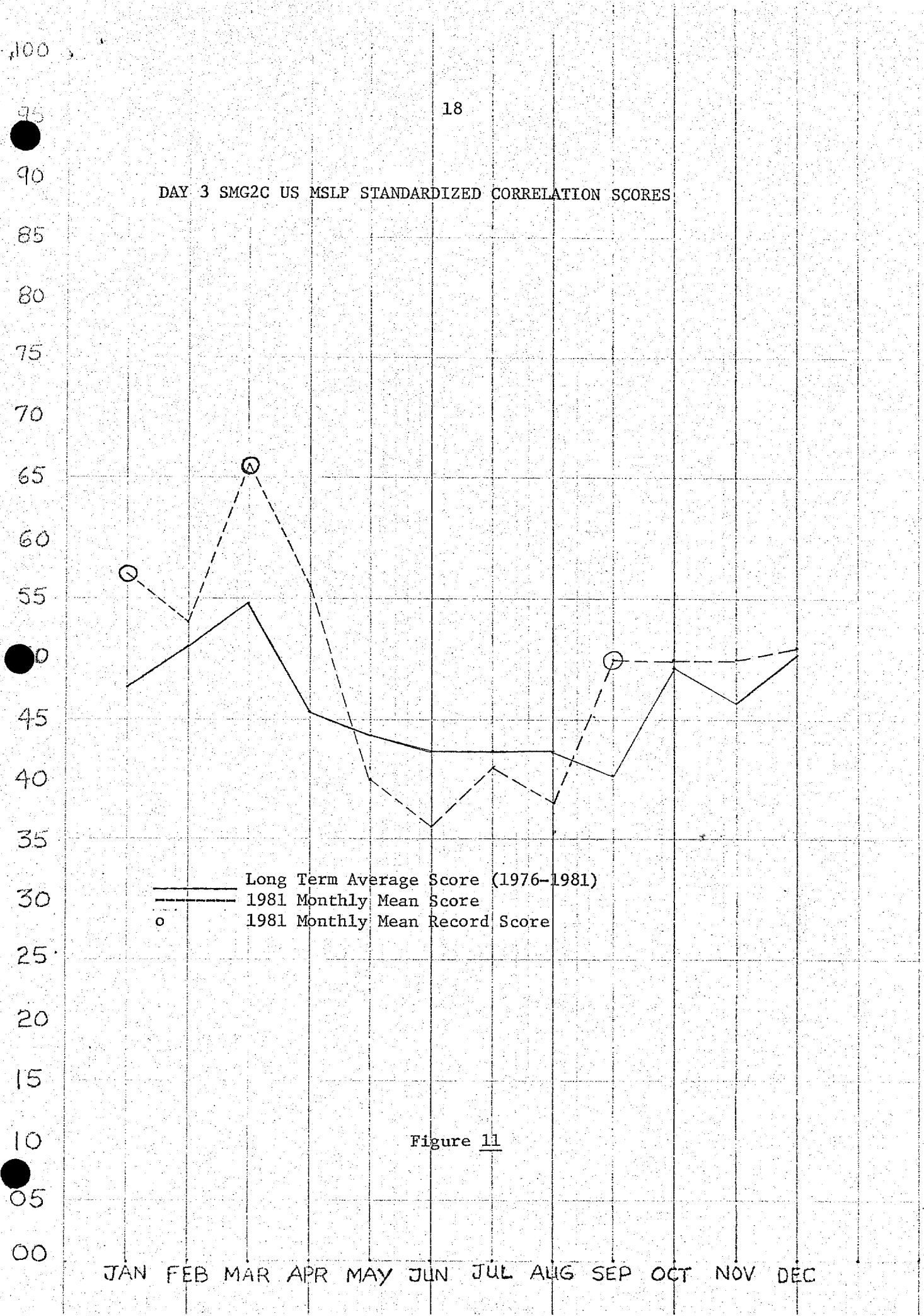


Figure 11

DAY 4 SMG26 US MSLP STANDARDIZED CORRELATION SCORES

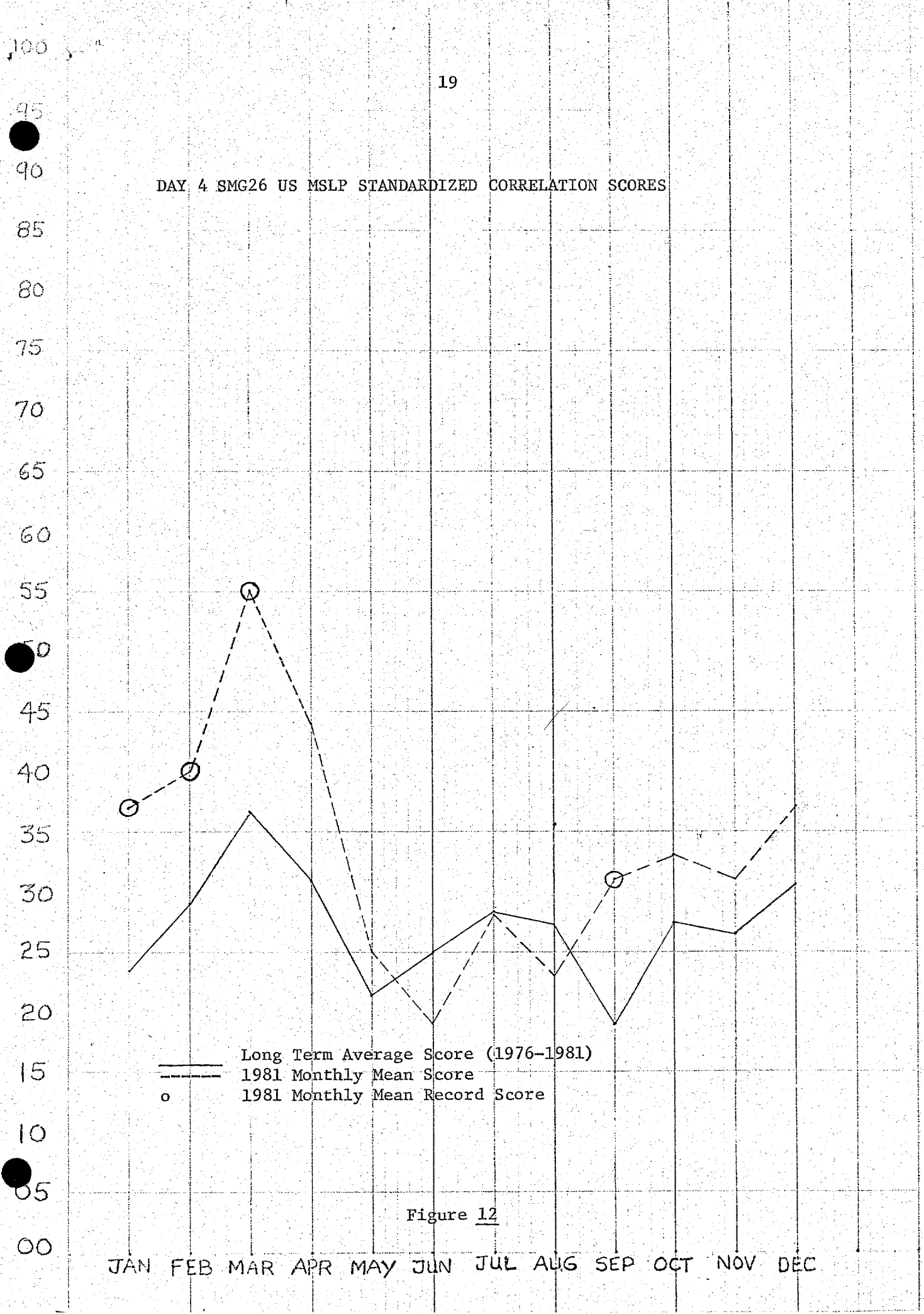


Figure 12

DAY 5 SMG26 US MSLP STANDARDIZED CORRELATION SCORES

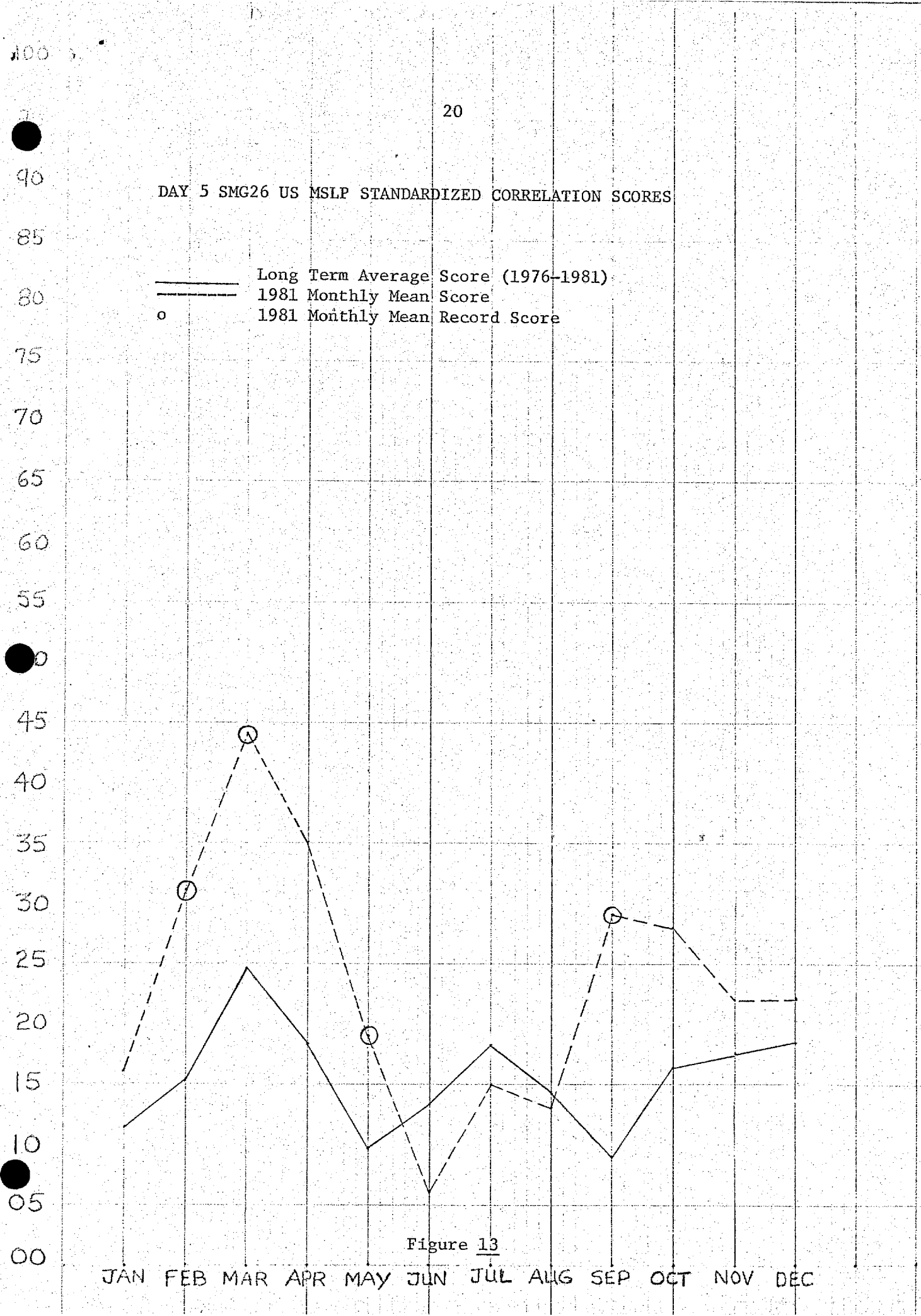


Figure 13

DAY 3 MAN NA MSLP UNSTANDARDIZED CORRELATION SCORES

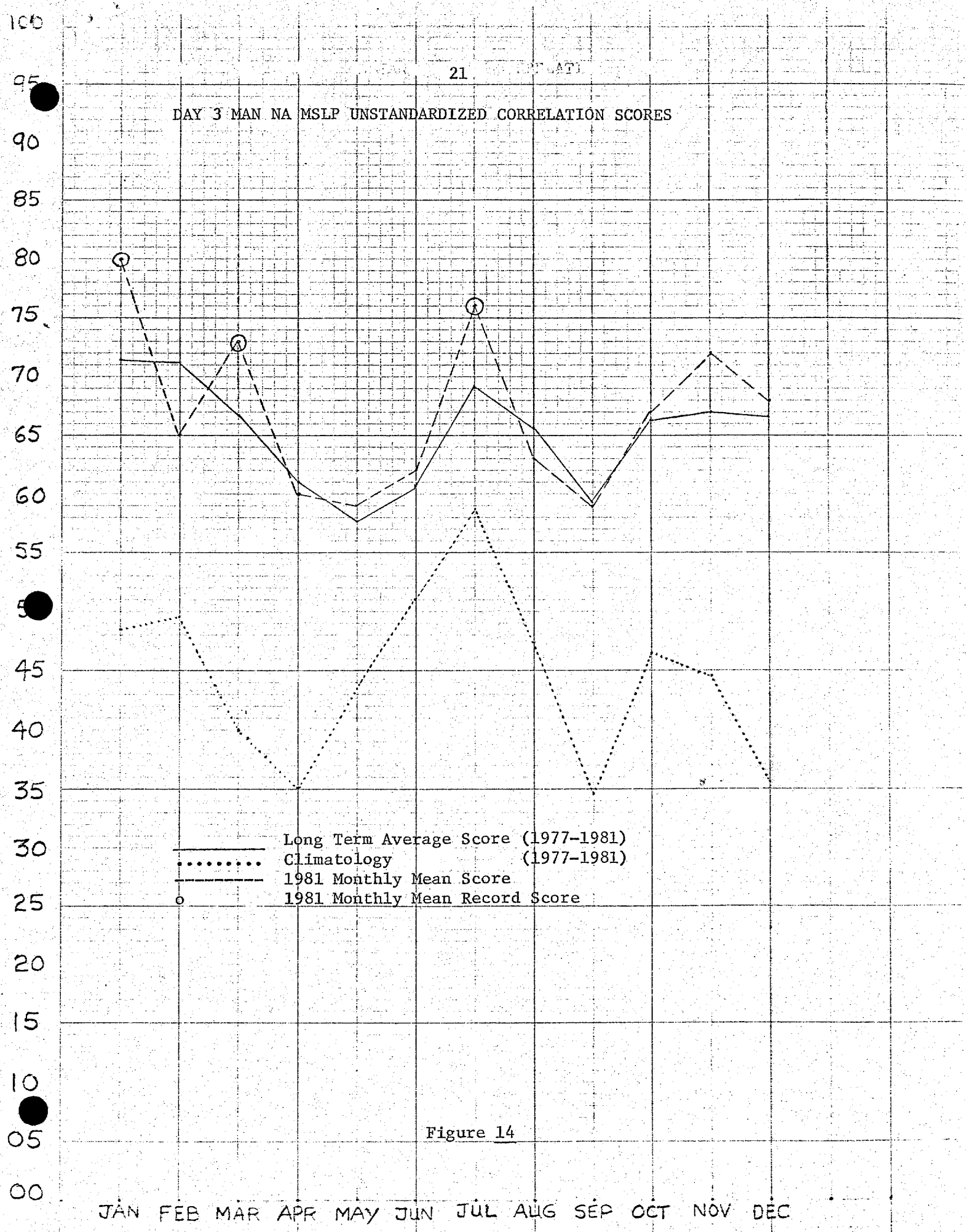


Figure 14

DAY 4 MAN NA MSLP UNSTANDARDIZED CORRELATION SCORES

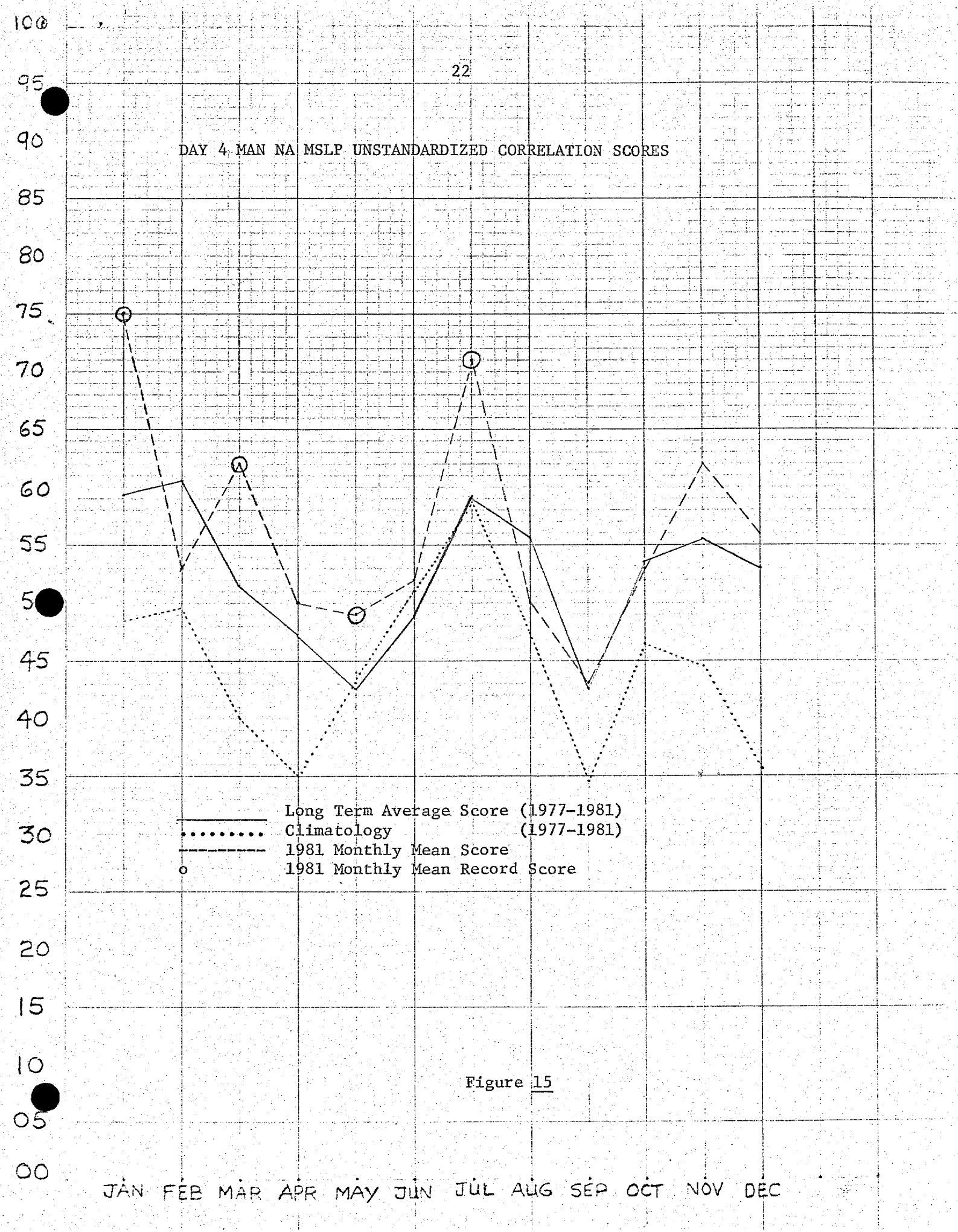


Figure 15

DAY 5 MAN NA MSLP UNSTANDARDIZED CORRELATION SCORES

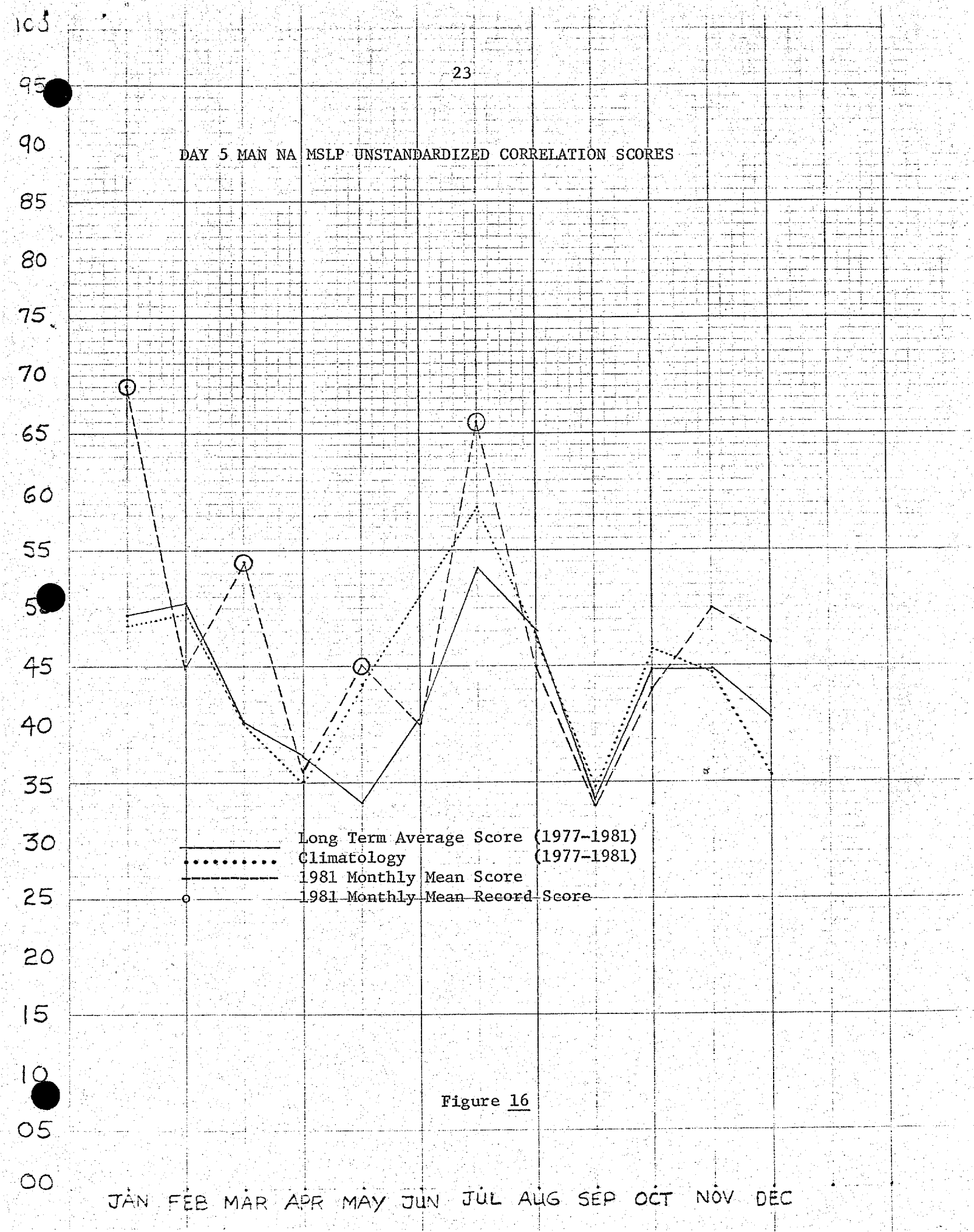


Figure 16

DAY 3 SMG2C NA MSLP UNSTANDARDIZED CORRELATION SCORES

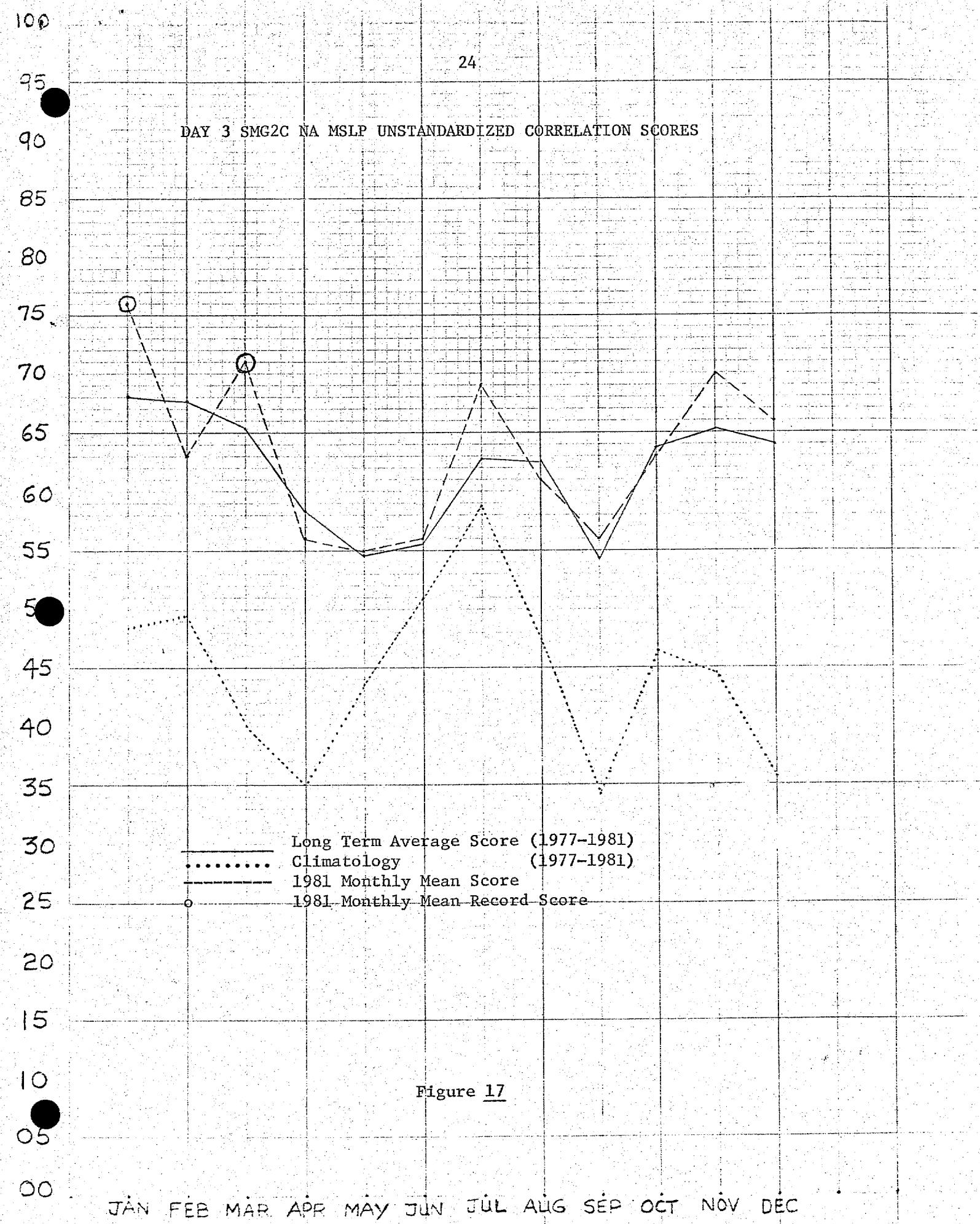


Figure 17

DAY 4 SMG26 NA MSLP UNSTANDARDIZED CORRELATION SCORES

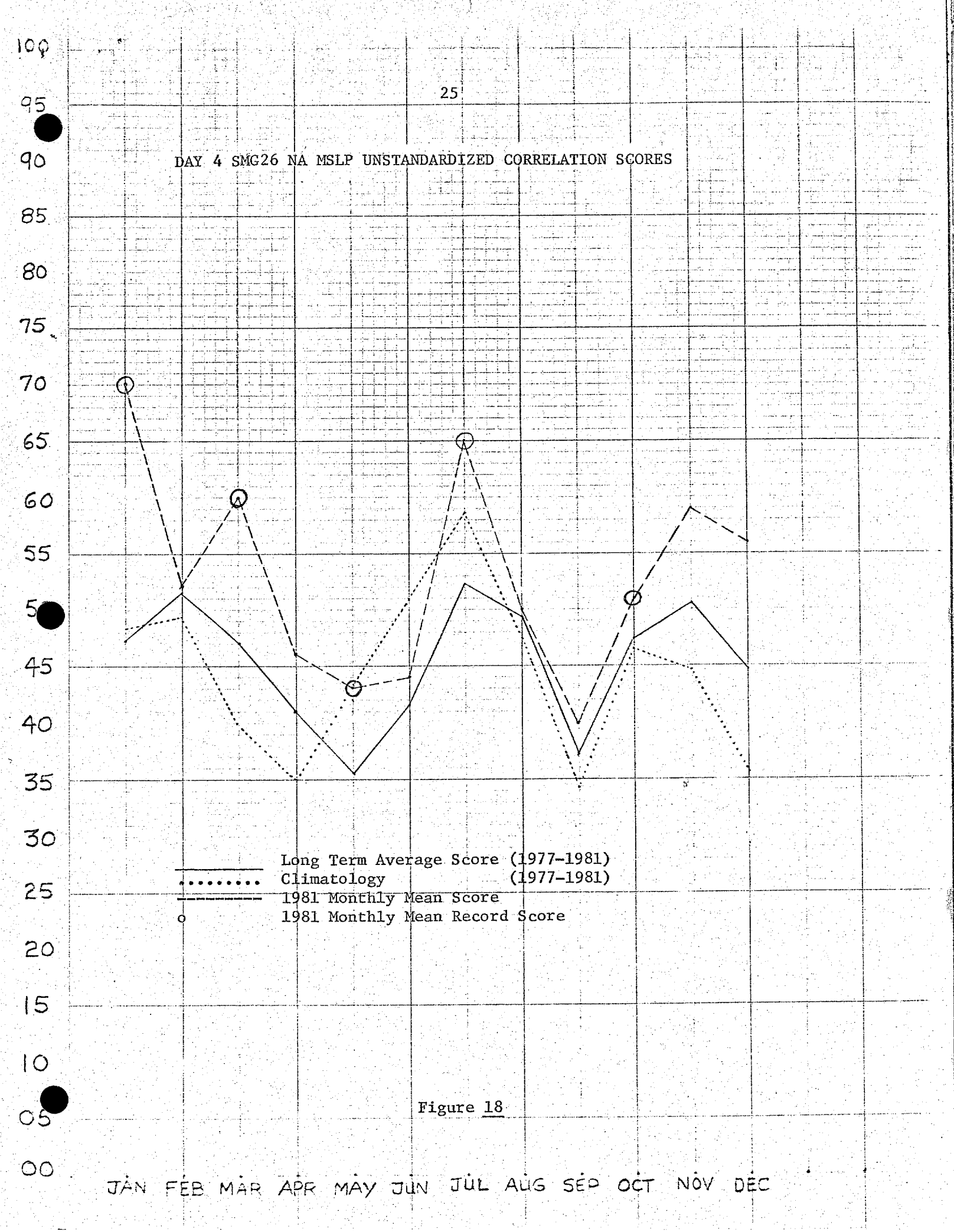


Figure 18

DAY 5 SMG26 NA MSLP UNSTANDARDIZED CORRELATION SCORES

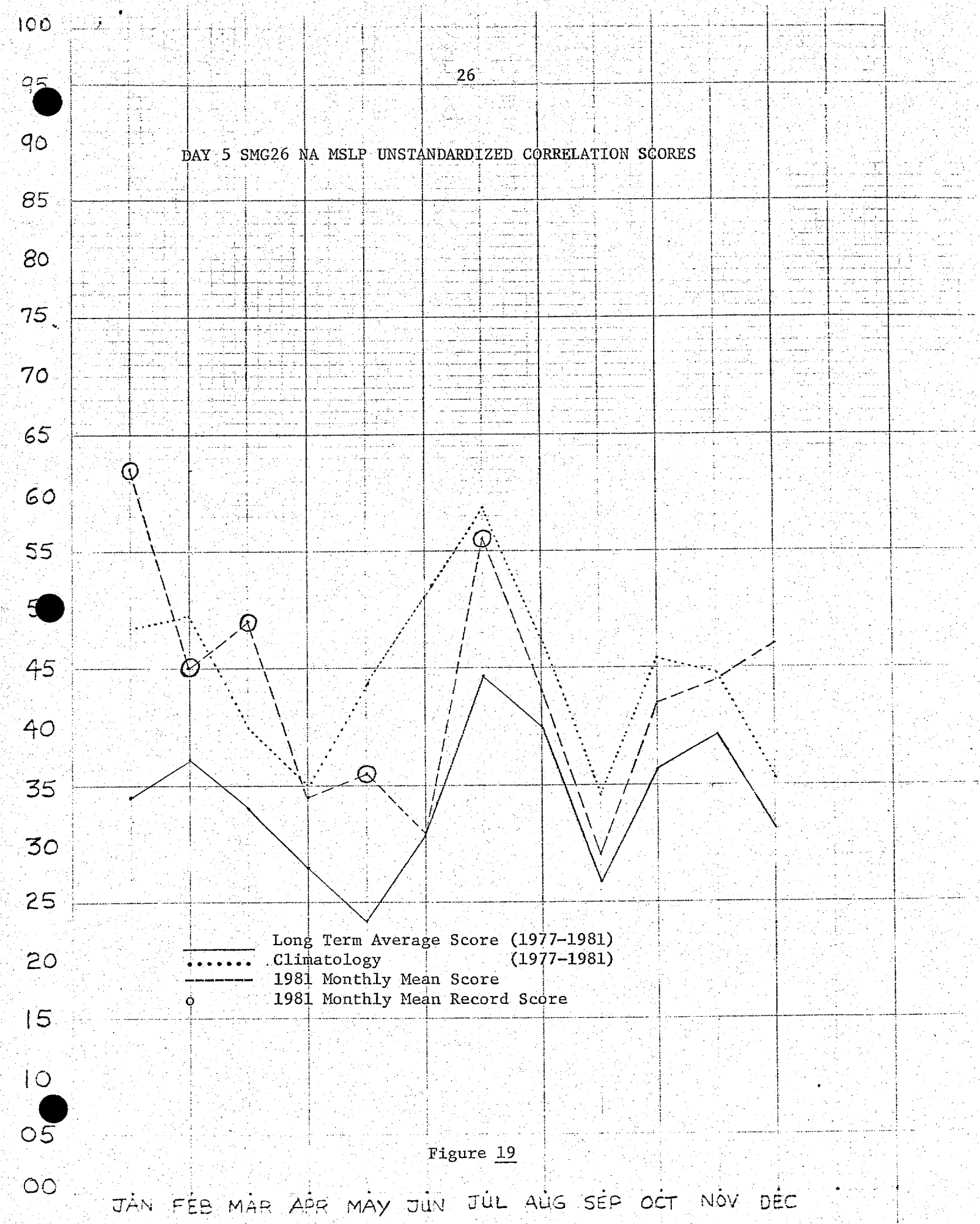
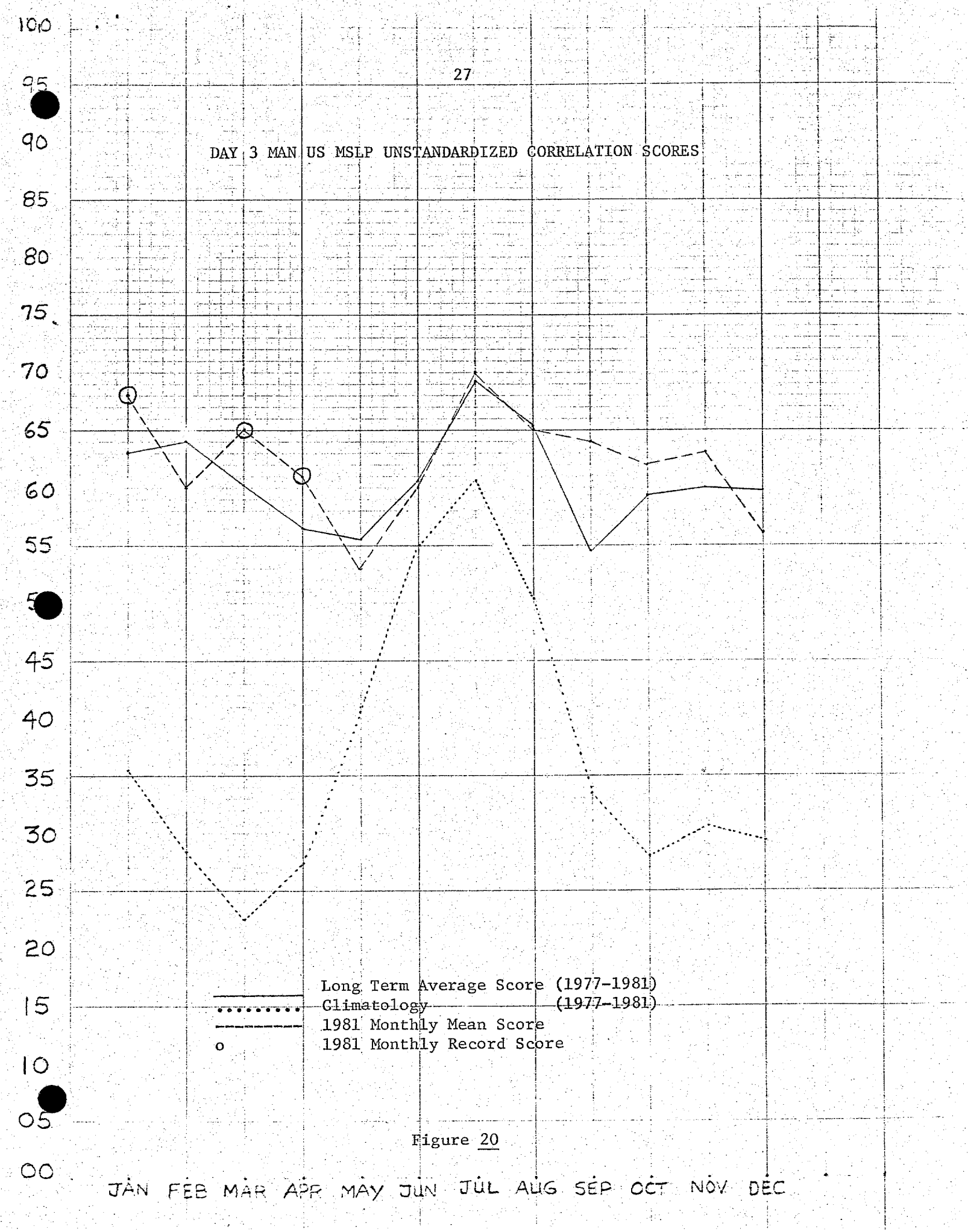


Figure 19


DAY 3 MAN US MSLP UNSTANDARDIZED CORRELATION SCORES
100
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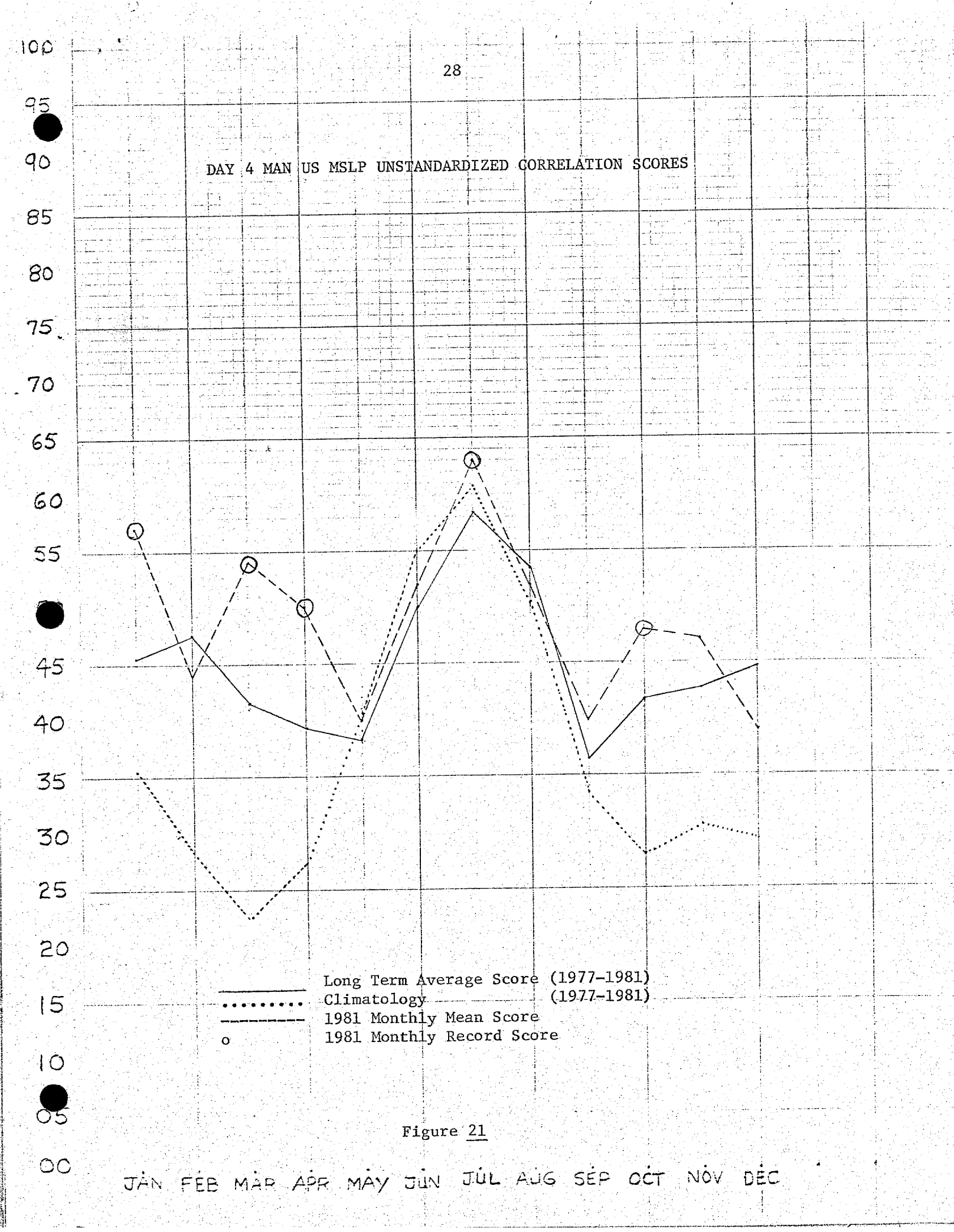
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
Long Term Average Score (1977-1981)
Climatology (1977-1981)
1981 Monthly Mean Score
o 1981 Monthly Record Score

Figure 20


DAY 4 MAN US MSLP UNSTANDARDIZED CORRELATION SCORES
100
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JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
Long Term Average Score (1977-1981)
Climatology (1977-1981)
1981 Monthly Mean Score
1981 Monthly Record Score

Figure 21

DAY 5 MAN US MSLP UNSTANDARDIZED CORRELATION SCORES

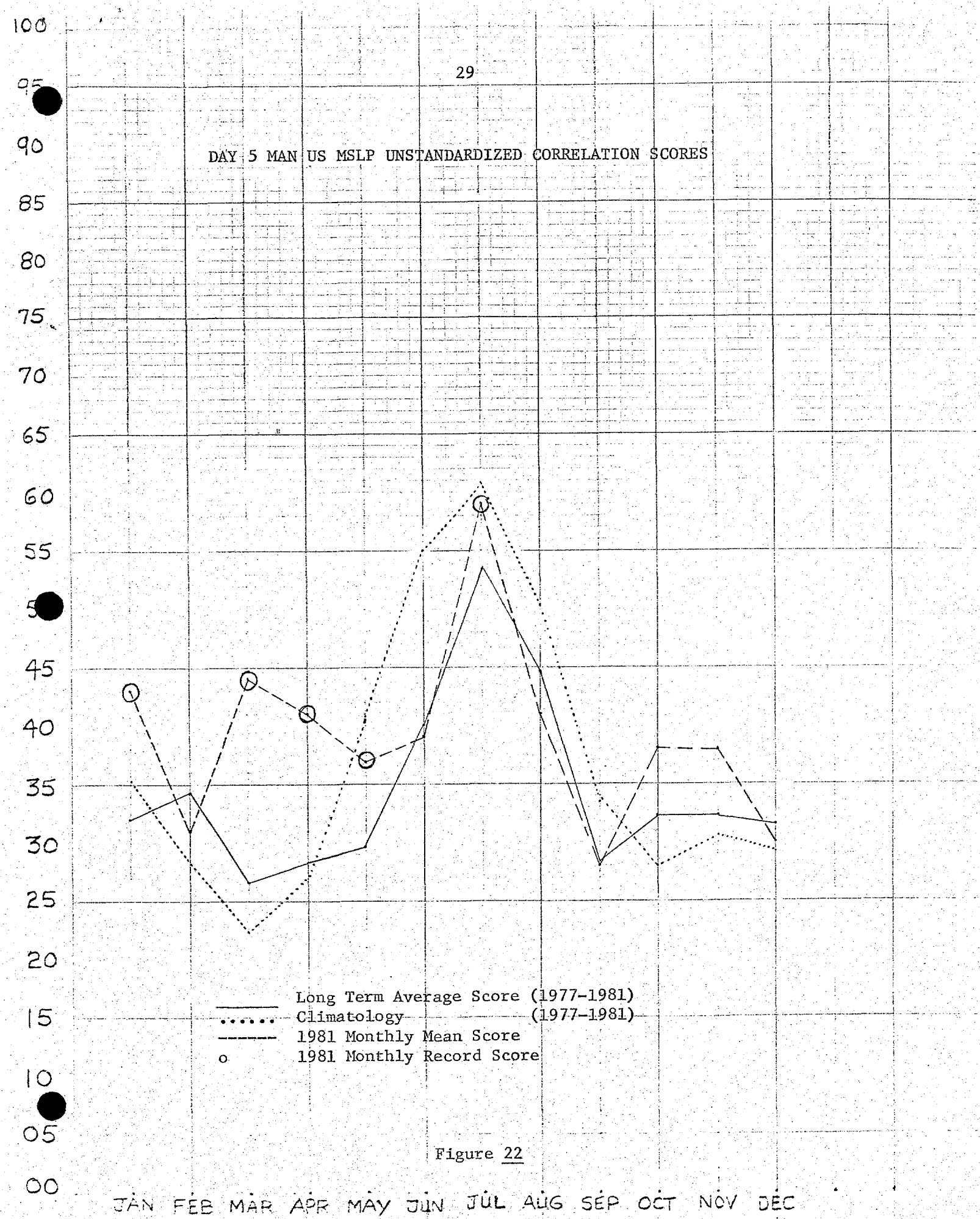

Figure 22

DAY 3 SMG2C US MSLP UNSTANDARDIZED CORRELATION SCORES

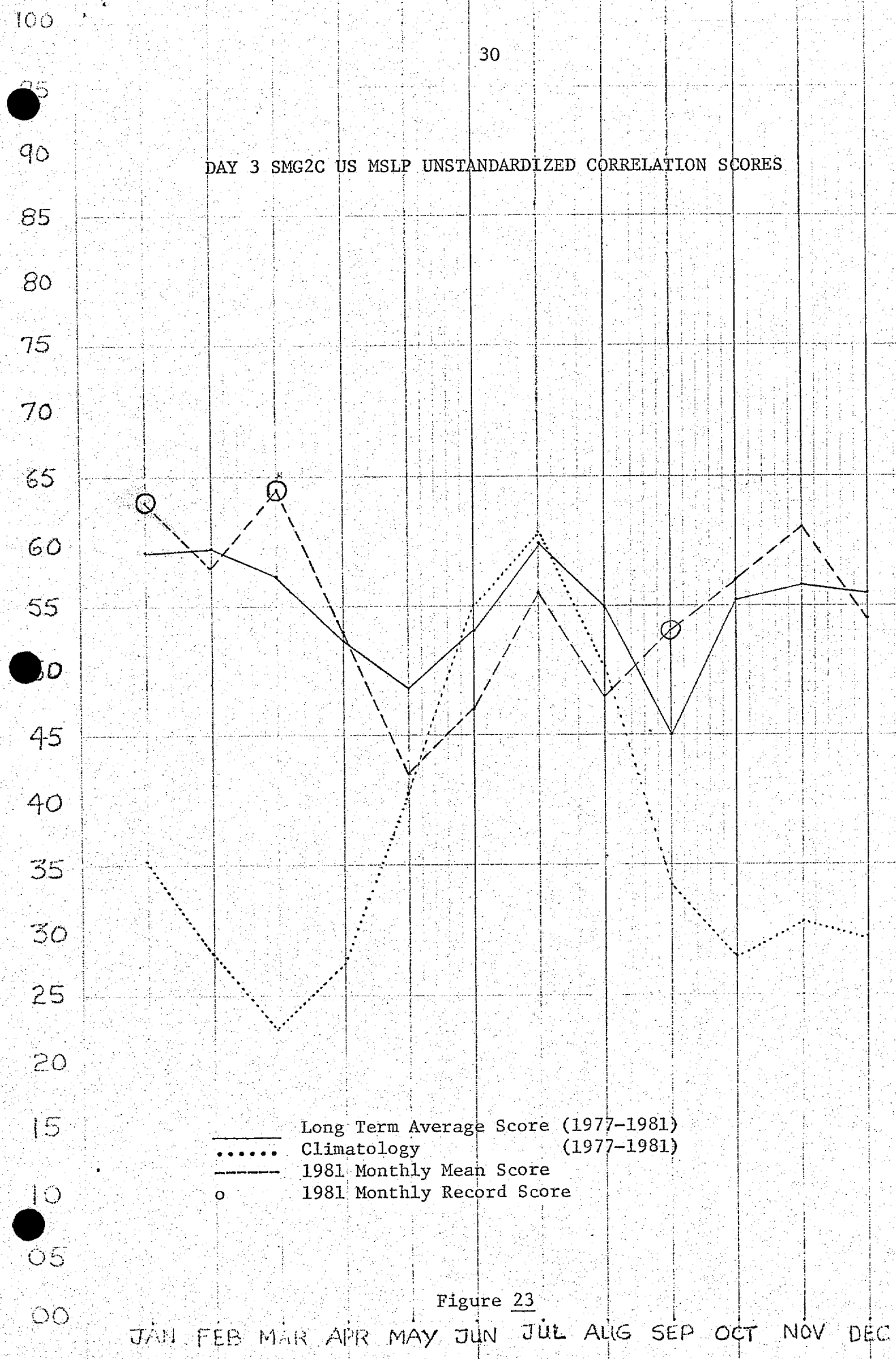

Figure 23

DAY 4 SMG26 US MSLP UNSTANDARDIZED CORRELATION SCORES

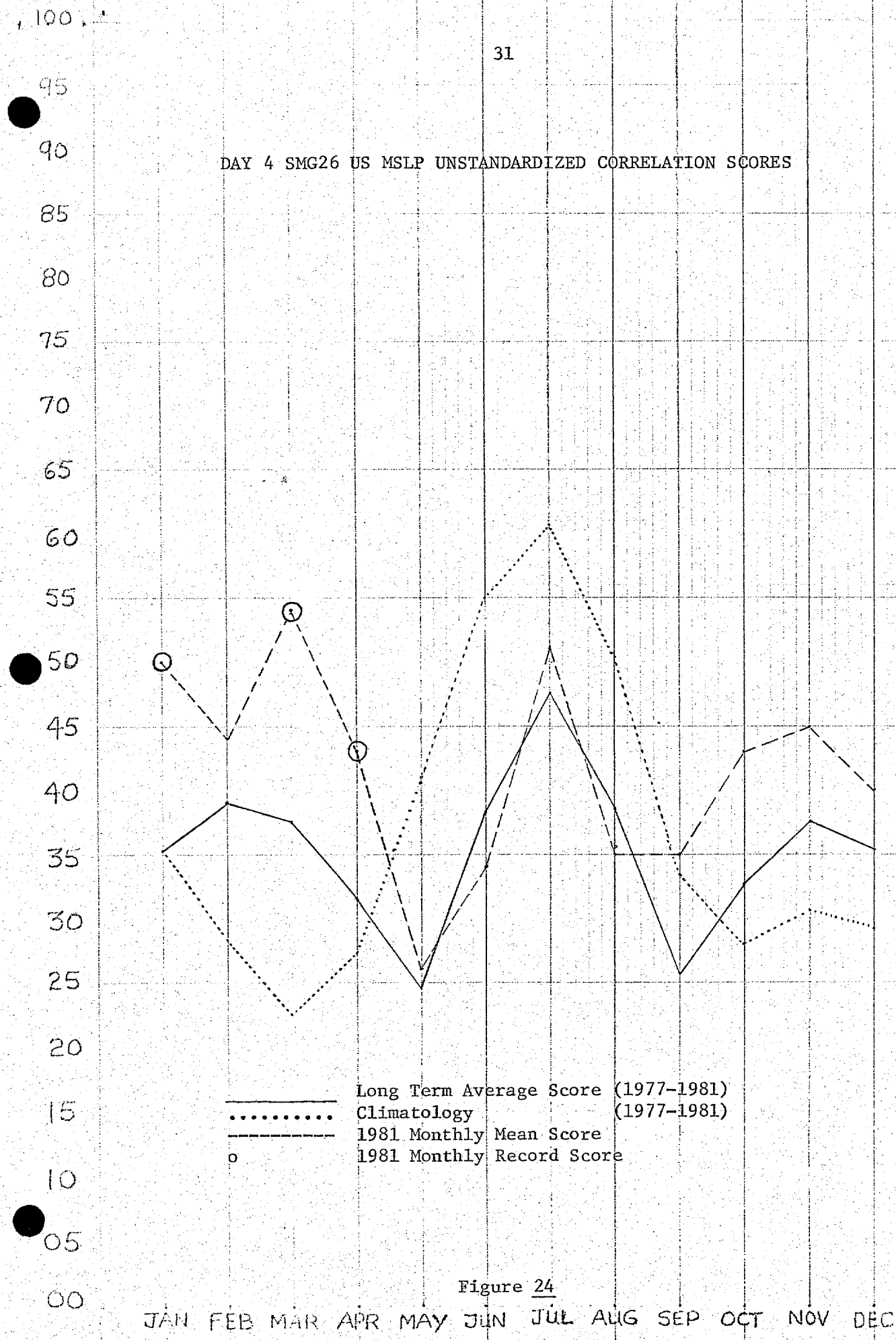

Figure 24

DAY 5 SMG26 US MSLP UNSTANDARDIZED CORRELATION SCORES

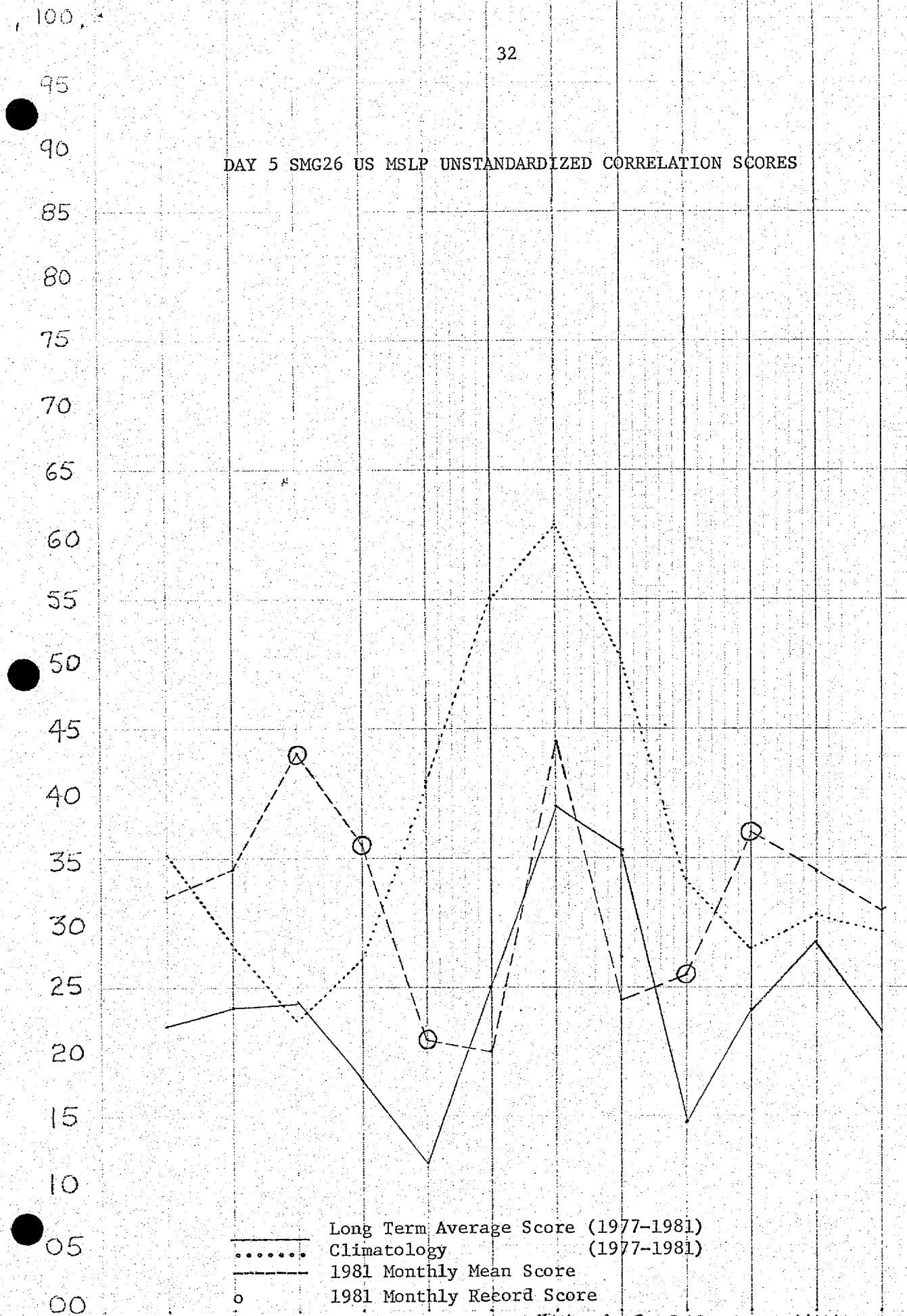

Figure 25

WINTER

DAYS 3, 4, 5 NORTH AMERICAN MEAN SEA LEVEL PRESSURE CORRELATION SCORES FOR $\frac{(DEC + JAN + FEB)}{3}$

$$\text{Correlation Score} = 100. \times \frac{(\text{Unstandardized Score} + \text{Standardized Score})}{2}$$

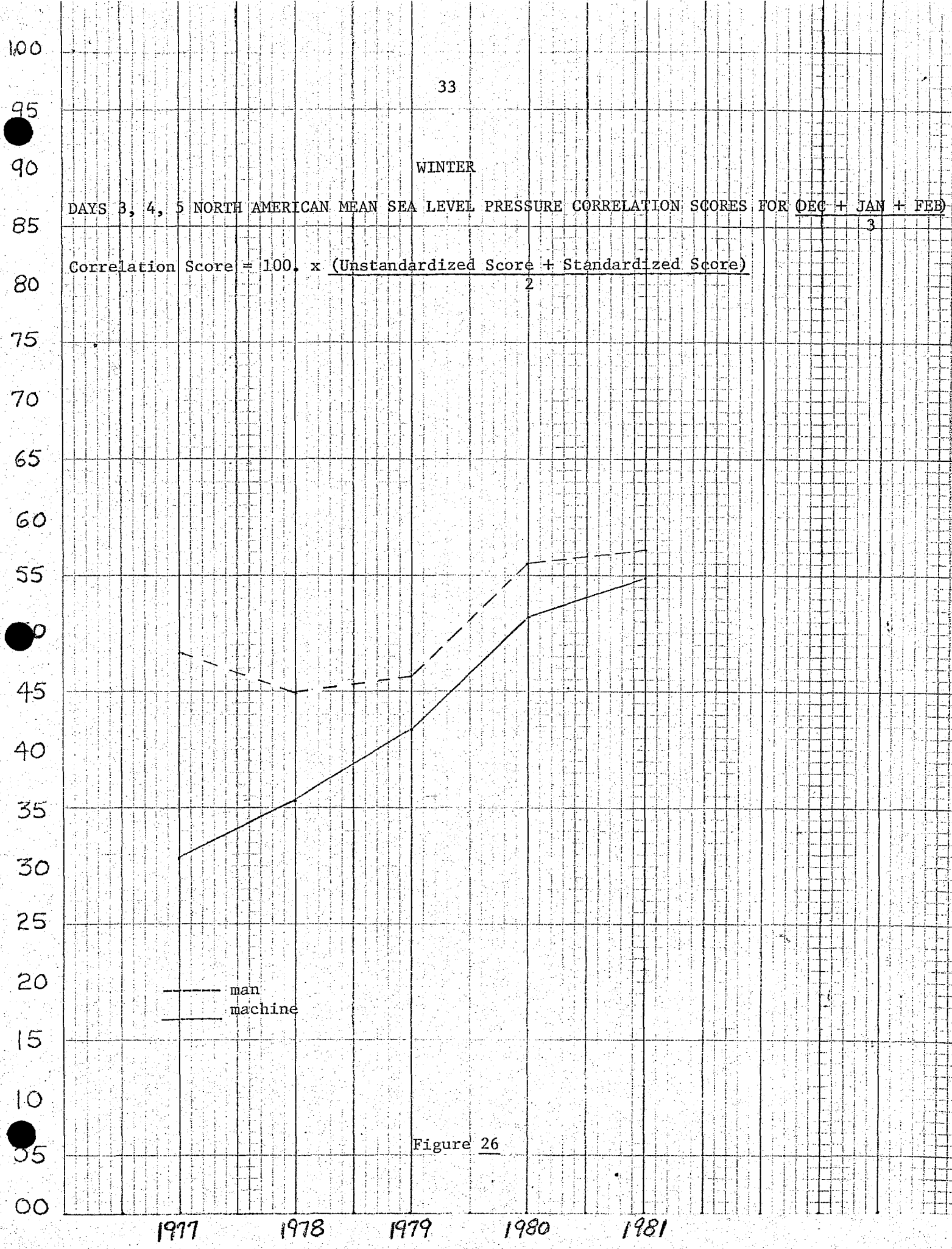

Figure 26

SPRING

DAYS 3, 4, 5 NORTH AMERICAN MEAN SEA LEVEL PRESSURE CORRELATION SCORES FOR $\frac{(MAR + APR + MAY)}{3}$

Correlation Score = 100. x $\frac{(\text{Unstandardized Score} + \text{Standardized Score})}{2}$

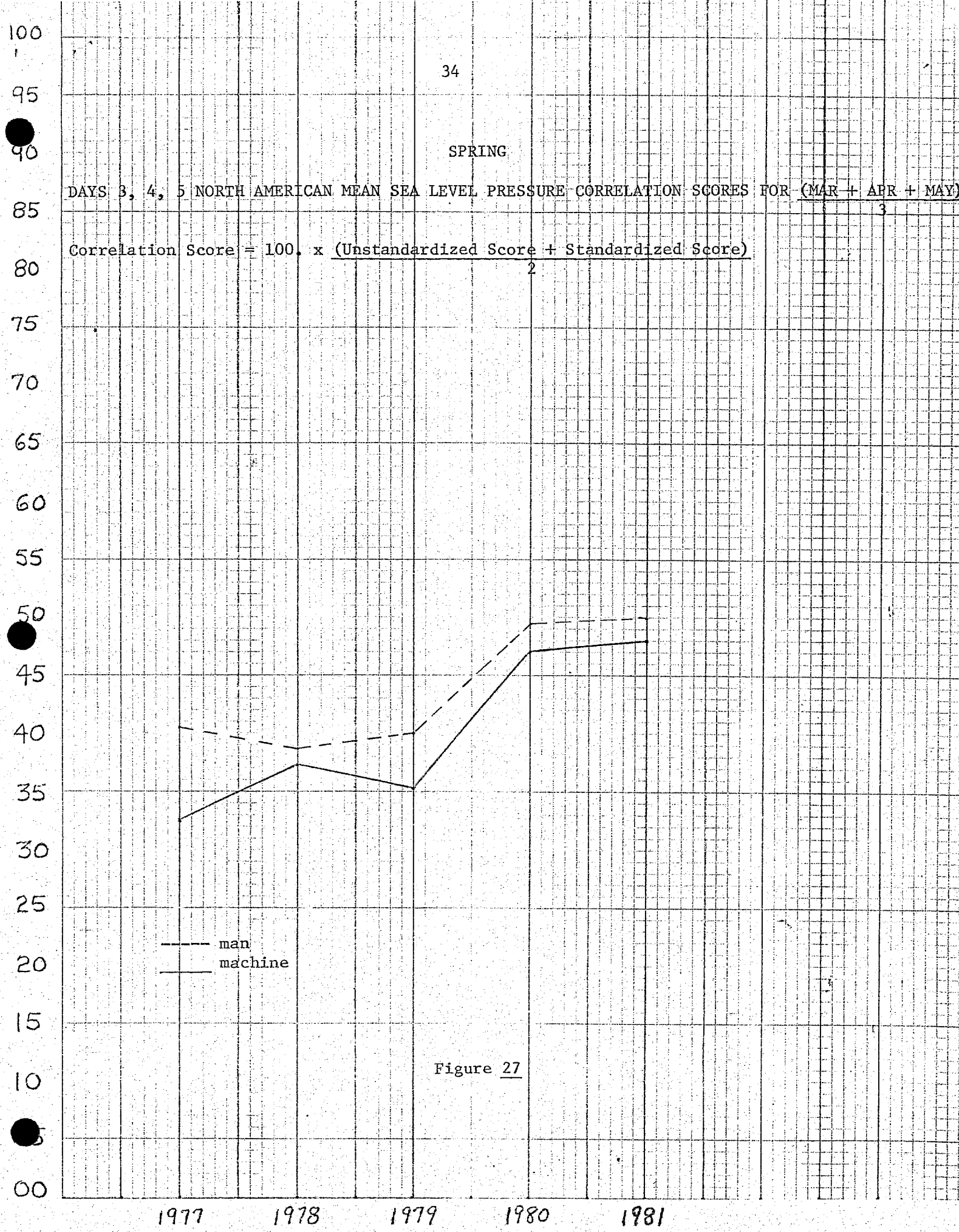

Figure 27

SUMMER

DAYS 3, 4, 5 NORTH AMERICAN MEAN SEA LEVEL PRESSURE CORRELATION SCORES FOR $\frac{(\text{JUN} + \text{JUL} + \text{AUG})}{3}$

$$\text{Correlation Score} = 100. \times \frac{(\text{Unstandardized Score} + \text{Standardized Score})}{2}$$

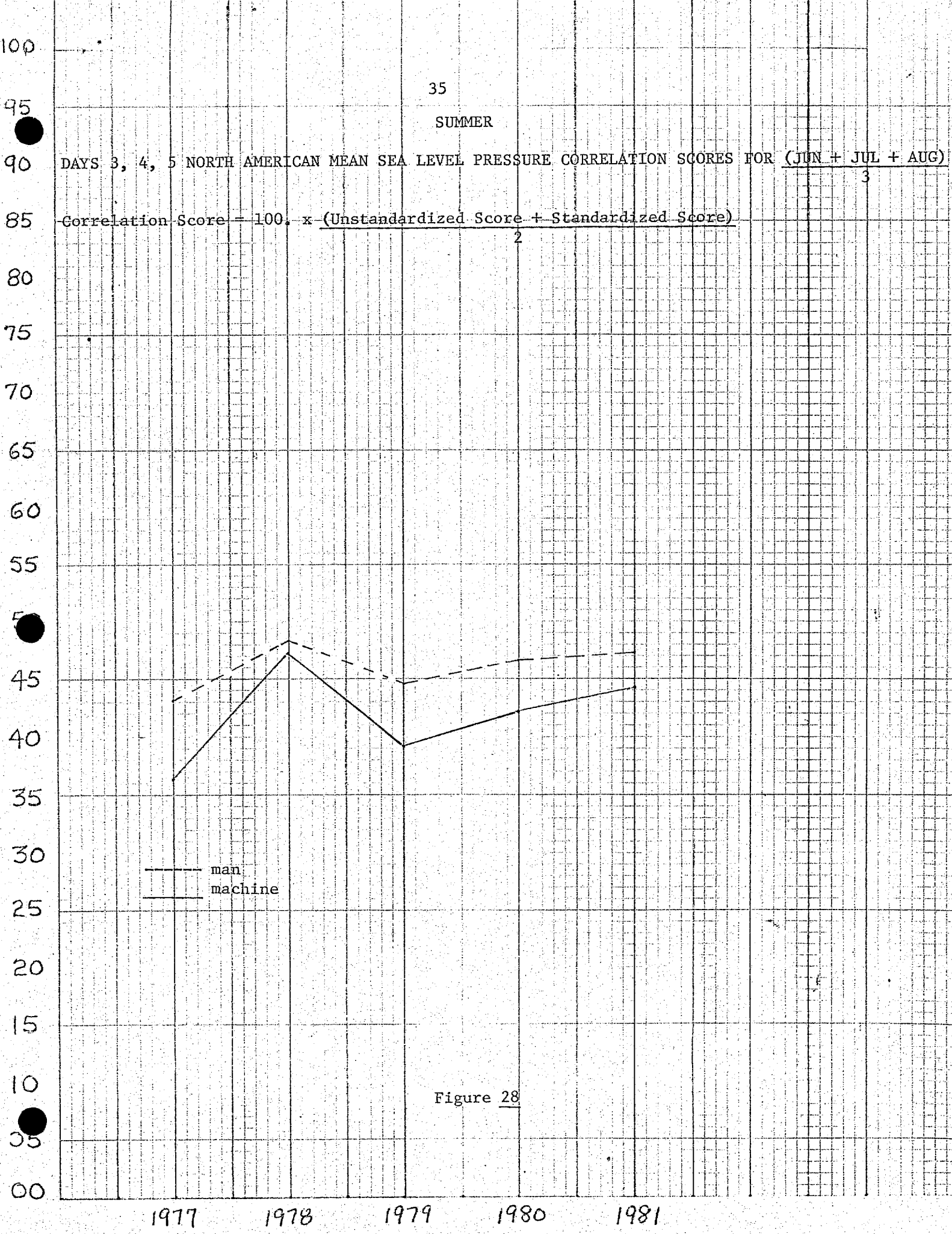

Figure 28

FALL

DAYS 3, 4, 5 NORTH AMERICAN MEAN SEA LEVEL PRESSURE CORRELATION SCORES FOR $\frac{(\text{SEP} + \text{OCT} + \text{NOV})}{3}$

Correlation Score = 100. x $\frac{(\text{Unstandardized Score} + \text{Standardized Score})}{2}$

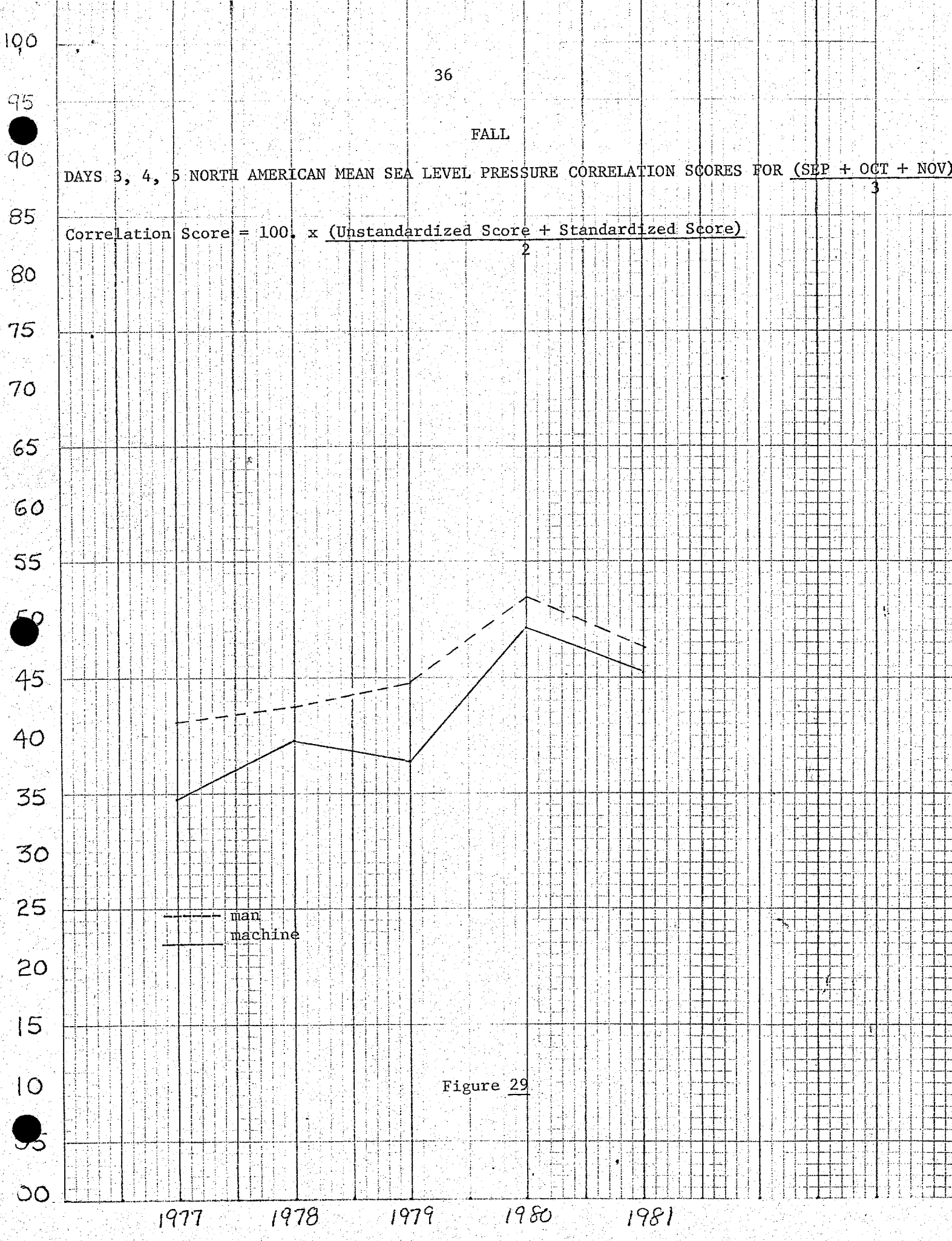

Figure 29

DAYS 3, 4, AND 5 $\frac{(NA + US)}{2}$ 500MB STANDARDIZED CORRELATION SCORES.

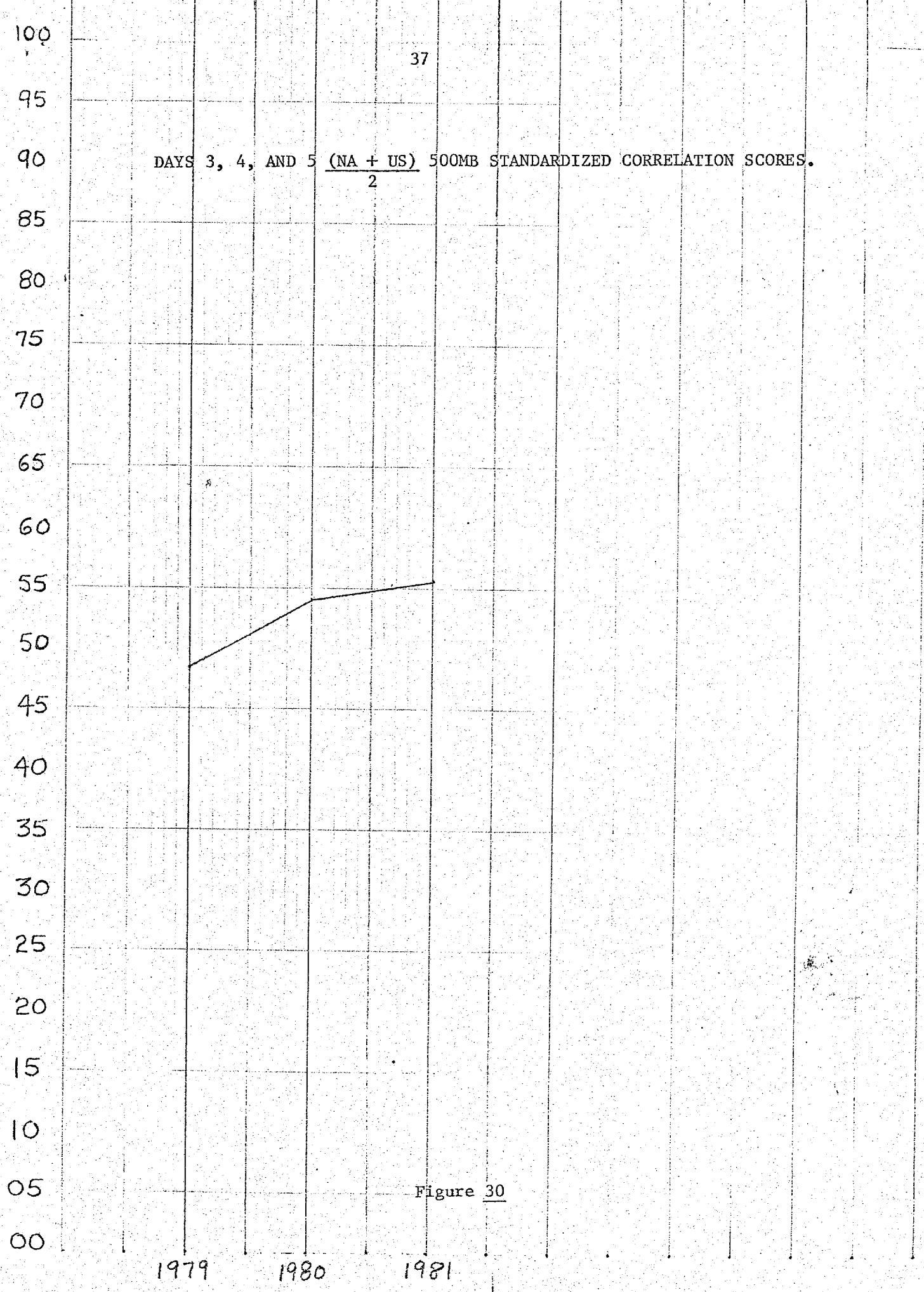

Figure 30

MSLP STANDARDIZED CORRELATION SCORES FOR DECEMBER 1981

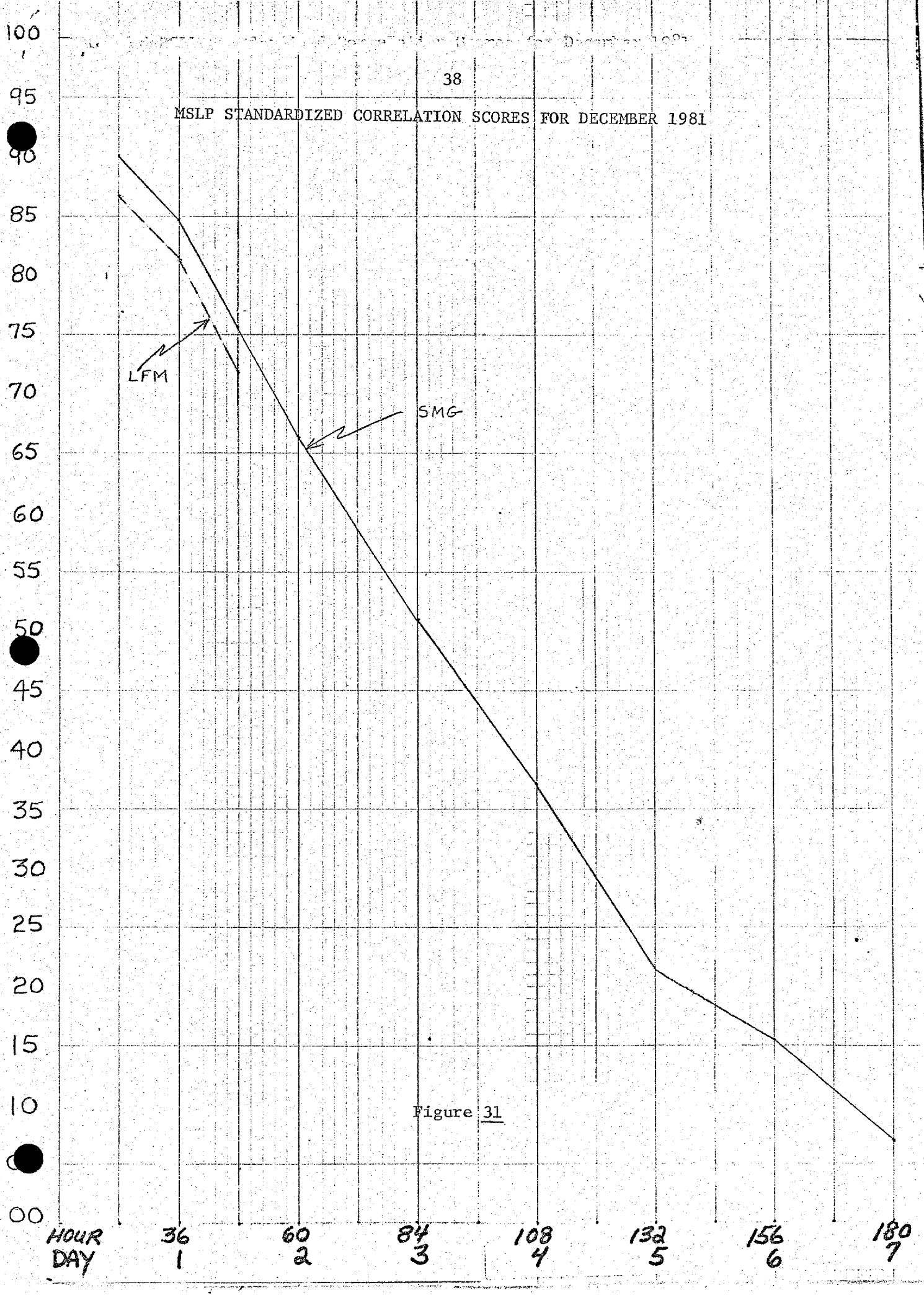

Figure 31

500MB STANDARDIZED CORRELATION SCORES FOR DECEMBER 1981

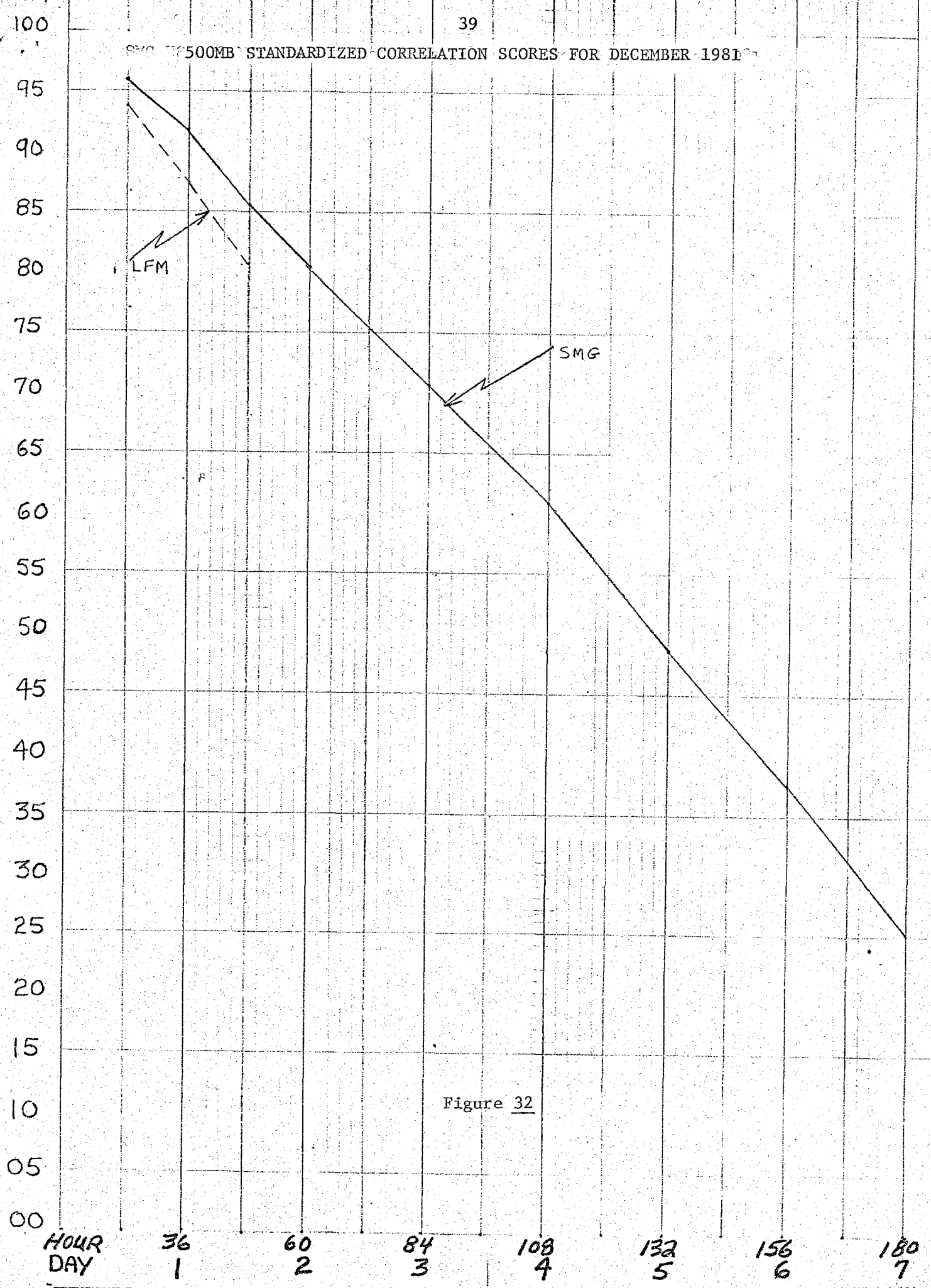

Figure 32

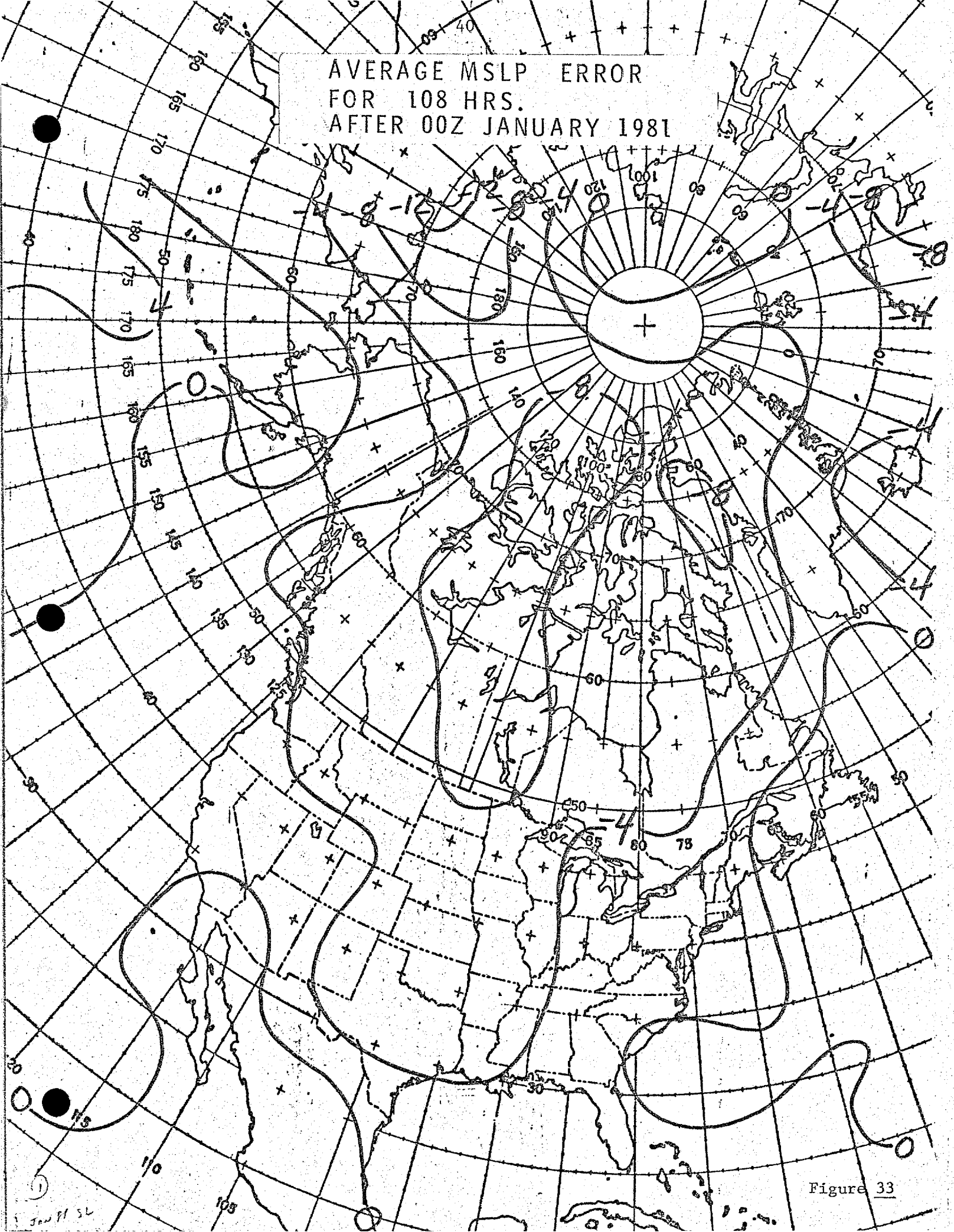

Figure 33

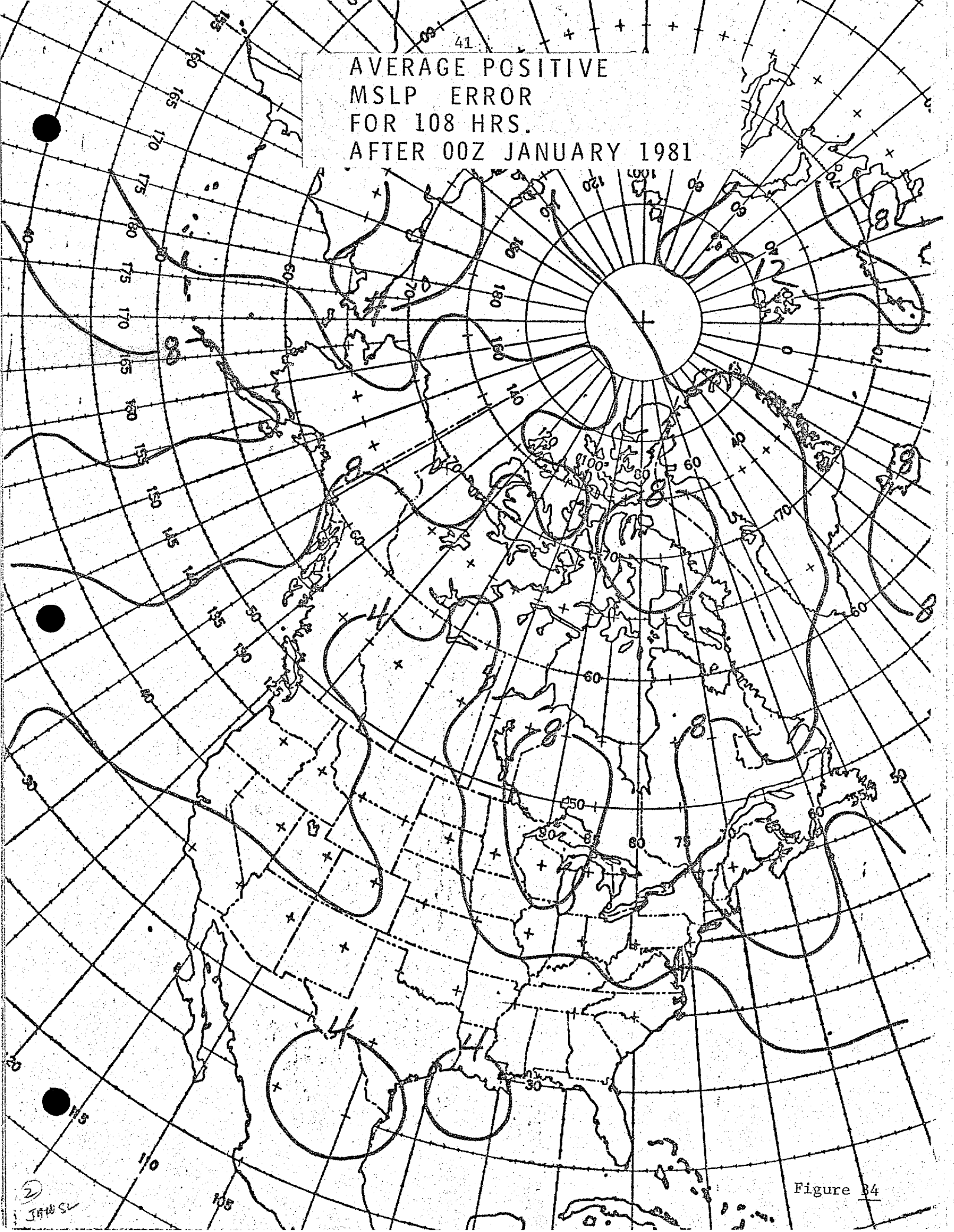
AVERAGE POSITIVE
MSLP ERROR
FOR 108 HRS.
AFTER 00Z JANUARY 1981

Figure 34

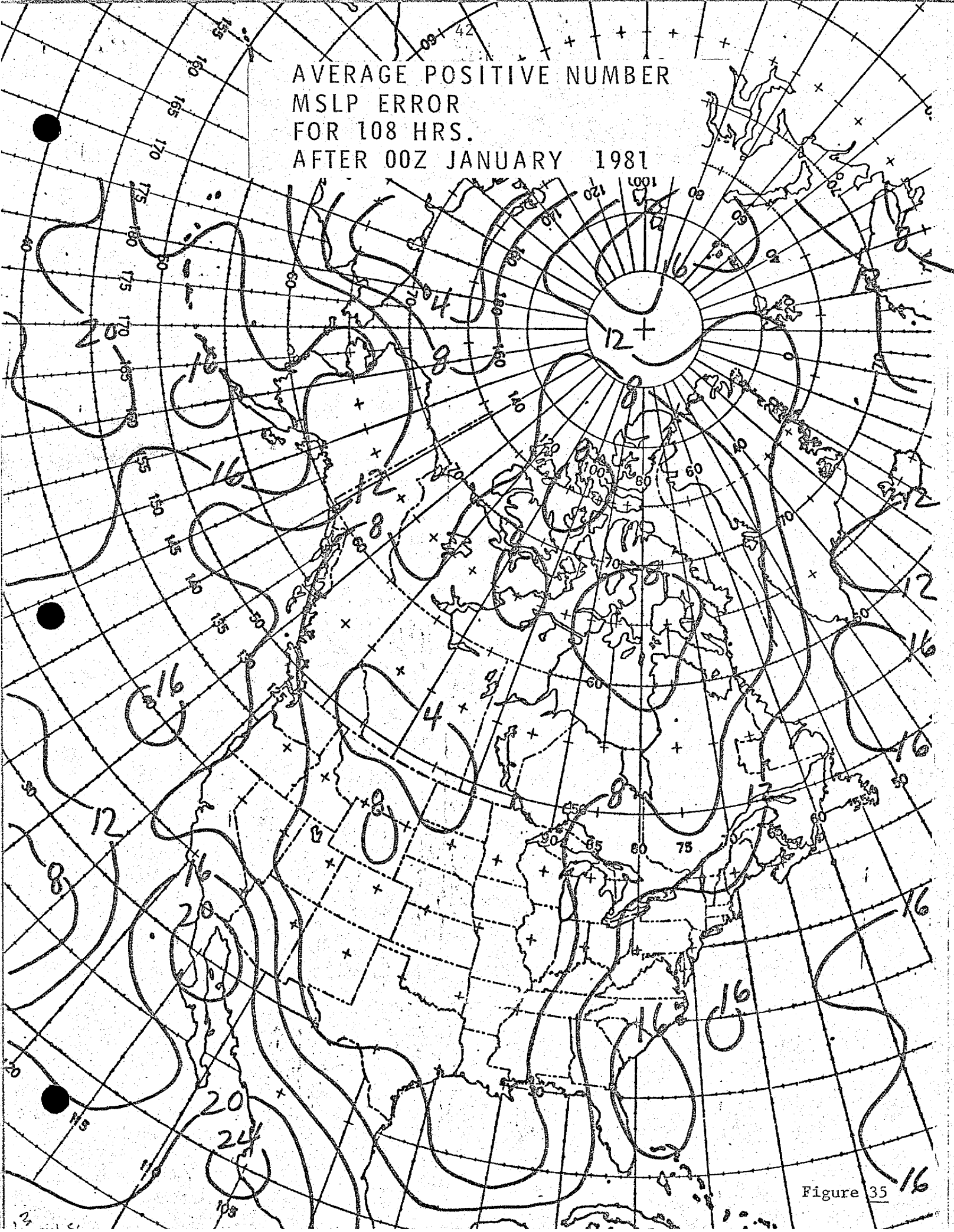
AVERAGE POSITIVE NUMBER
MSLP ERROR
FOR 108 HRS.
AFTER 00Z JANUARY 1981

Figure 35

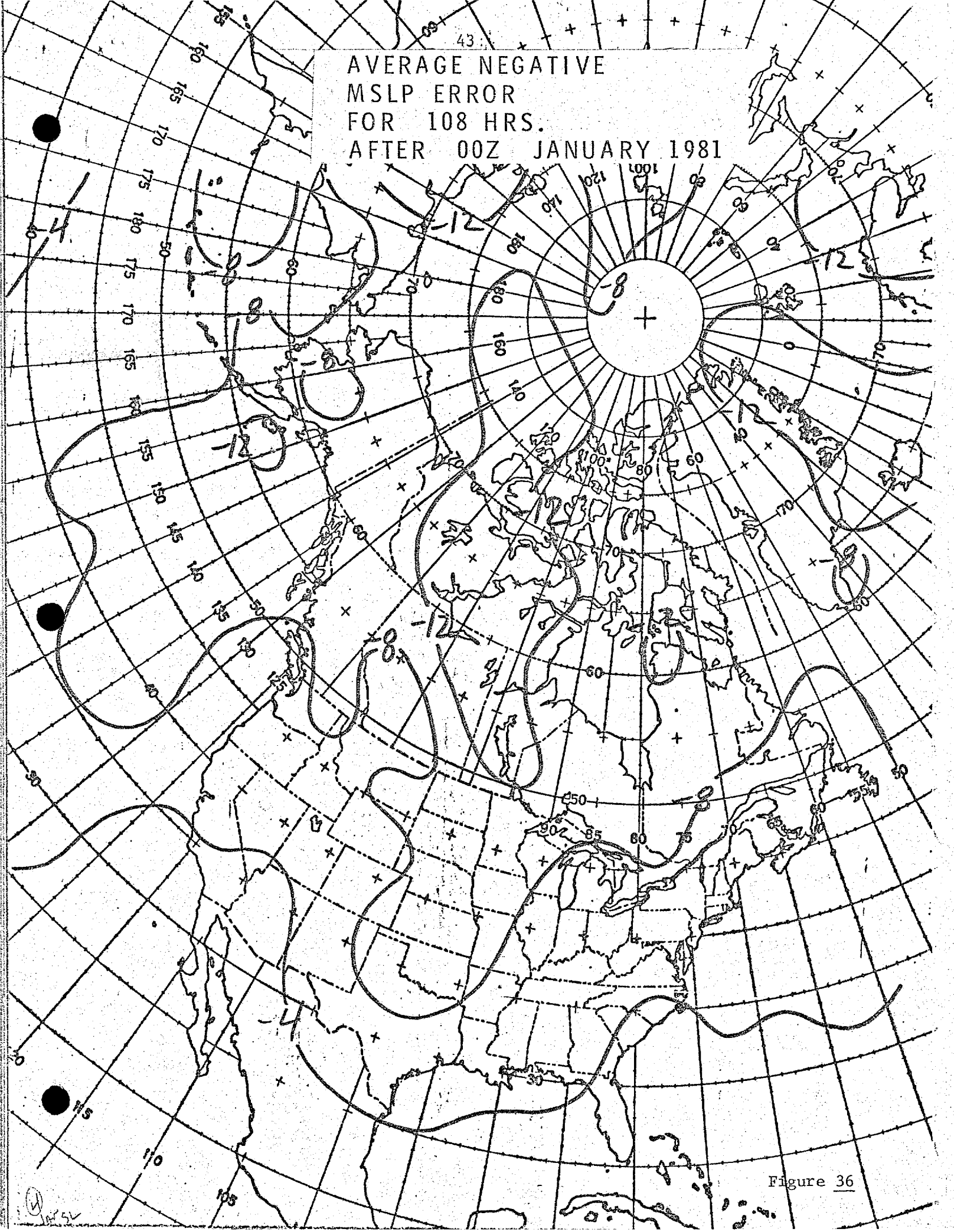
AVERAGE NEGATIVE
MSLP ERROR
FOR 108 HRS.
AFTER 00Z JANUARY 1981

Figure 36

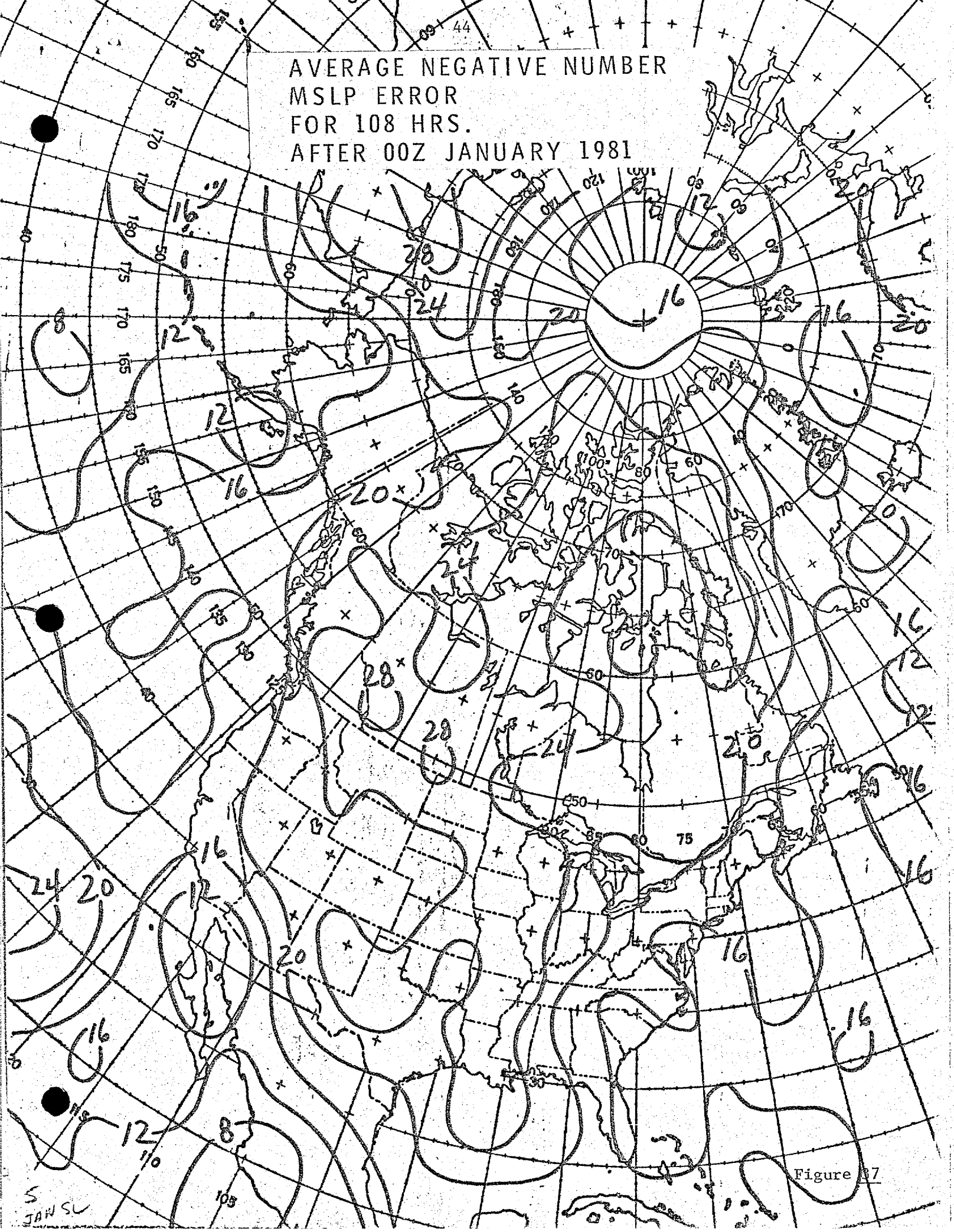
AVERAGE NEGATIVE NUMBER
MSLP ERROR
FOR 108 HRS.
AFTER 00Z JANUARY 1981
S
JAN SC

Figure 17

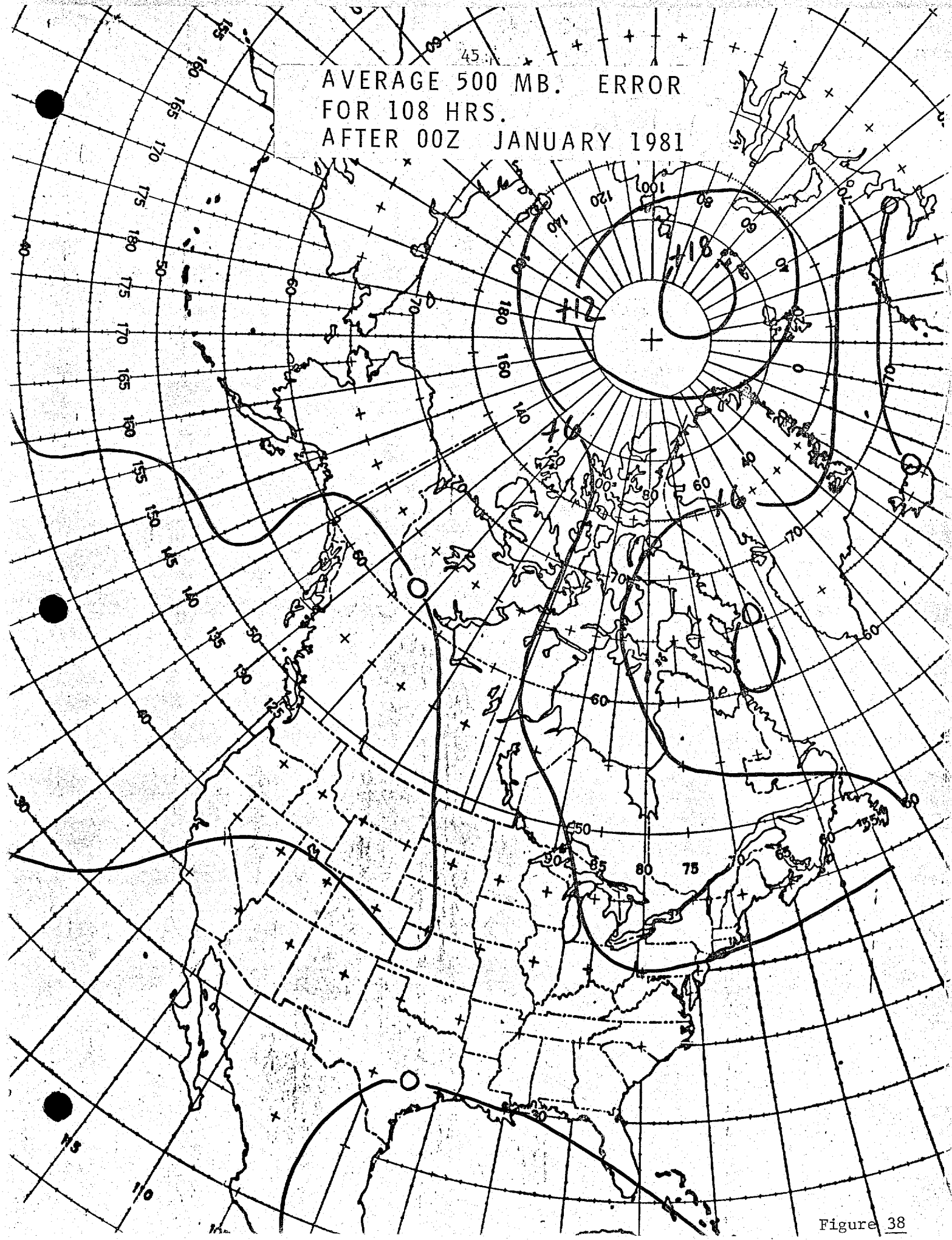

Figure 38

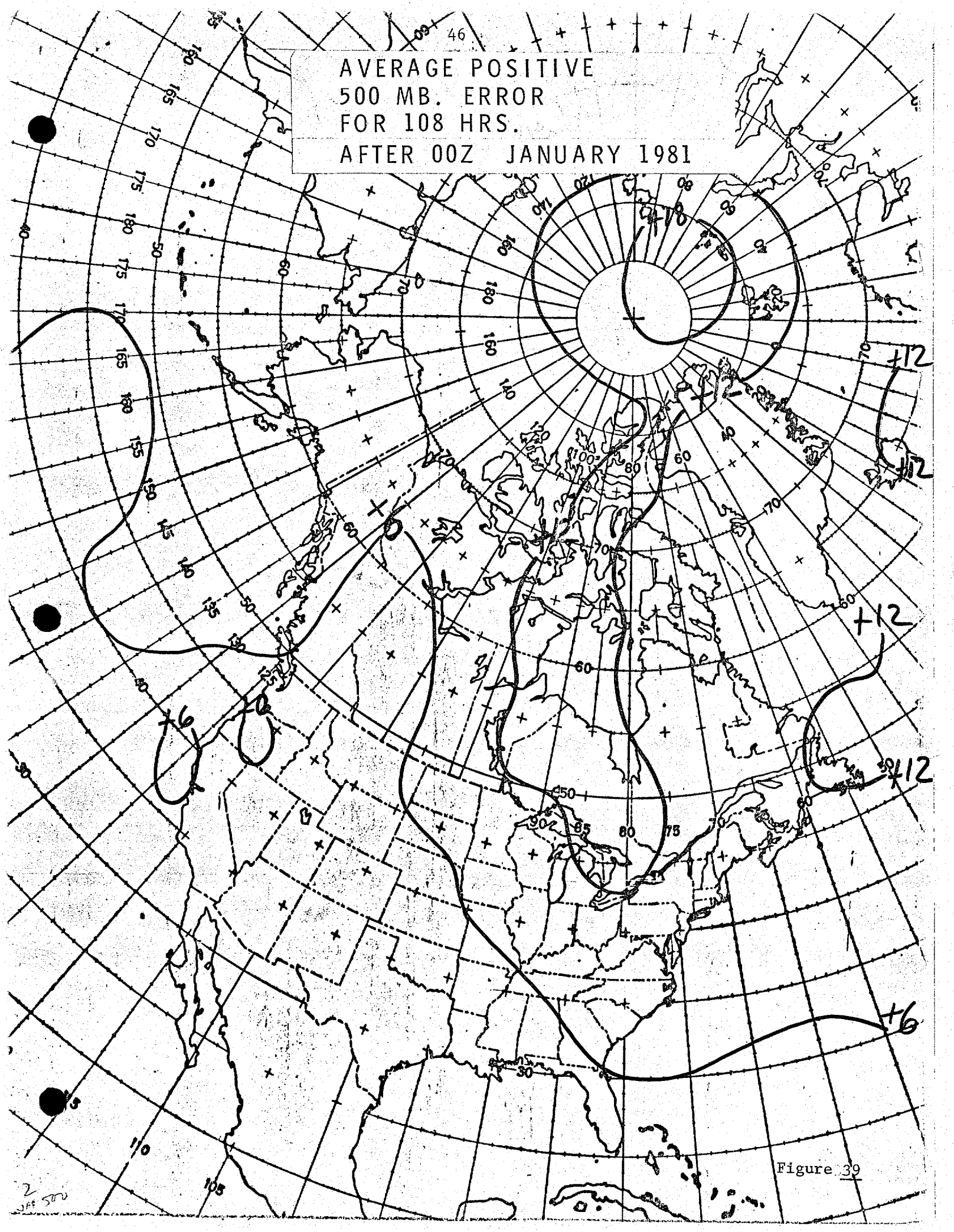
AVERAGE POSITIVE
500 MB. ERROR
FOR 108 HRS.
AFTER 00Z JANUARY 1981
+18
+12
+12
+12
+12
+6
+6

Figure 39

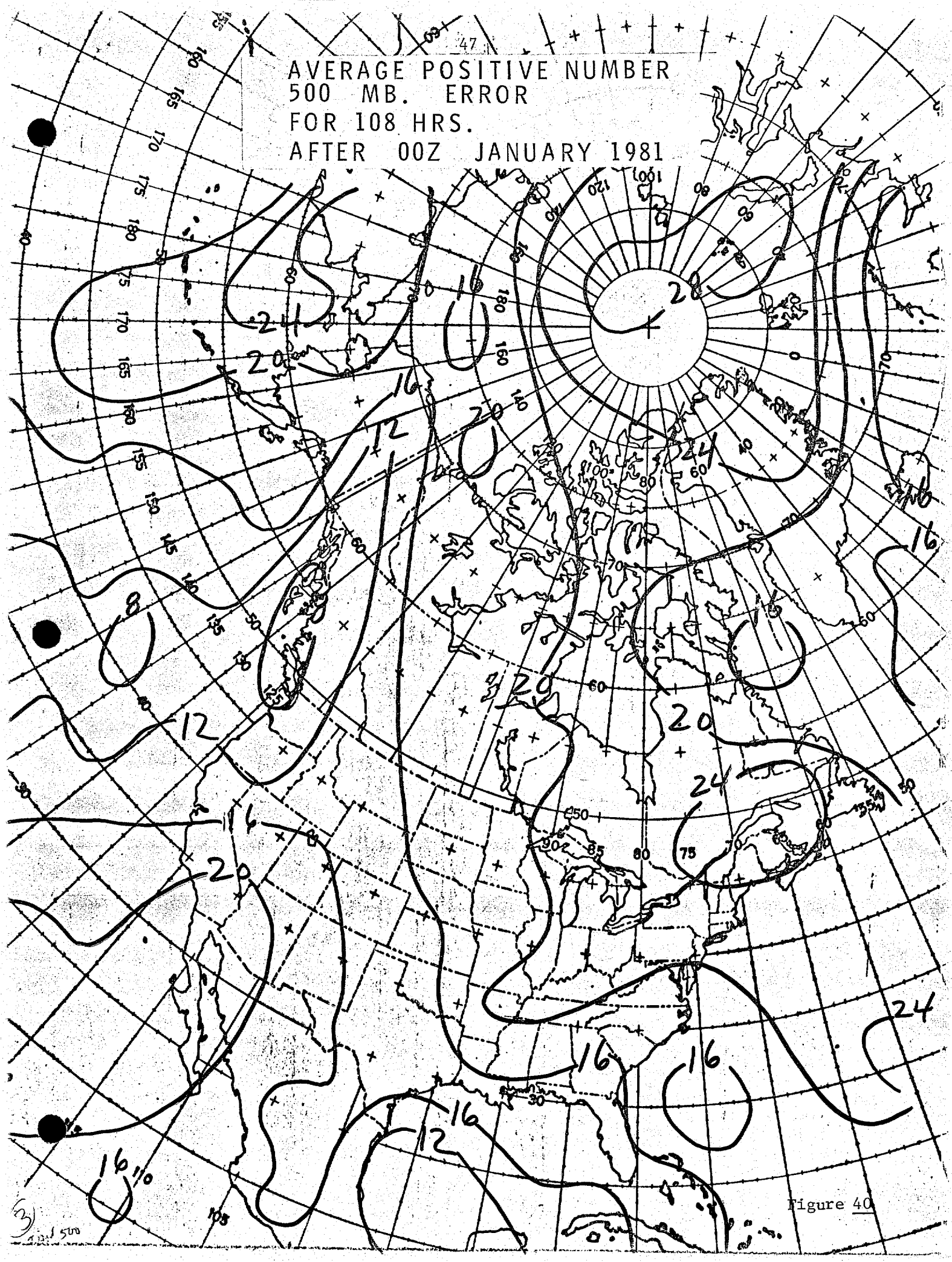
AVERAGE POSITIVE NUMBER
500 MB. ERROR
FOR 108 HRS.
AFTER 00Z JANUARY 1981

Figure 40

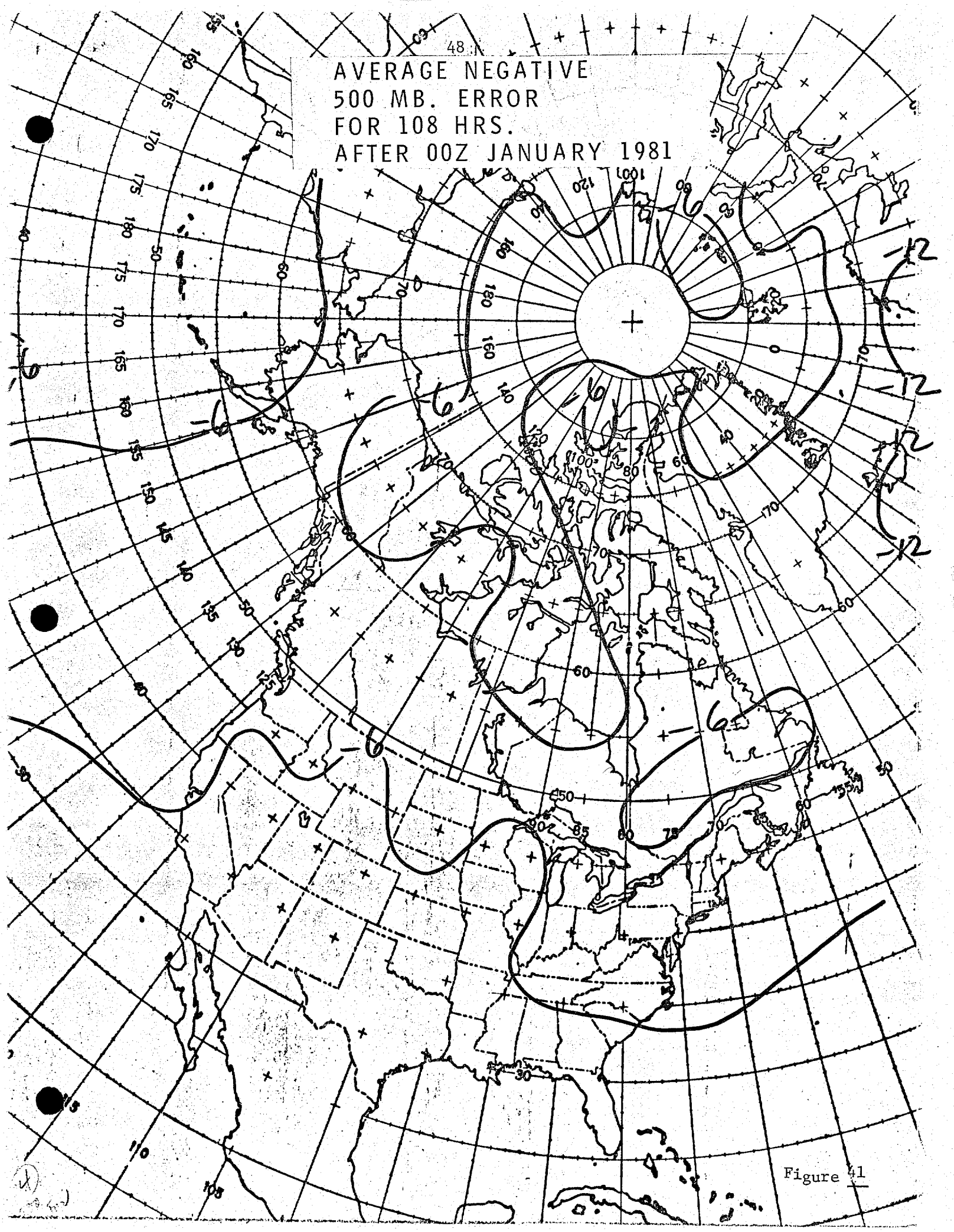
AVERAGE NEGATIVE
500 MB. ERROR
FOR 108 HRS.
AFTER 00Z JANUARY 1981

Figure 41

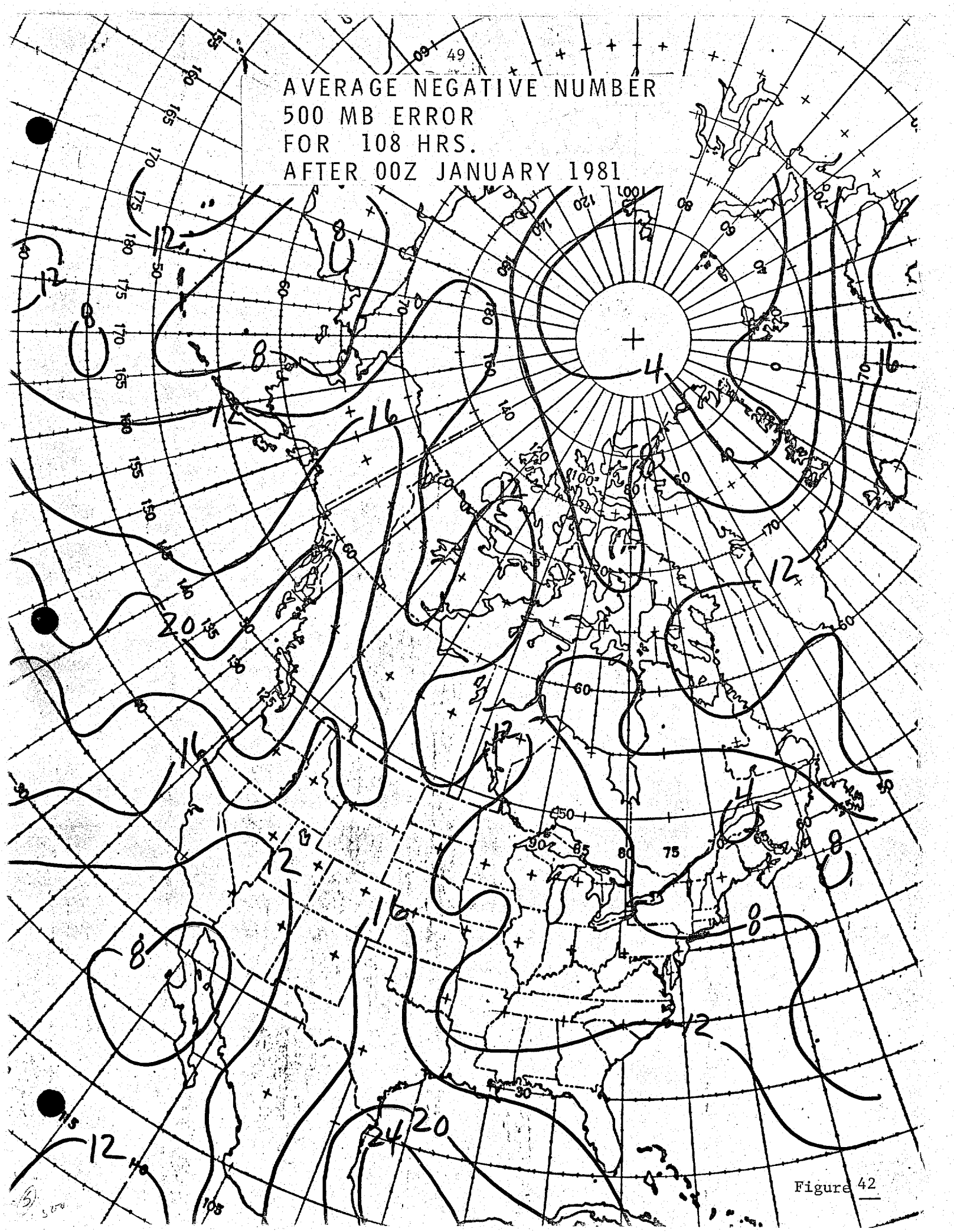
AVERAGE NEGATIVE NUMBER
500 MB ERROR
FOR 108 HRS.
AFTER 00Z JANUARY 1981

Figure 42

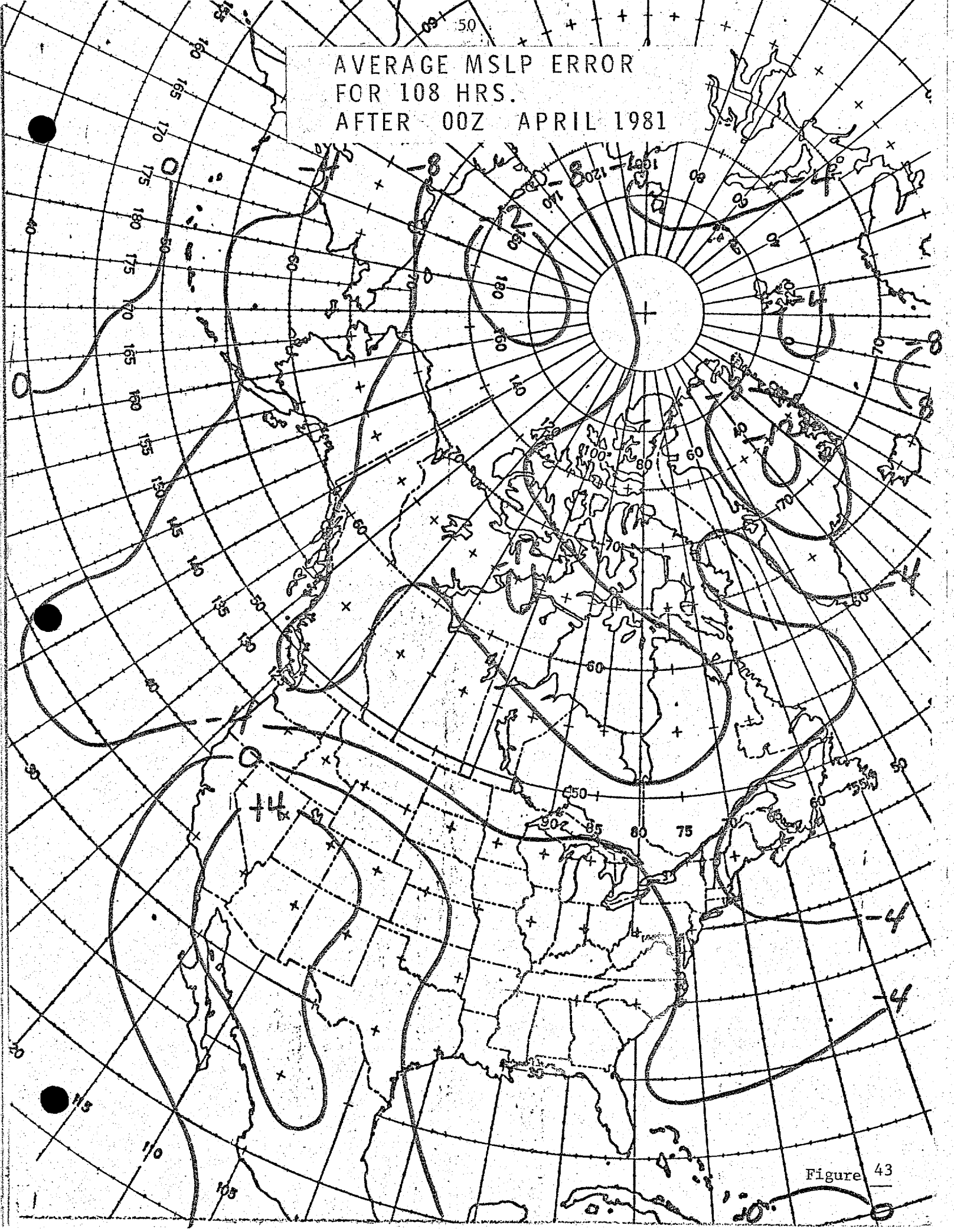

Figure 43

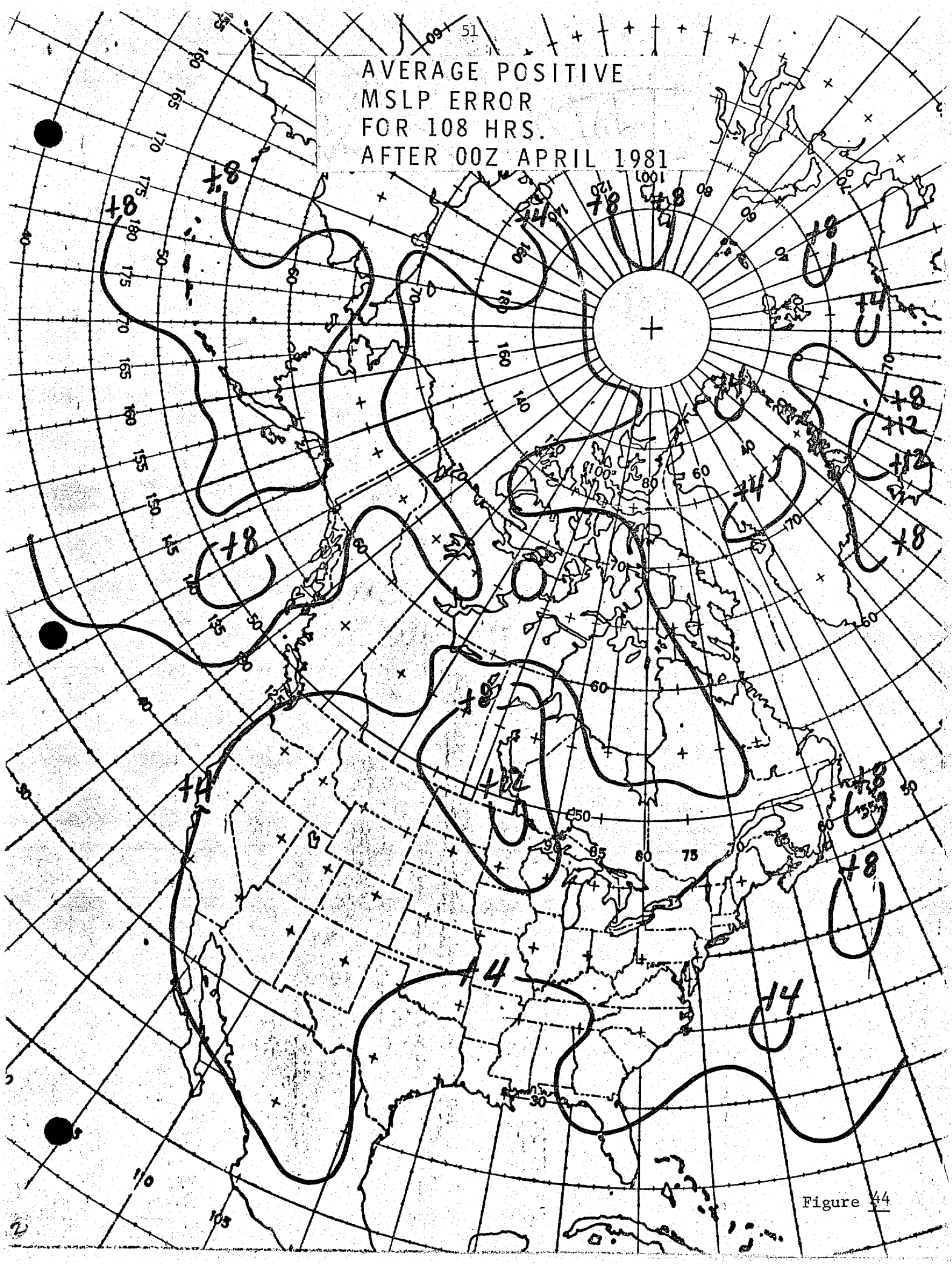
AVERAGE POSITIVE
MSLP ERROR
FOR 108 HRS.
AFTER 00Z APRIL 1981

Figure 44

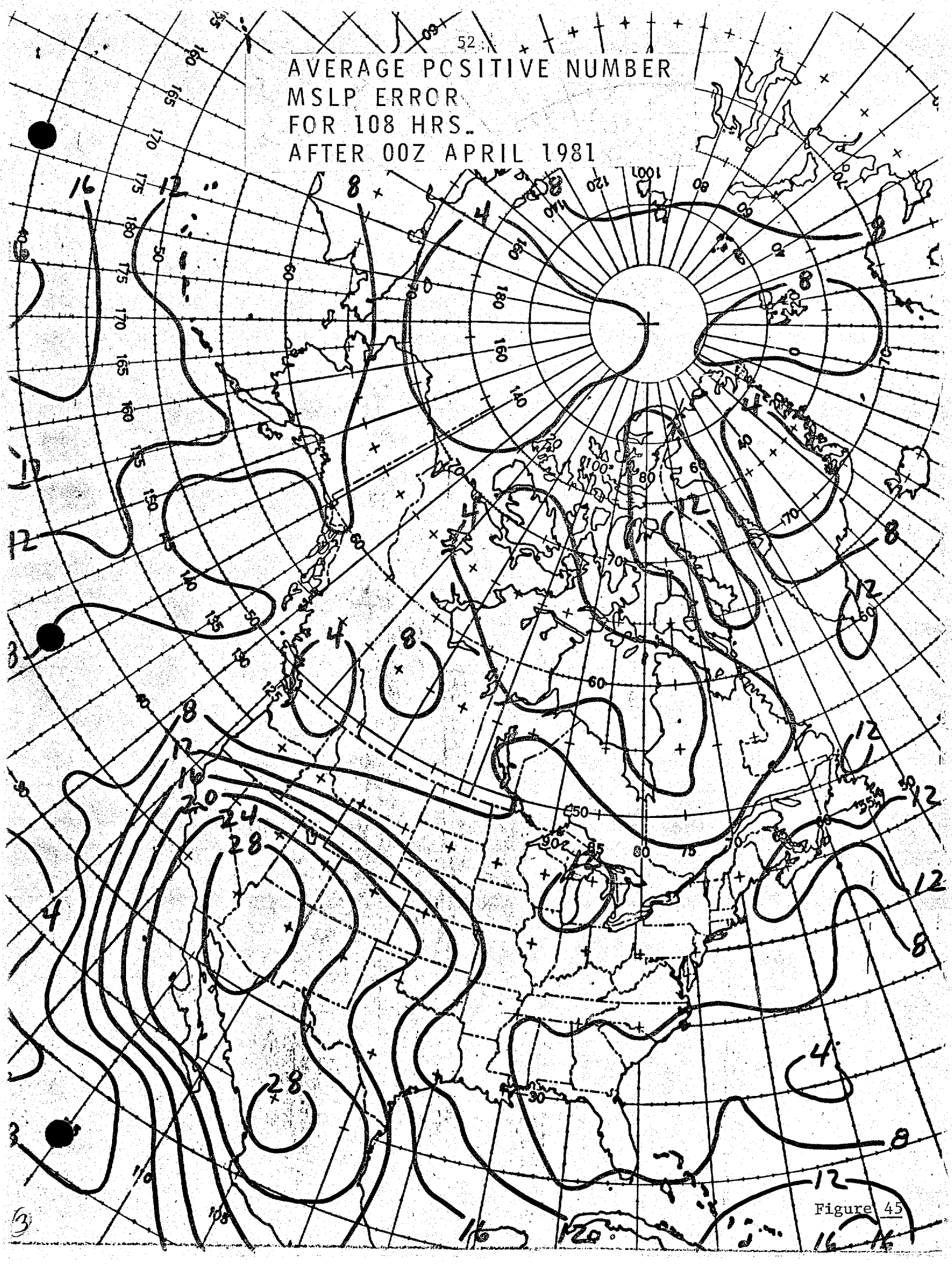
AVERAGE POSITIVE NUMBER
MSLP ERROR
FOR 108 HRS.
AFTER 00Z APRIL 1981

Figure 45

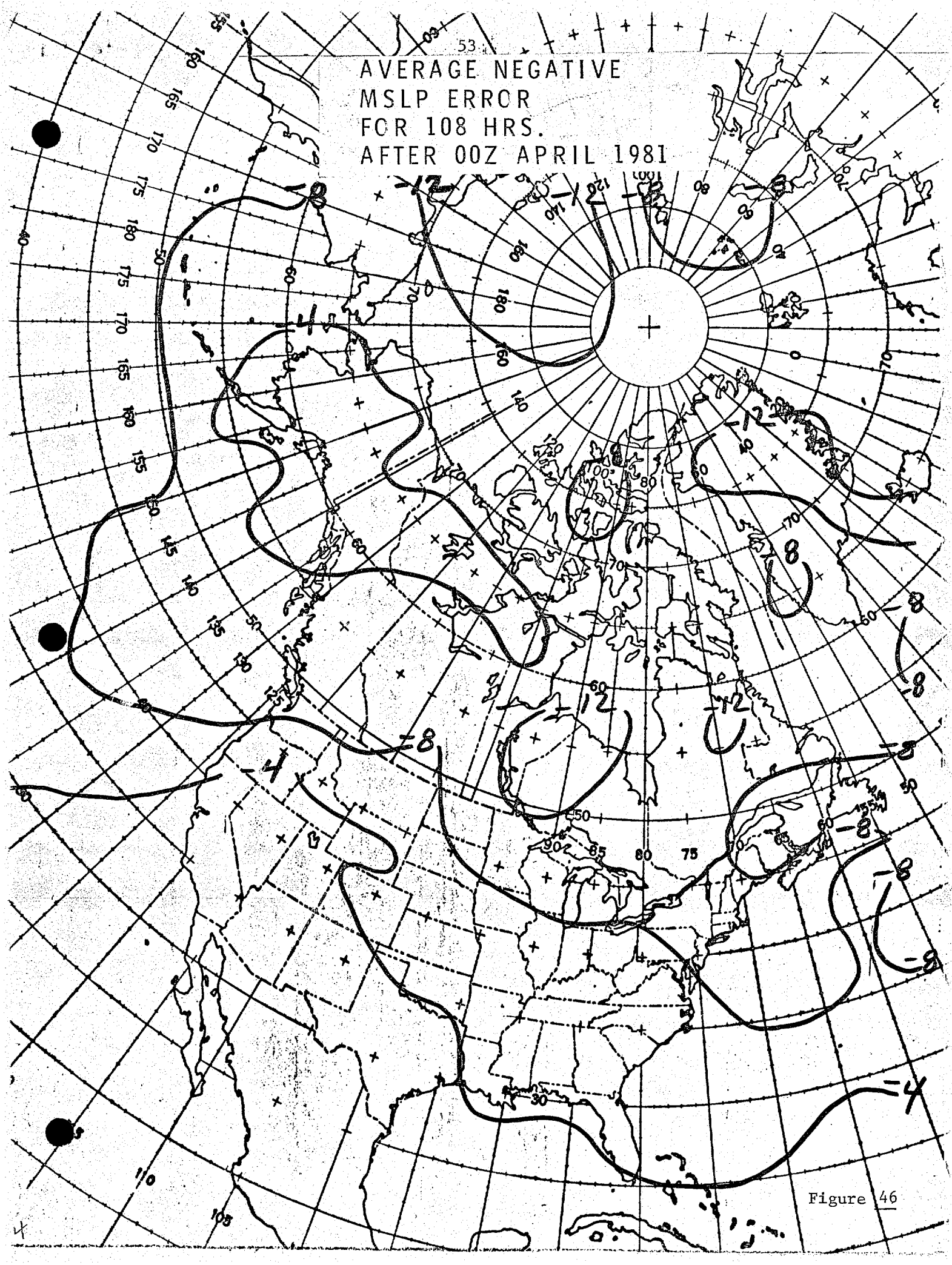
AVERAGE NEGATIVE
MSLP ERROR
FOR 108 HRS.
AFTER 00Z APRIL 1981

Figure 46

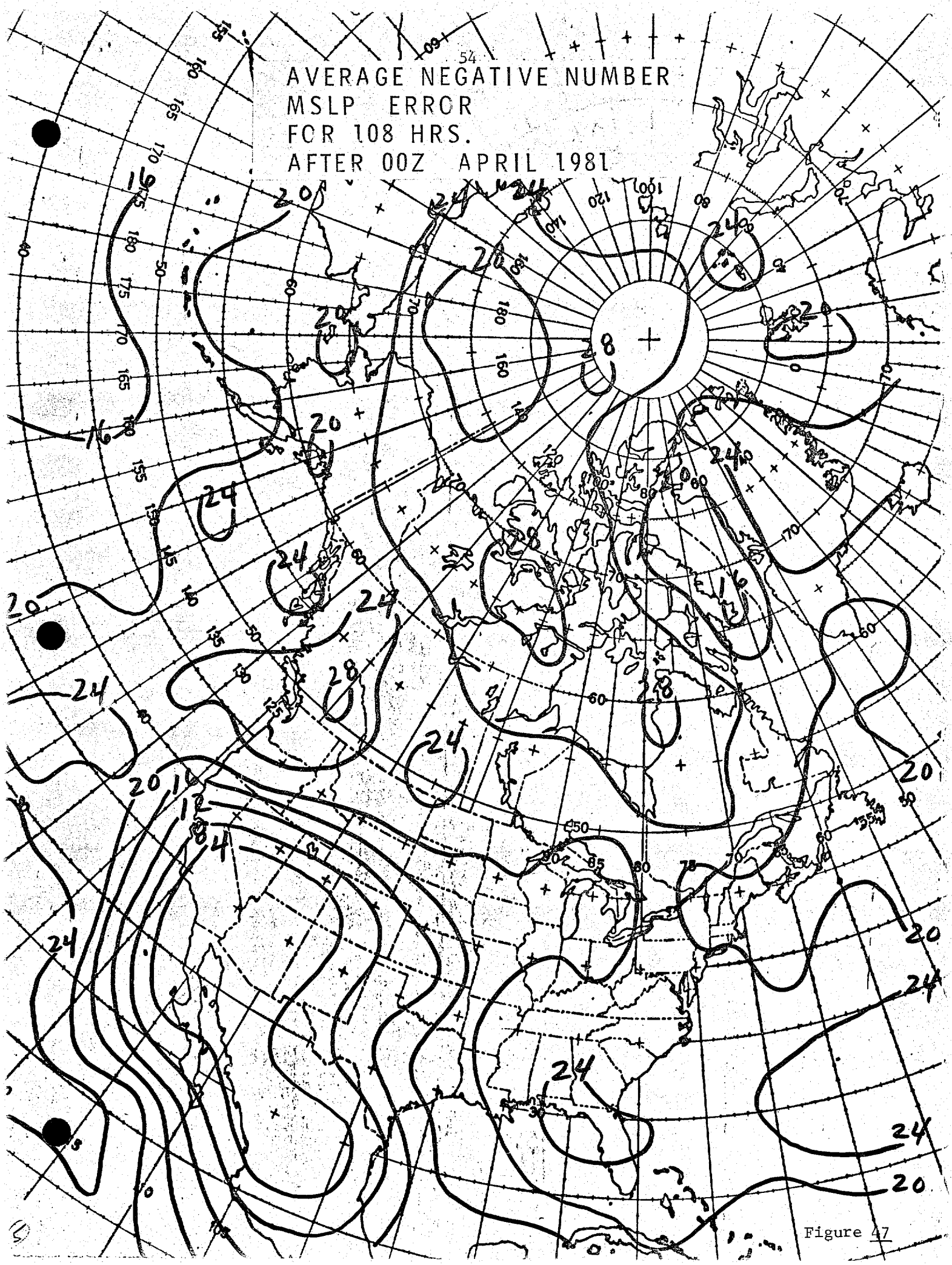
AVERAGE NEGATIVE NUMBER
MSLP ERROR
FOR 108 HRS.
AFTER 00Z APRIL 1981

Figure 47

AVERAGE 500 MB. ERROR
FOR 108 HRS.
AFTER 00Z APRIL 1981

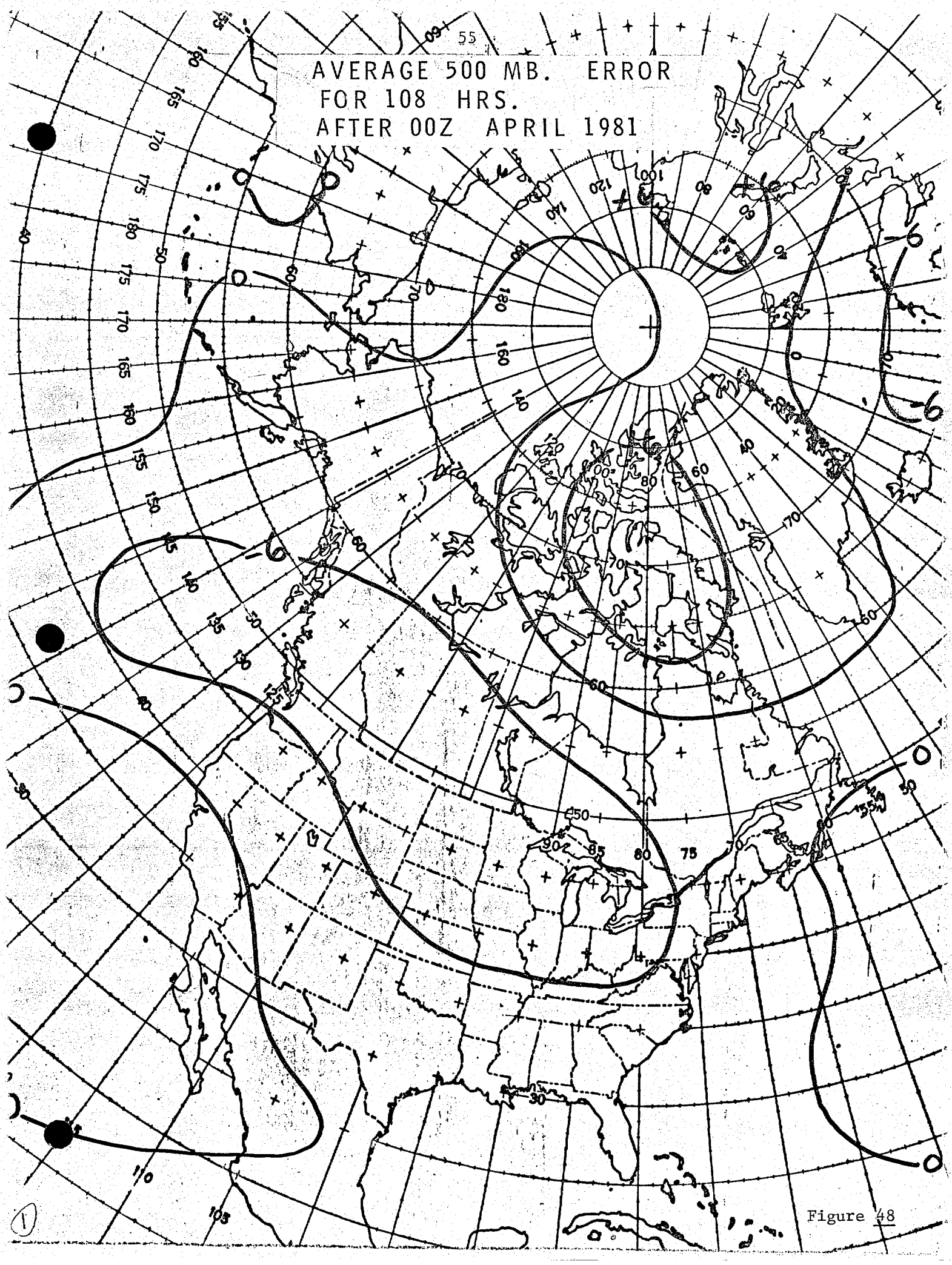

Figure 48

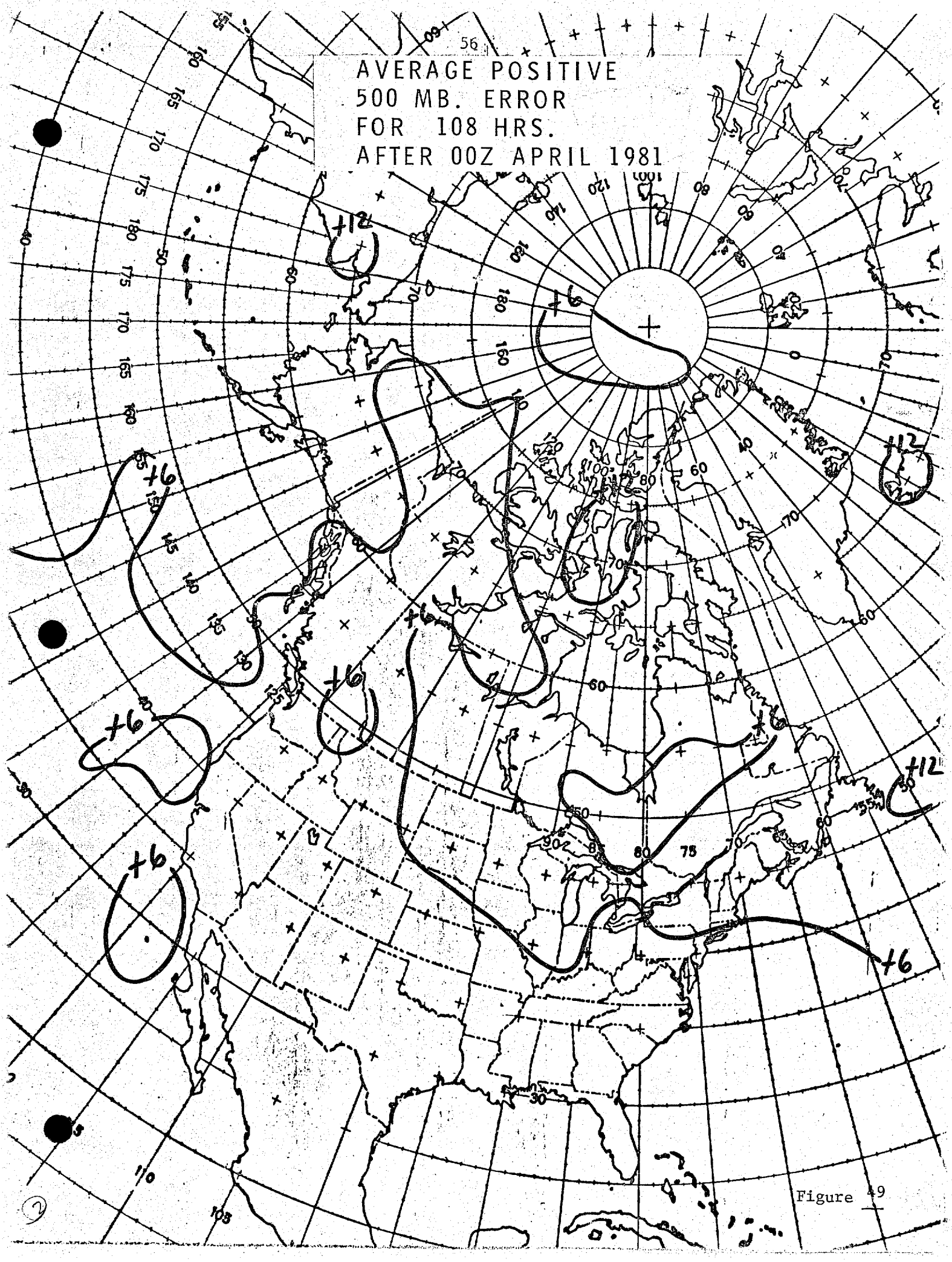
AVERAGE POSITIVE
500 MB. ERROR
FOR 108 HRS.
AFTER 00Z APRIL 1981
+12
+6
+6
+6
+6
+6
+6
+12
+12
+6

Figure 49

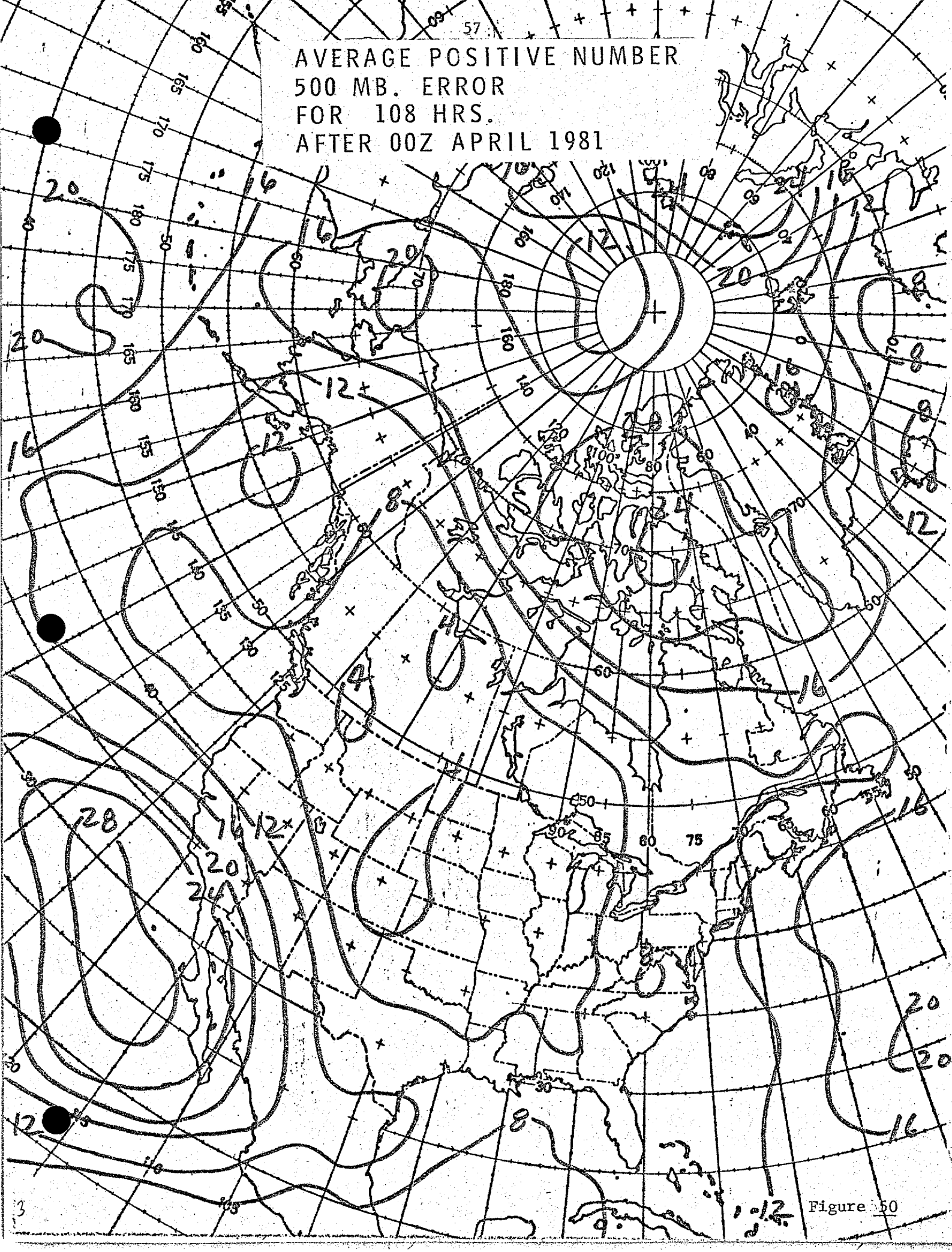
AVERAGE POSITIVE NUMBER
500 MB. ERROR
FOR 108 HRS.
AFTER 00Z APRIL 1981

Figure 50

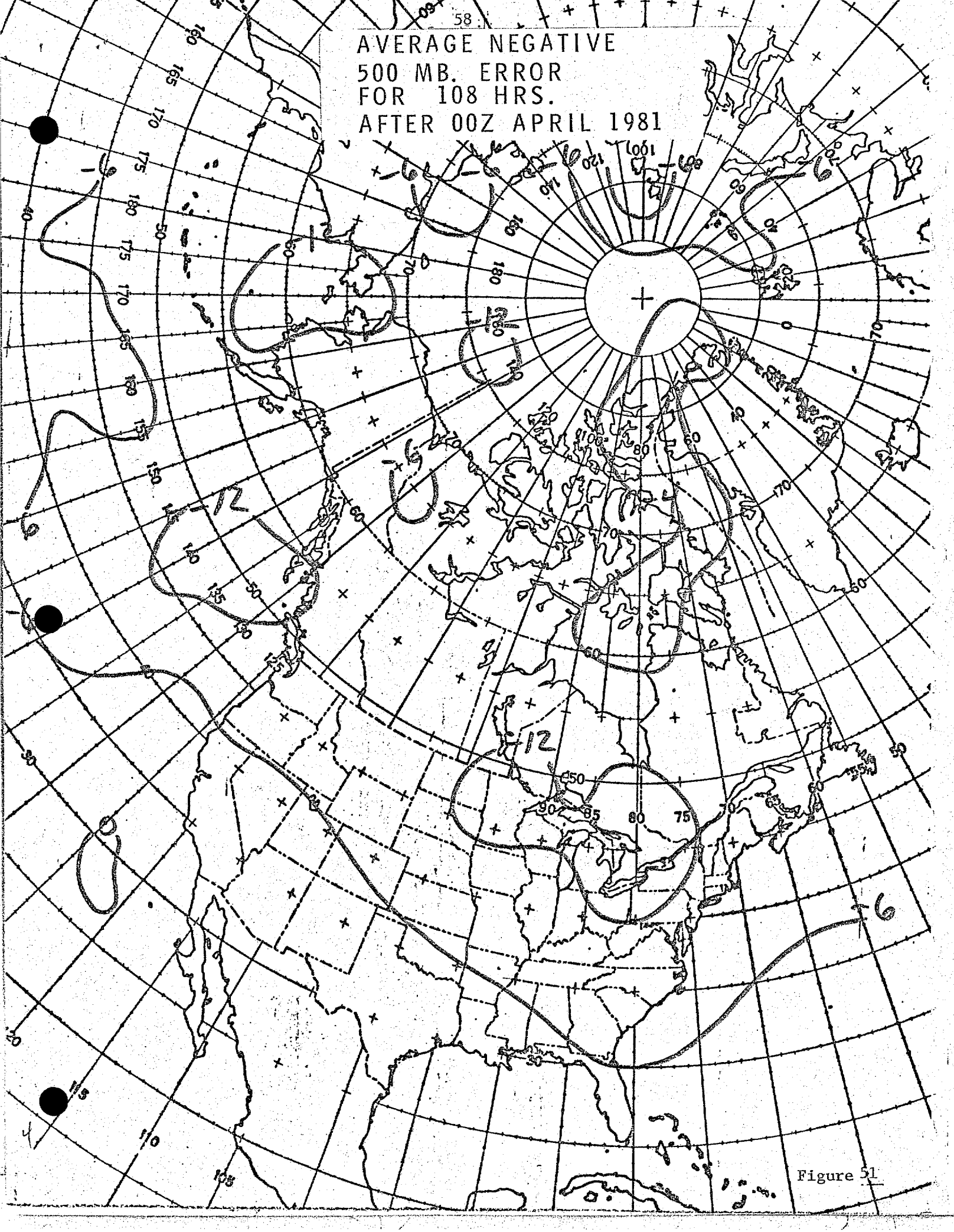
AVERAGE NEGATIVE
500 MB. ERROR
FOR 108 HRS.
AFTER 00Z APRIL 1981

Figure 51

AVERAGE NEGATIVE NUMBER
500 MB. ERROR
FOR 108 HRS.
AFTER 00Z APRIL 1981

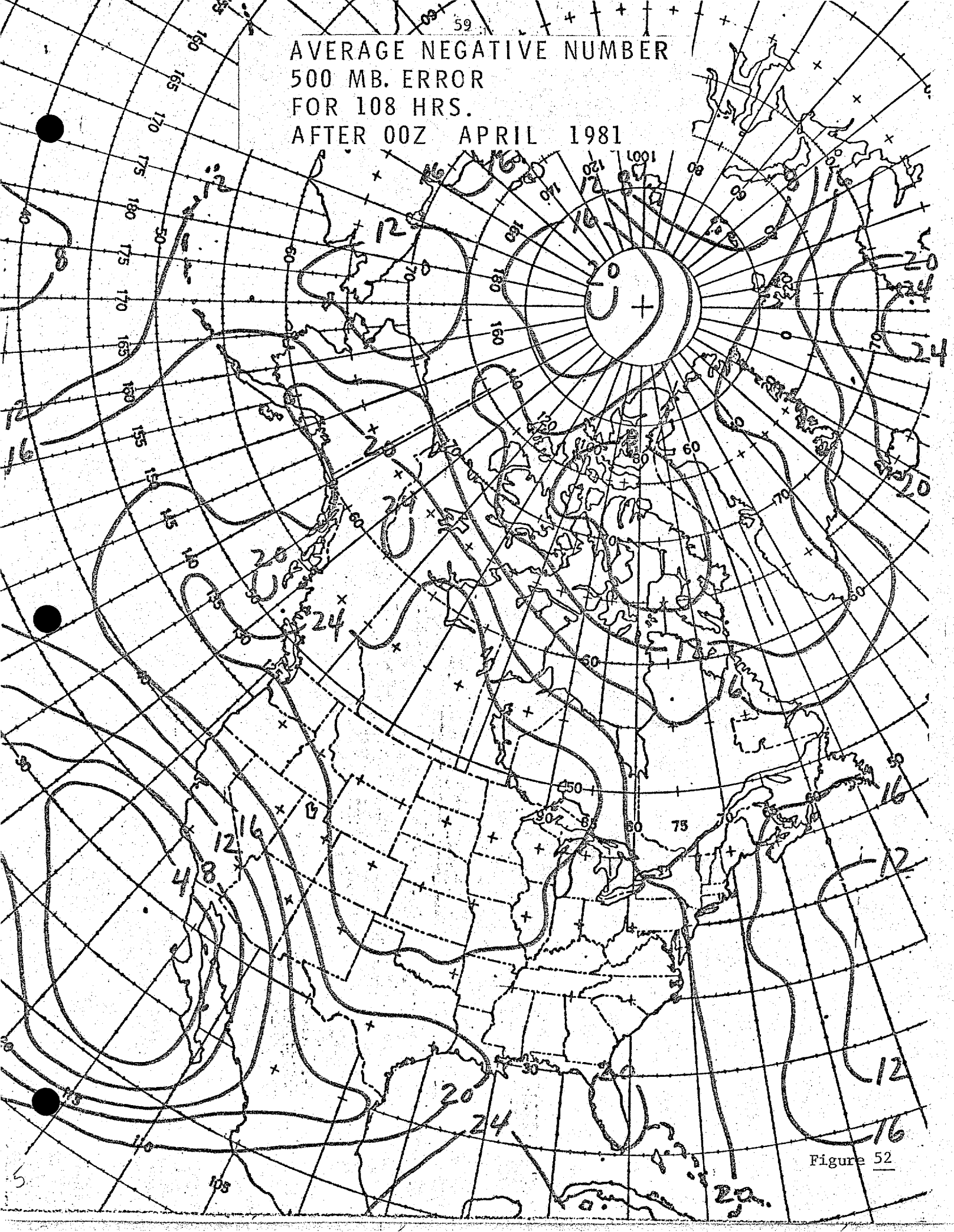

Figure 52

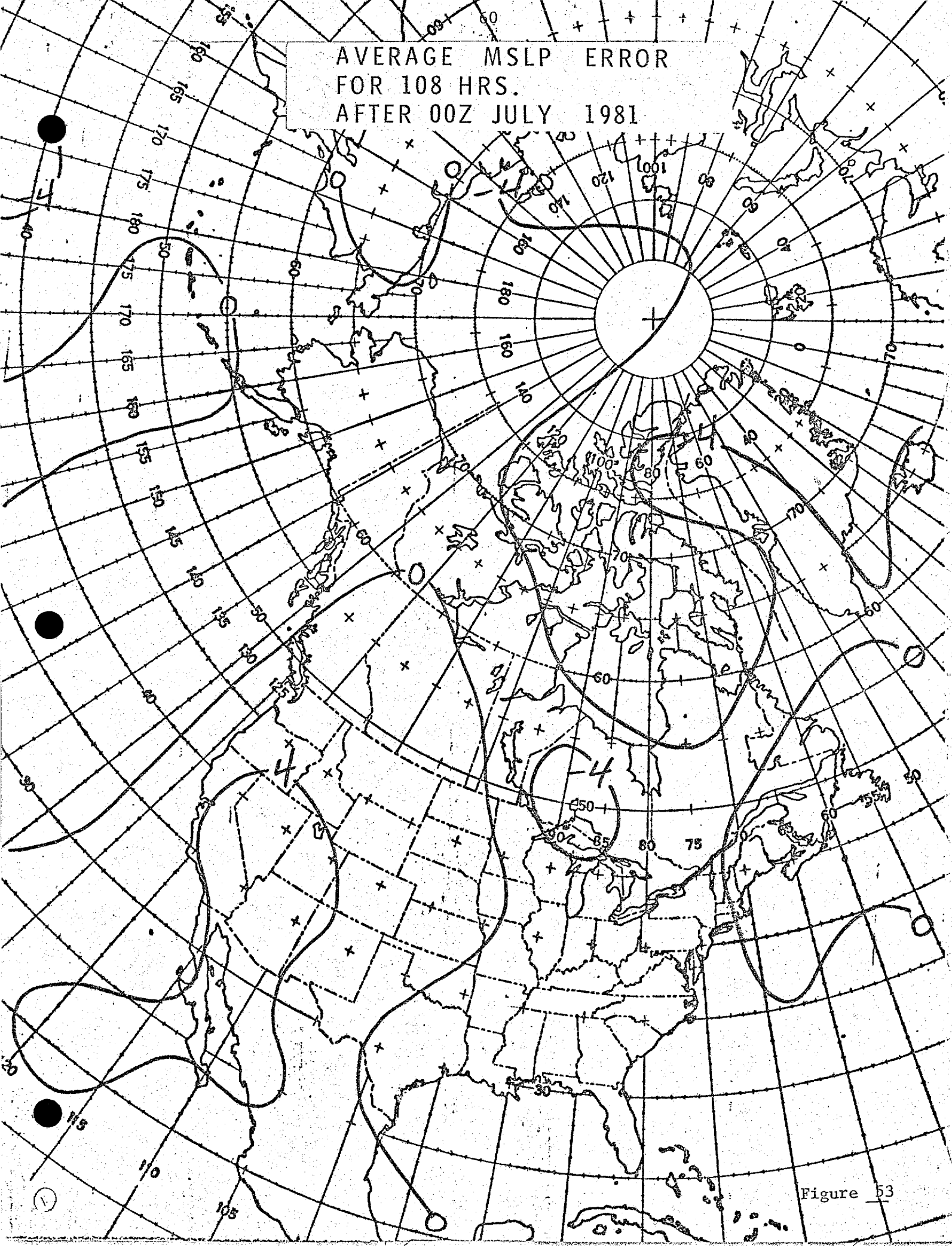

Figure 53

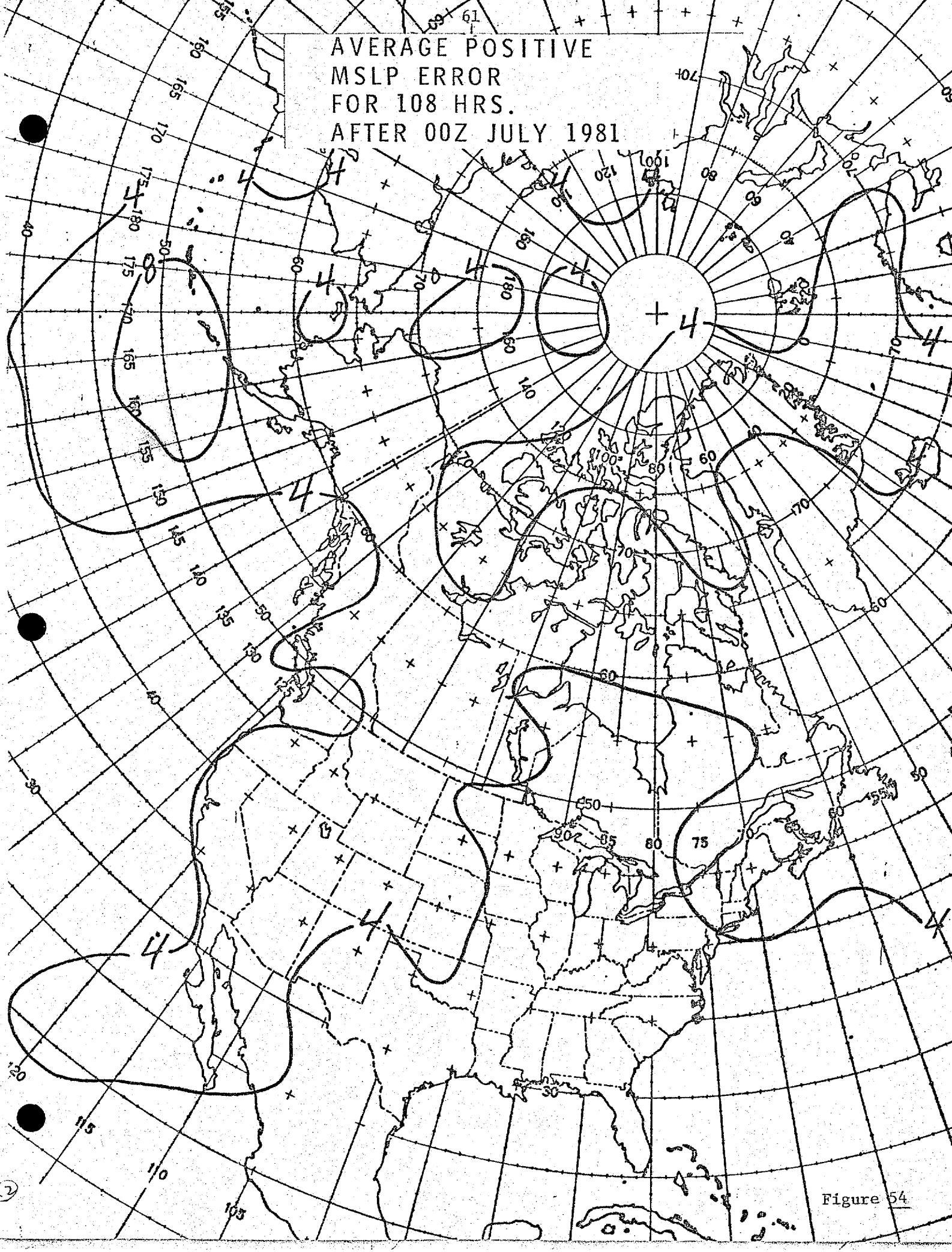

Figure 54

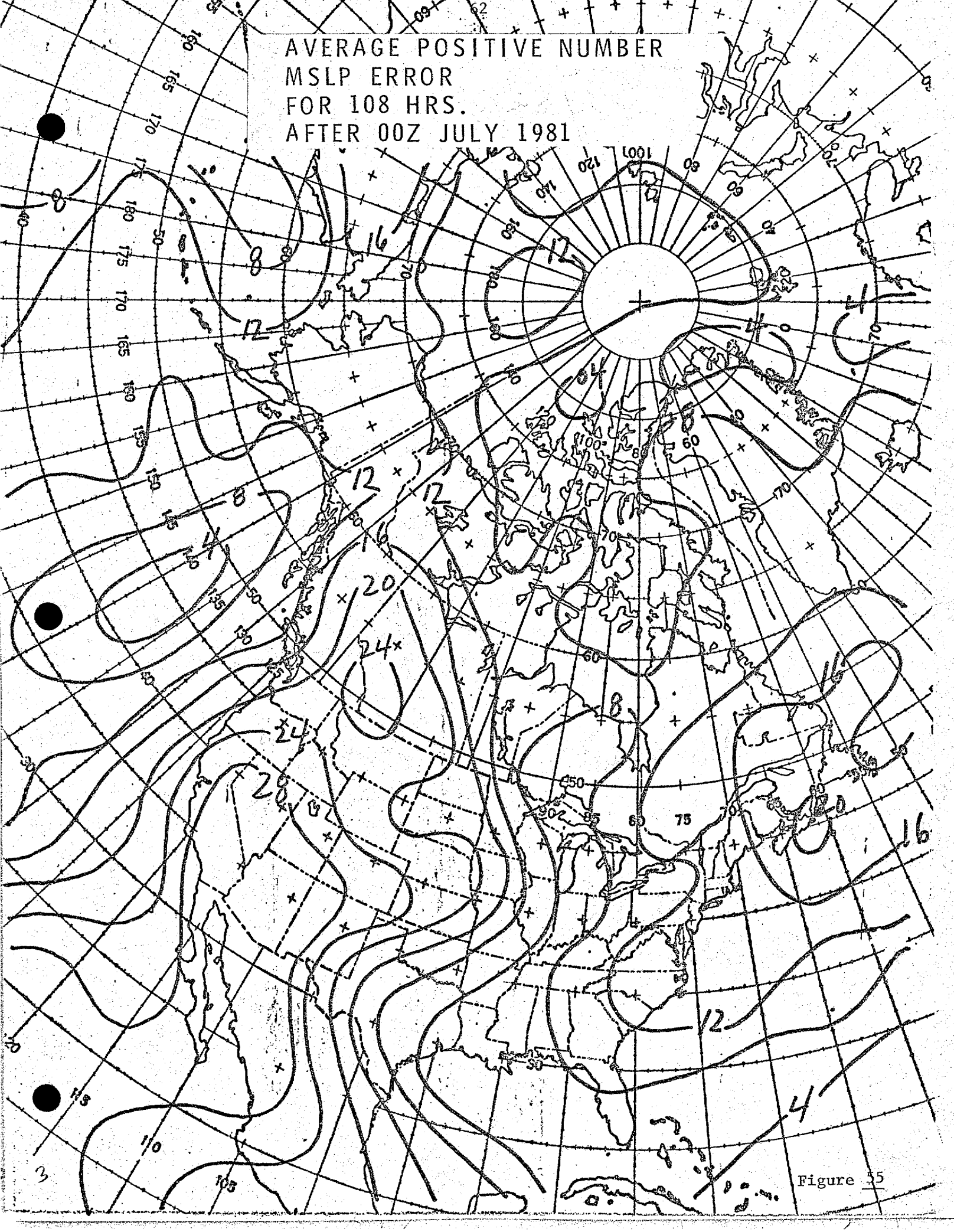
AVERAGE POSITIVE NUMBER
MSLP ERROR
FOR 108 HRS.
AFTER 00Z JULY 1981

Figure 55

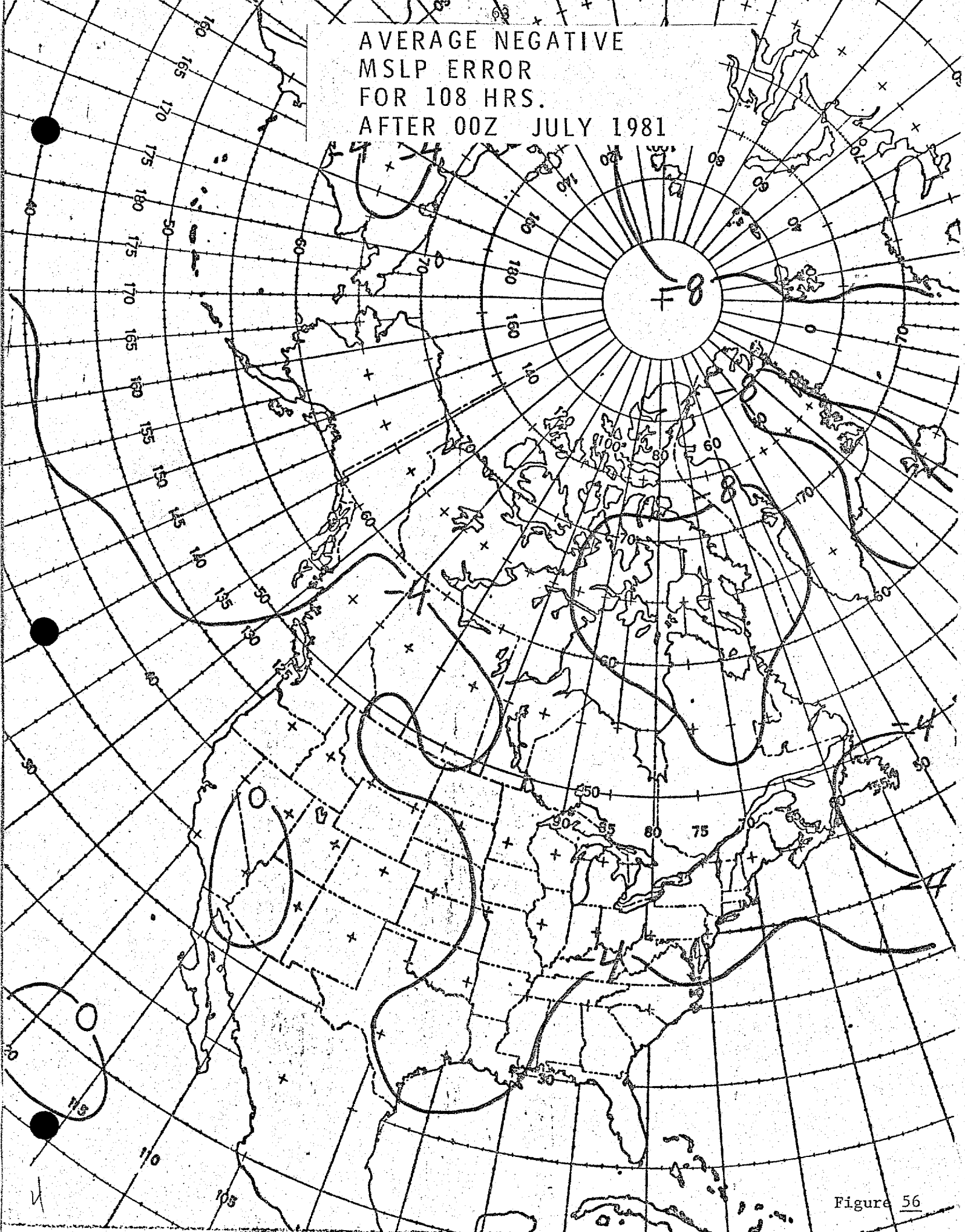

Figure 56

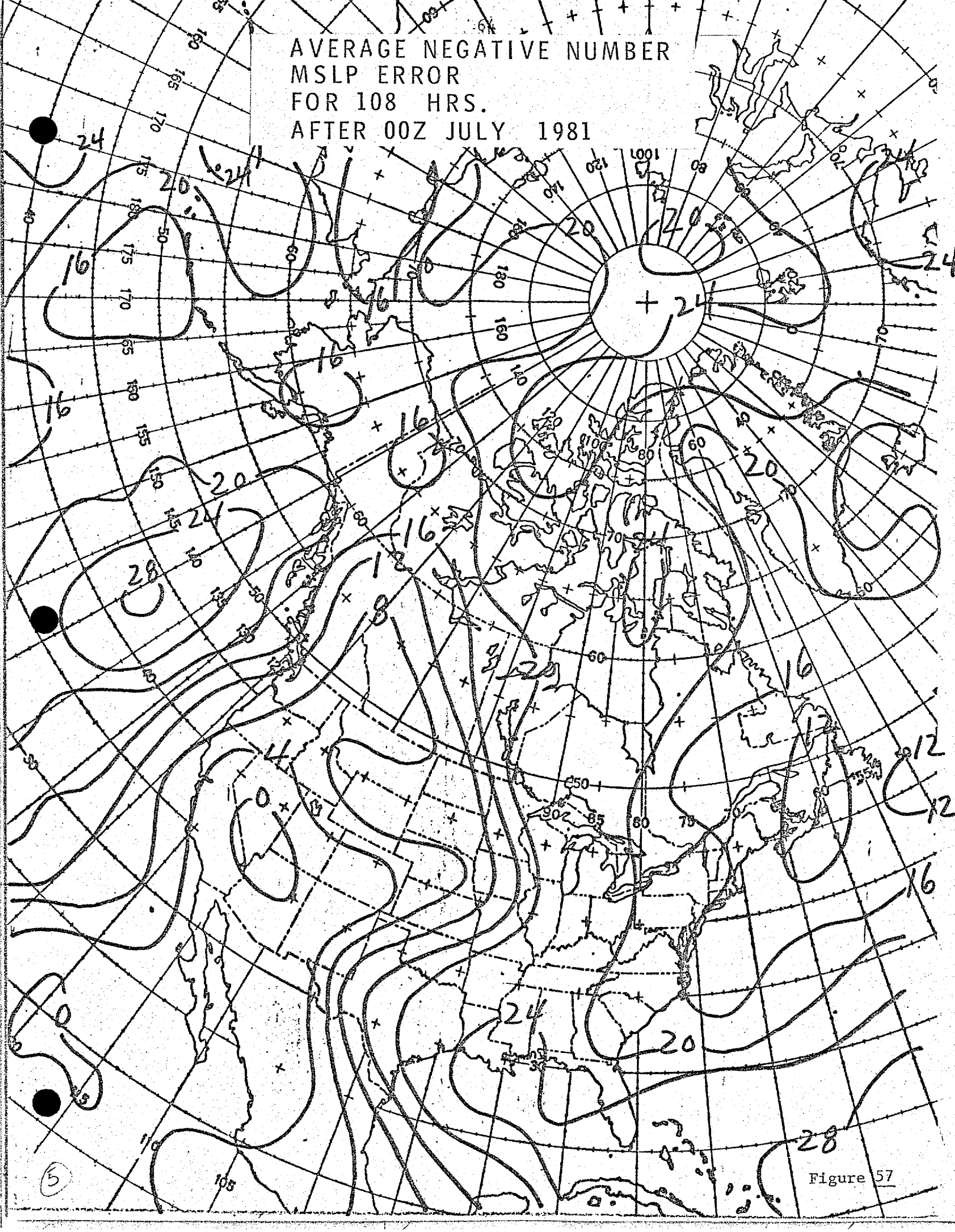
AVERAGE NEGATIVE NUMBER
MSLP ERROR
FOR 108 HRS.
AFTER 00Z JULY 1981

Figure 57

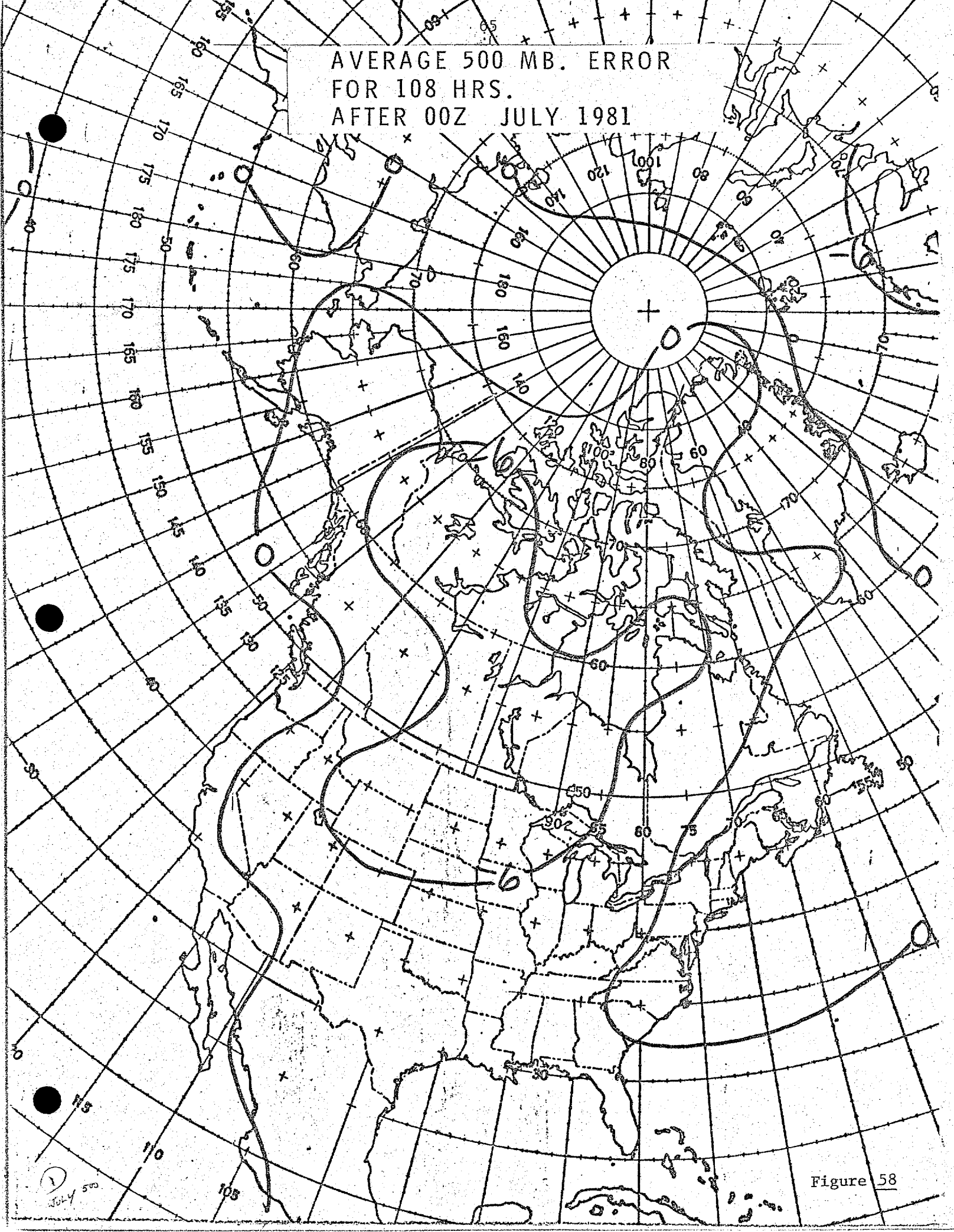

Figure 58

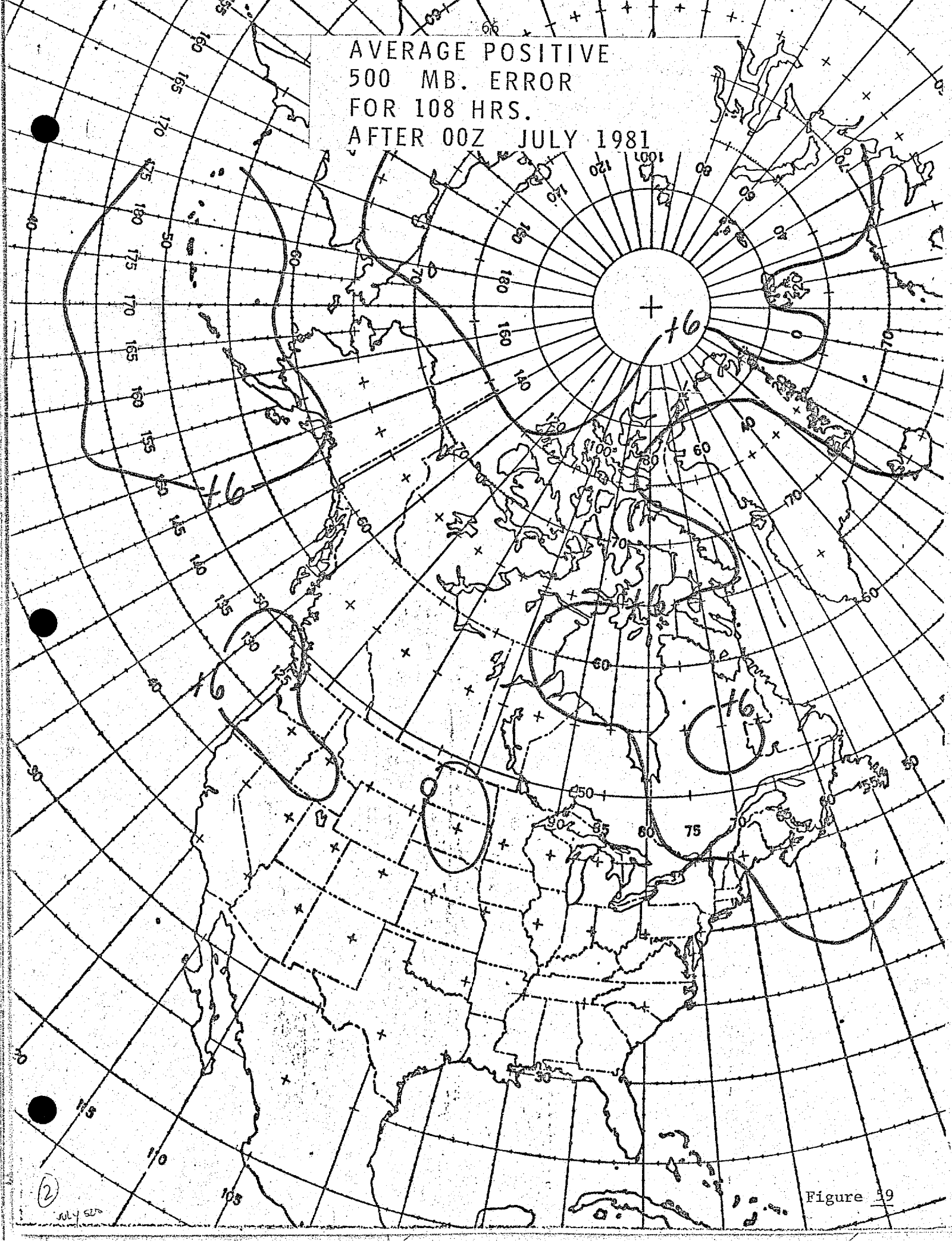
AVERAGE POSITIVE
500 MB. ERROR
FOR 108 HRS.
AFTER 00Z JULY 1981

Figure 19

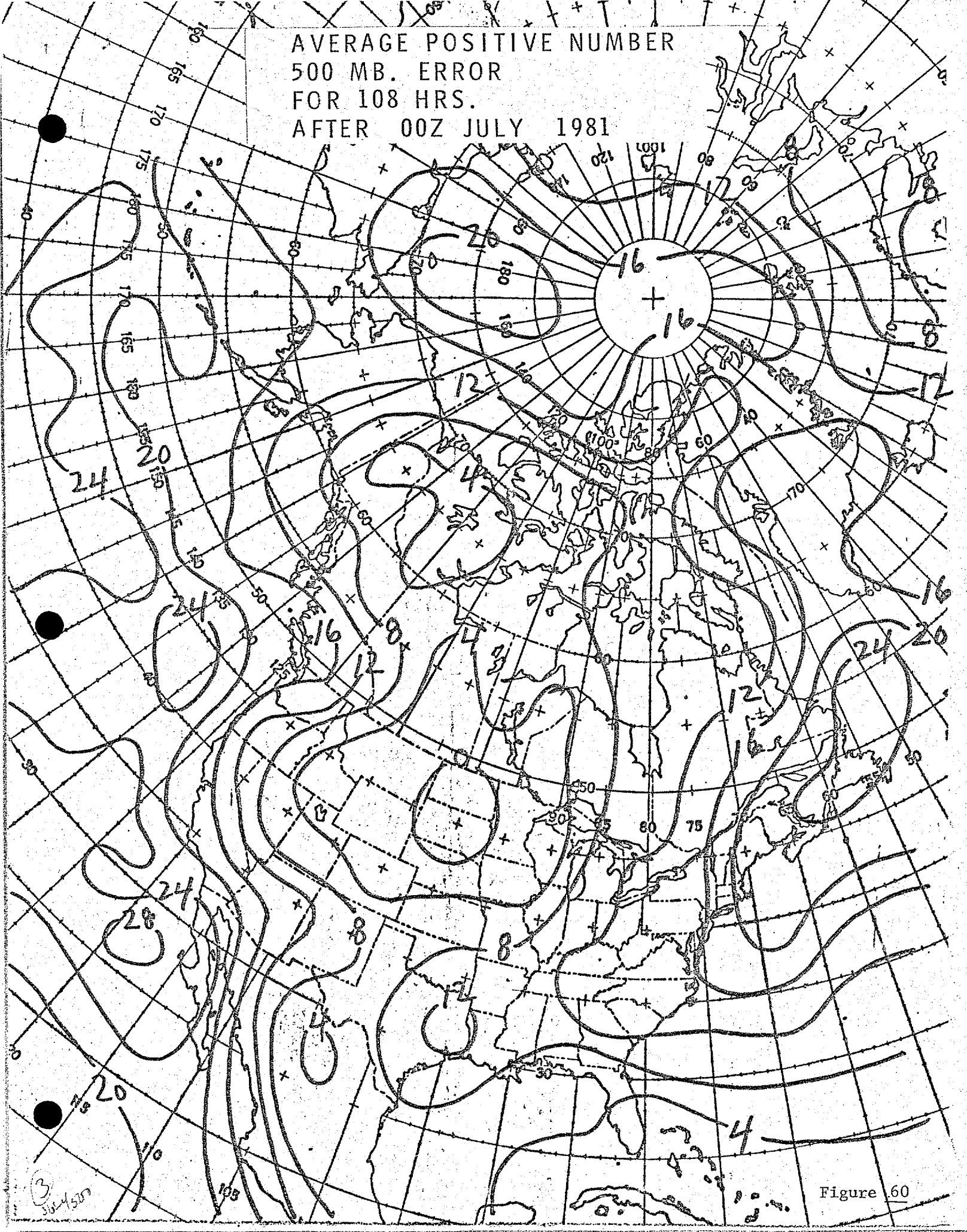
AVERAGE POSITIVE NUMBER
500 MB. ERROR
FOR 108 HRS.
AFTER 00Z JULY 1981

Figure 60

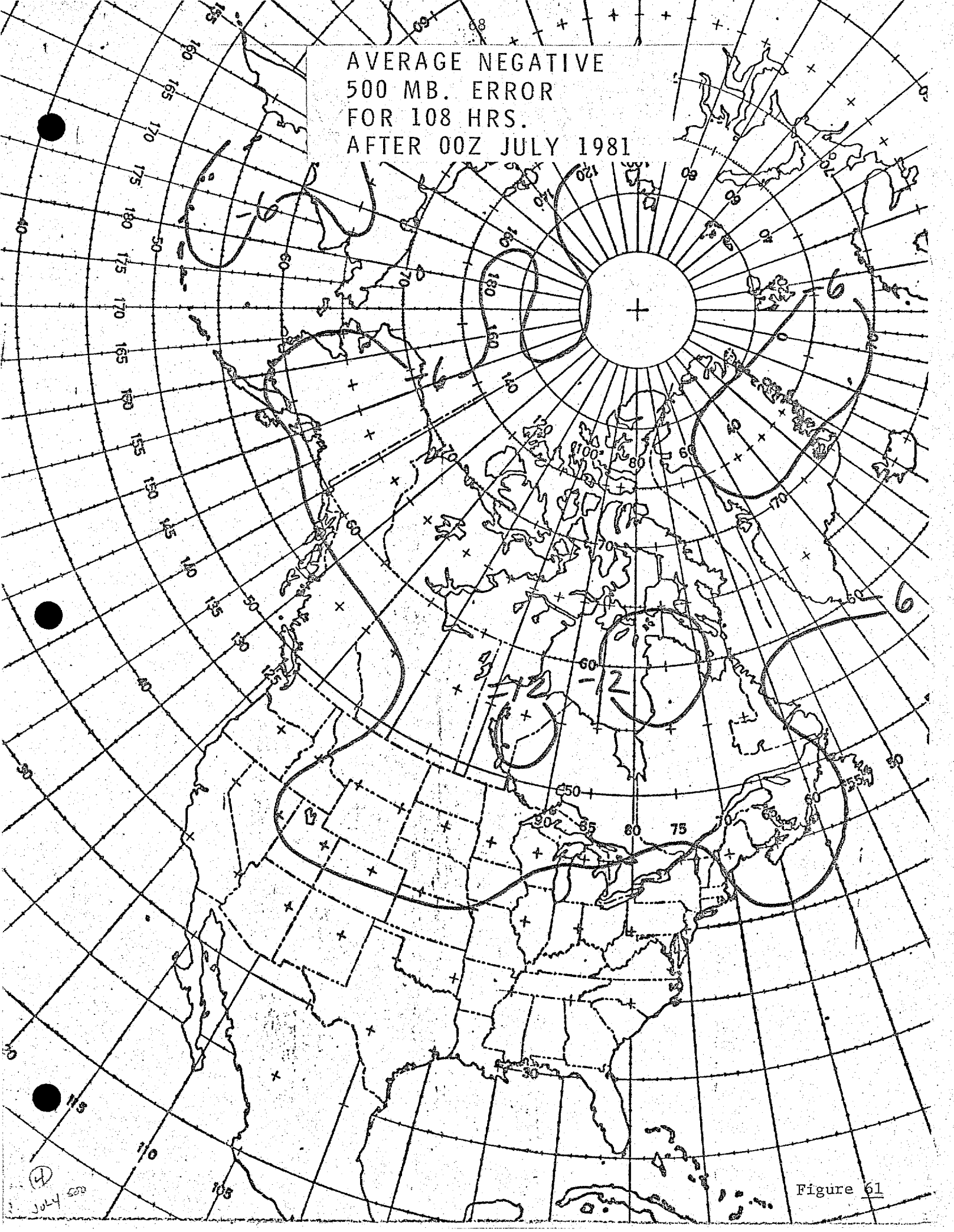
AVERAGE NEGATIVE
500 MB. ERROR
FOR 108 HRS.
AFTER 00Z JULY 1981
-6
-6
-6
-12
-12
JULY 500

Figure 61

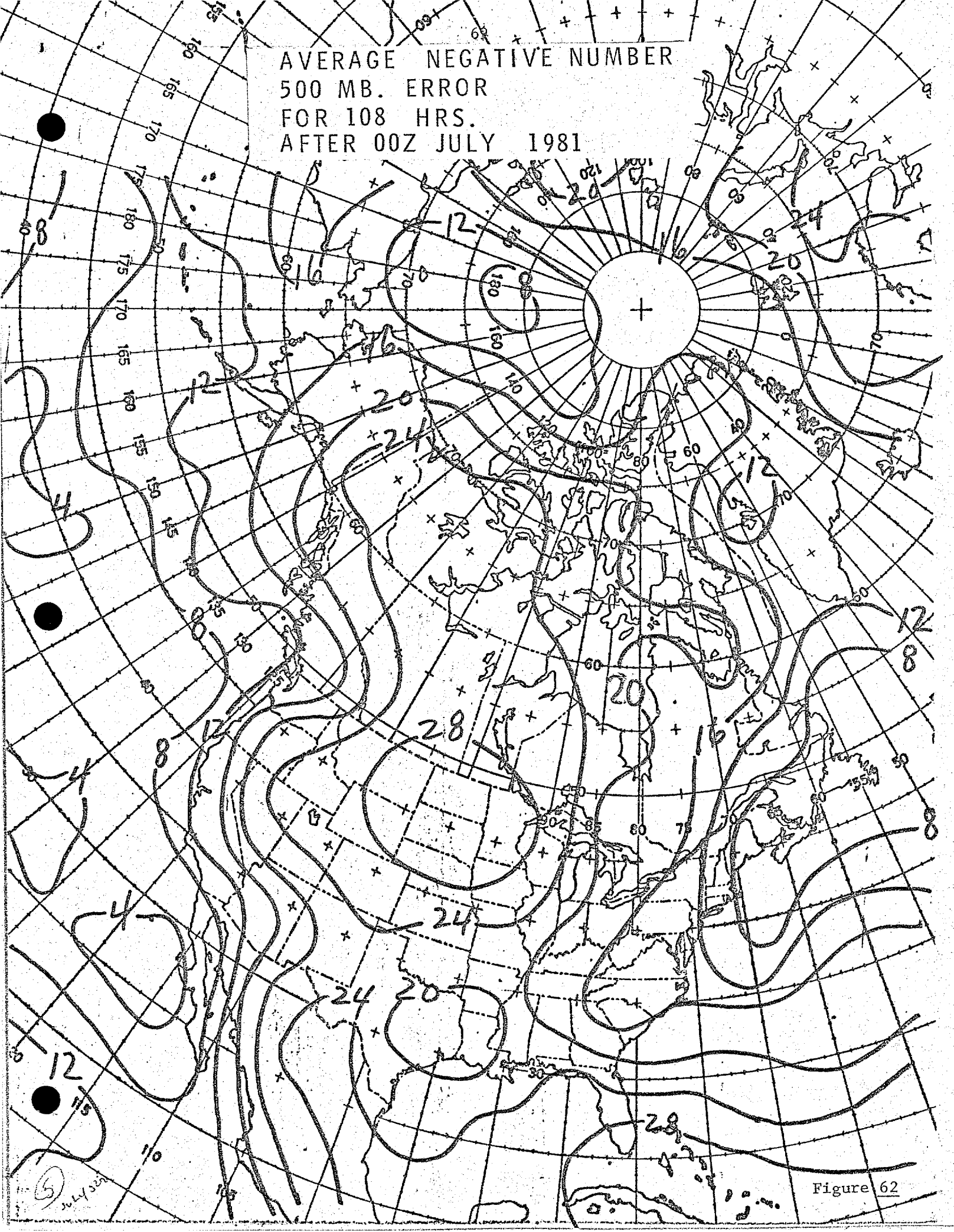
AVERAGE NEGATIVE NUMBER
500 MB. ERROR
FOR 108 HRS.
AFTER 00Z JULY 1981

Figure 62

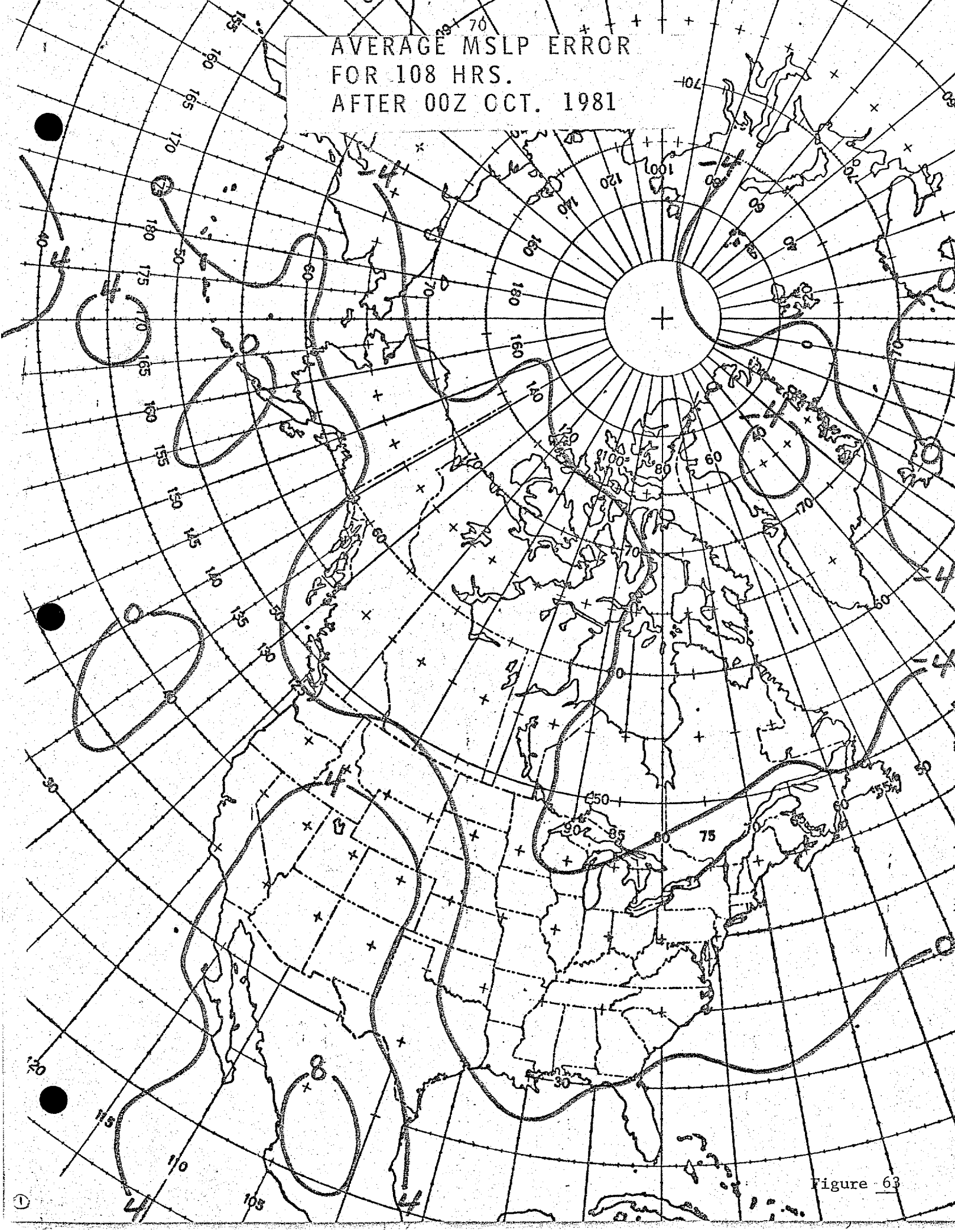

Figure 63

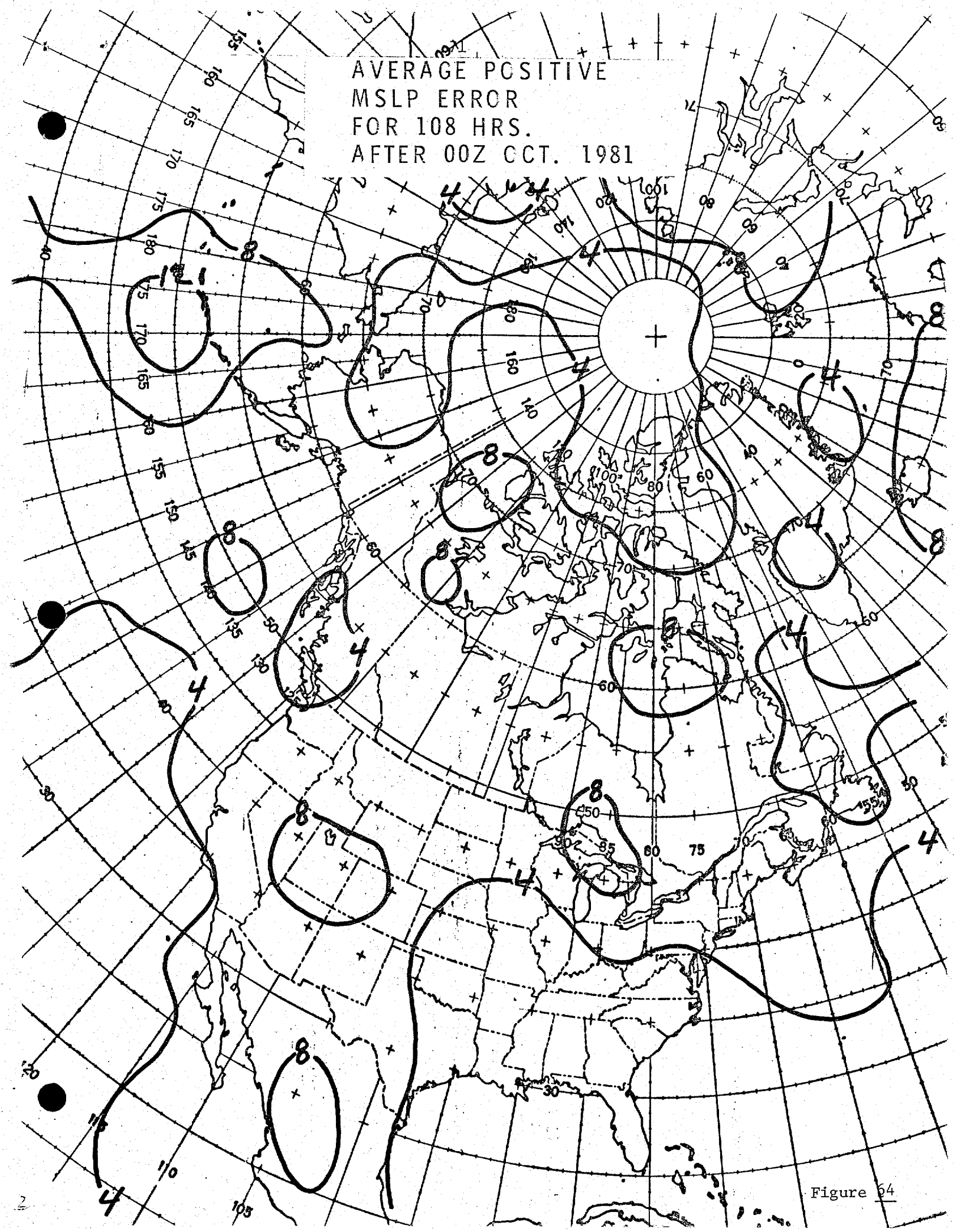

Figure 64

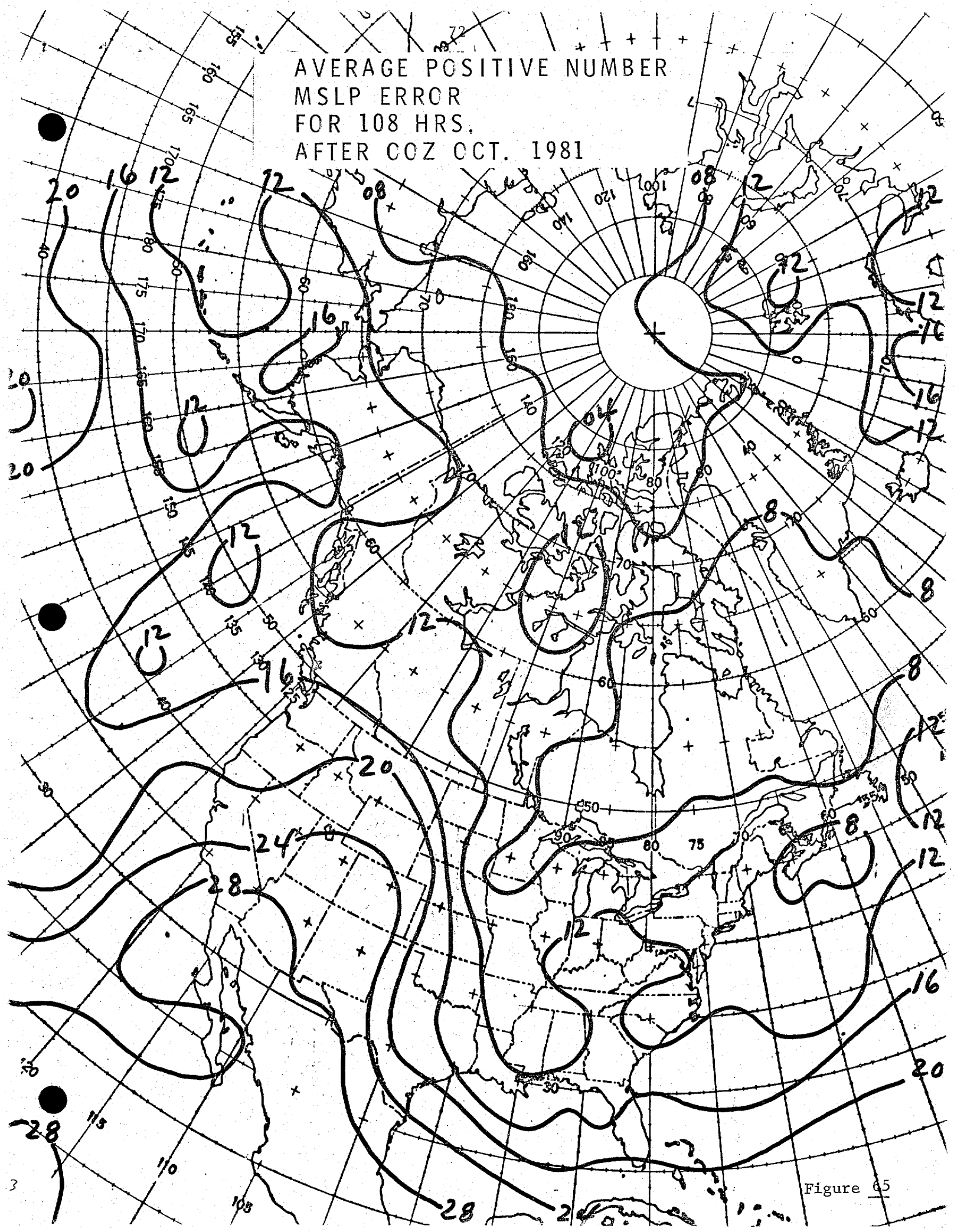
AVERAGE POSITIVE NUMBER
MSLP ERROR
FOR 108 HRS.
AFTER COZ OCT. 1981

Figure 65

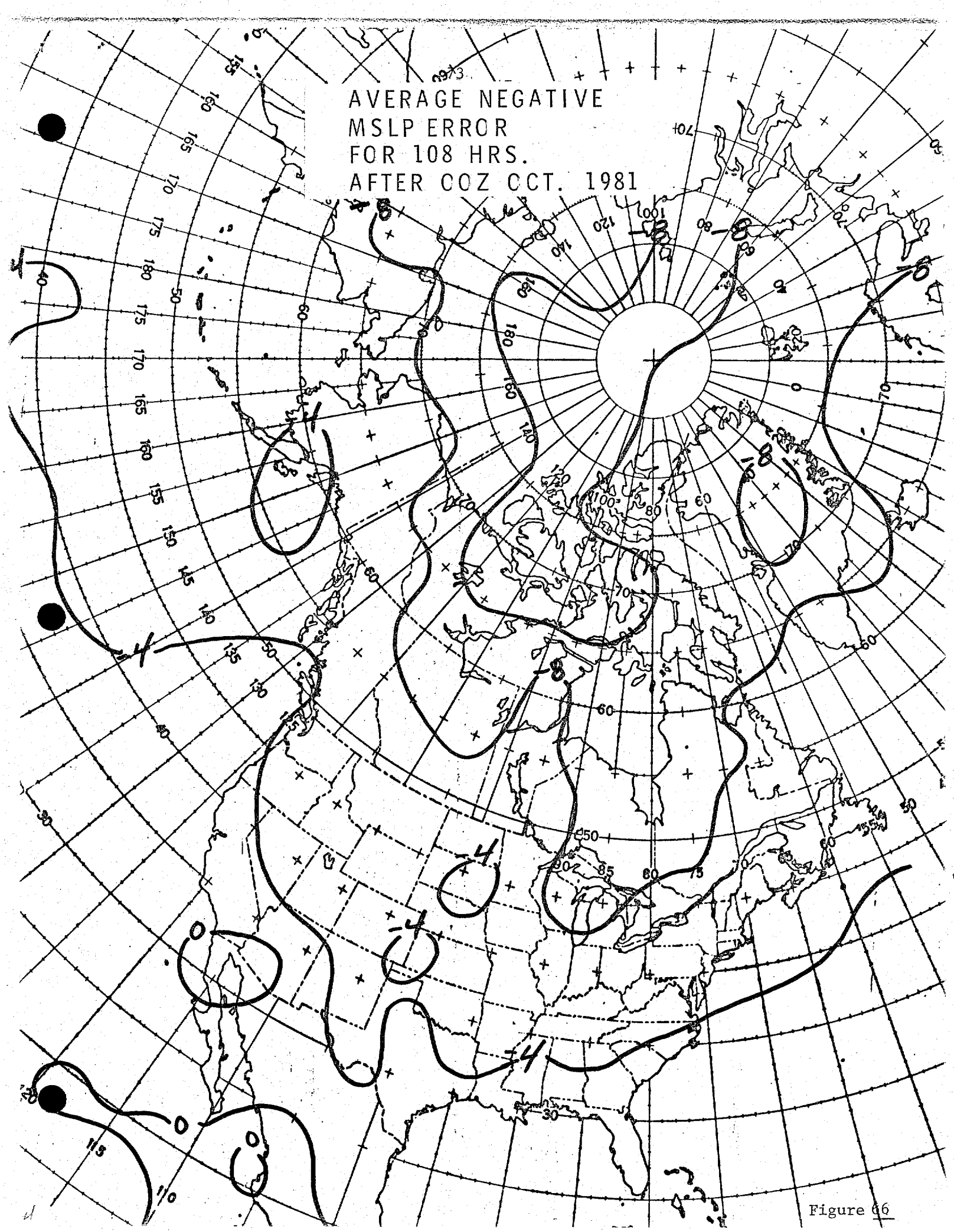

Figure 66

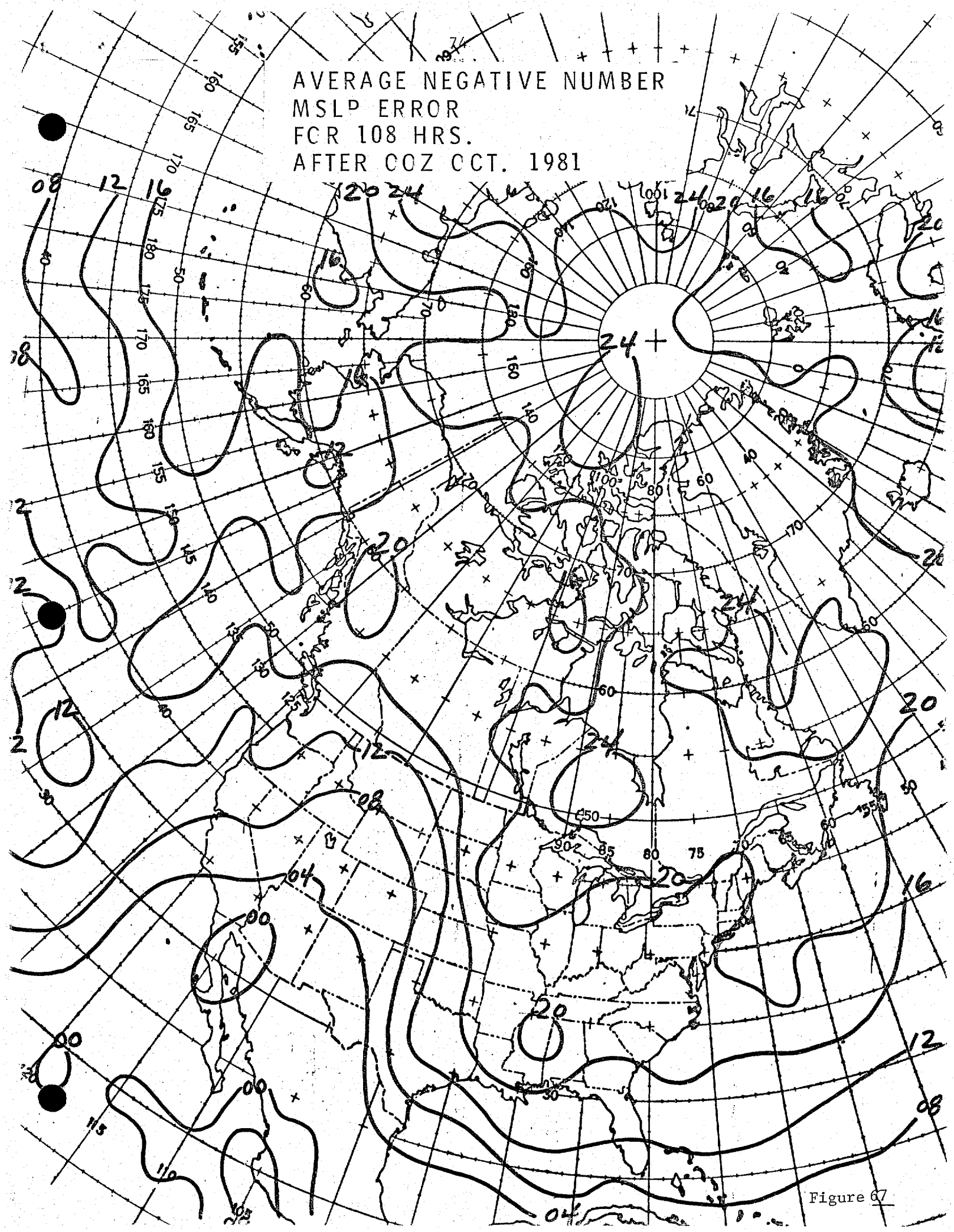
AVERAGE NEGATIVE NUMBER
MSLP ERROR
FOR 108 HRS.
AFTER COZ OCT. 1981

Figure 67

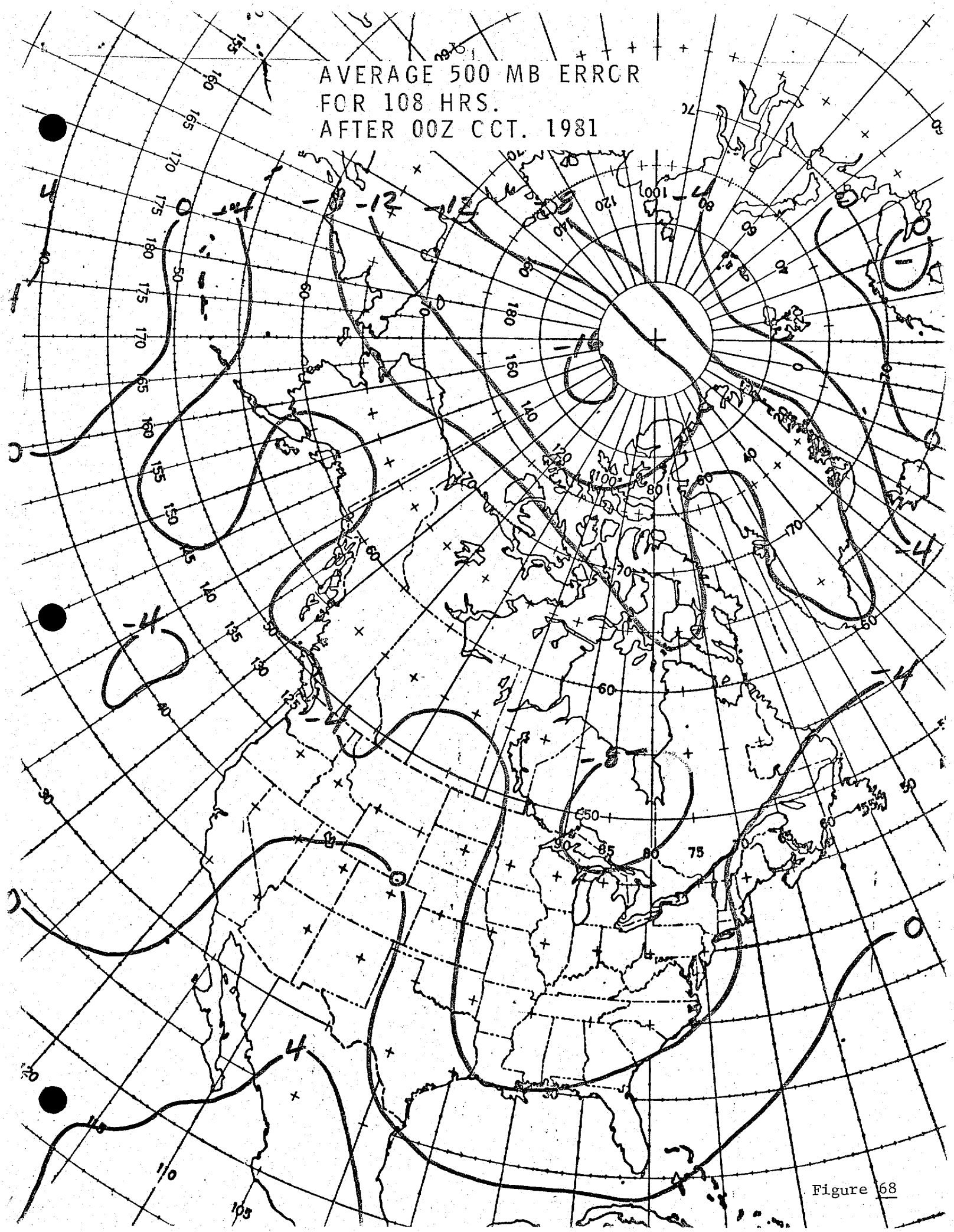

Figure 68

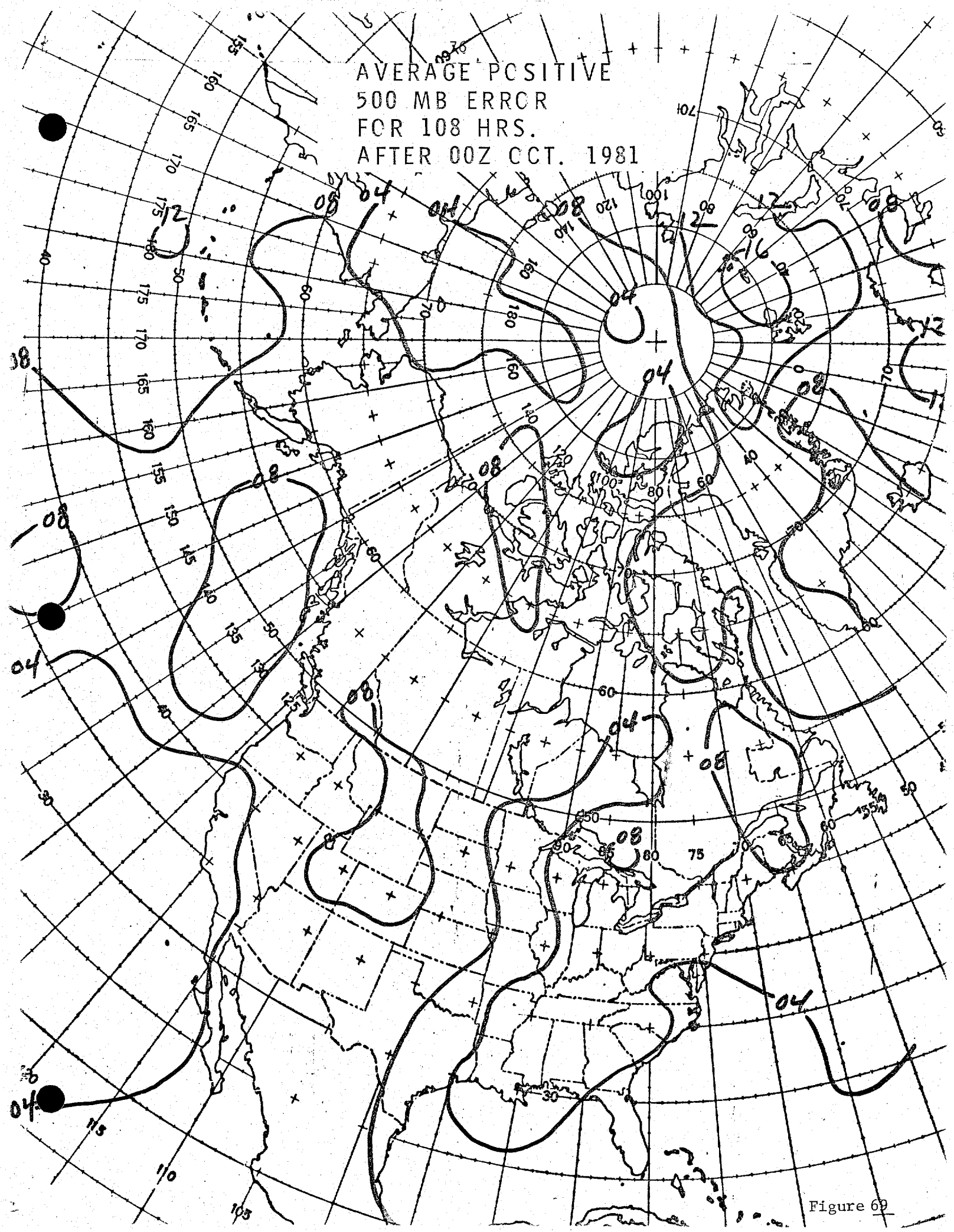

Figure 69

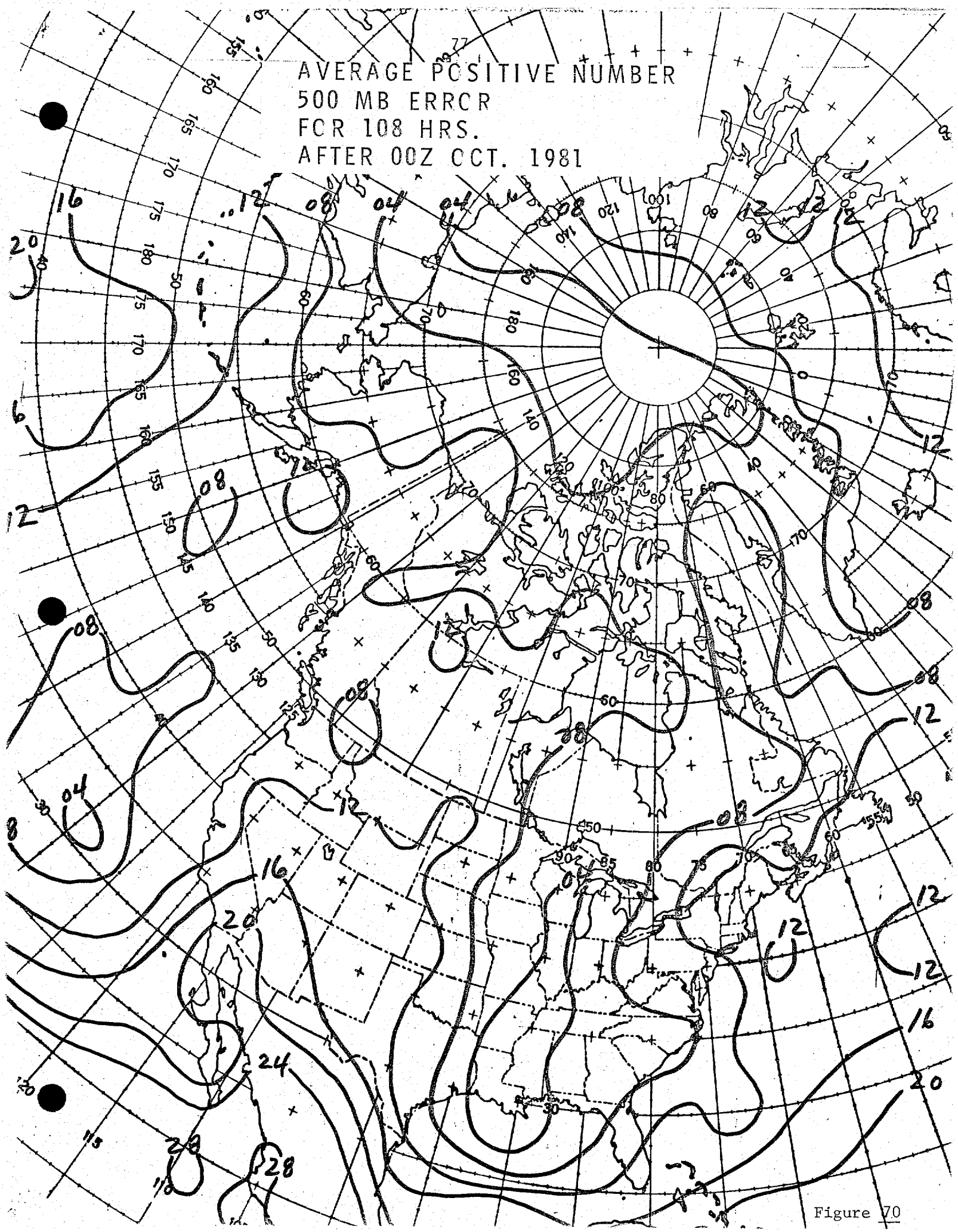
AVERAGE POSITIVE NUMBER
500 MB ERROR
FOR 108 HRS.
AFTER 00Z OCT. 1981

Figure 70

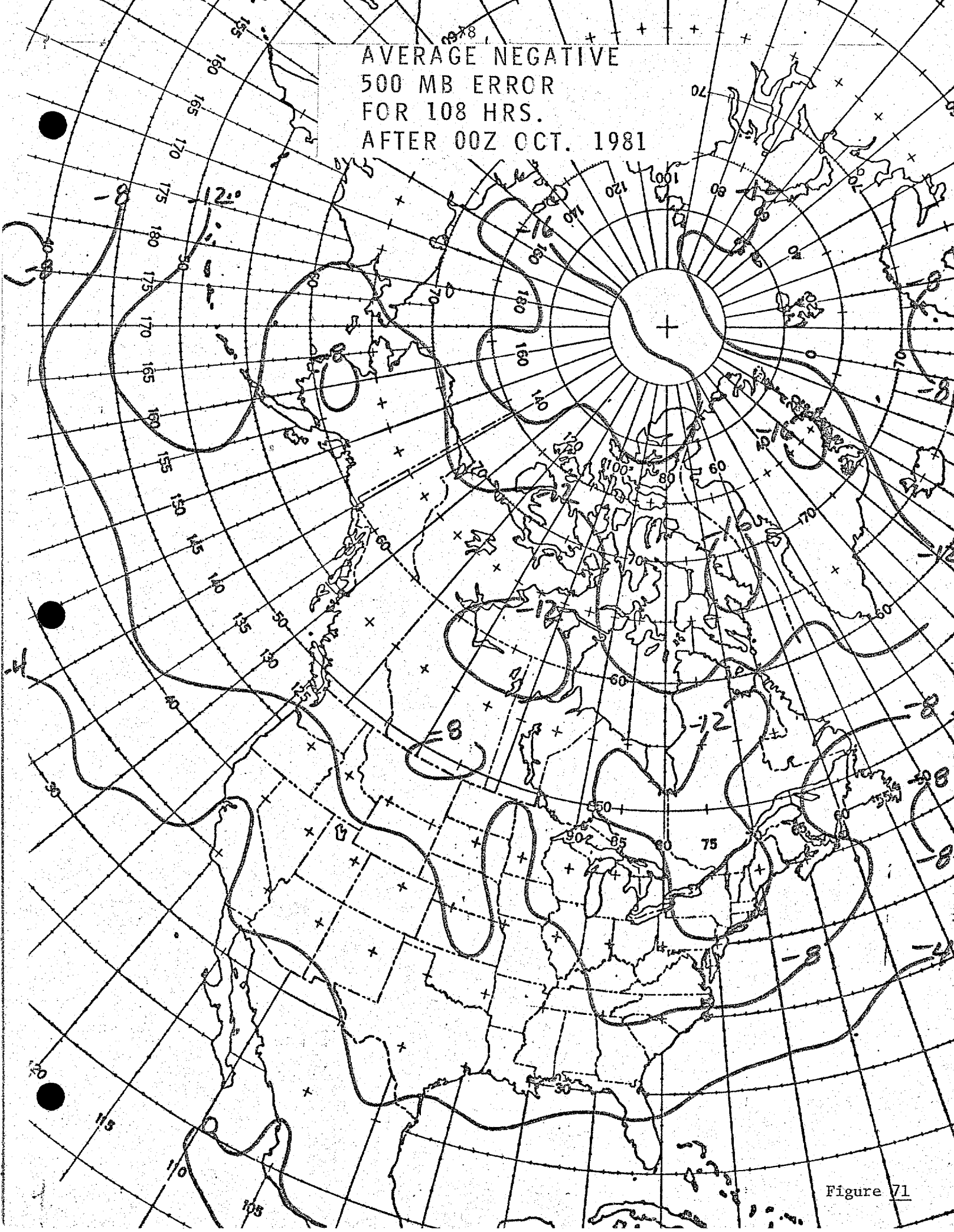

Figure 71

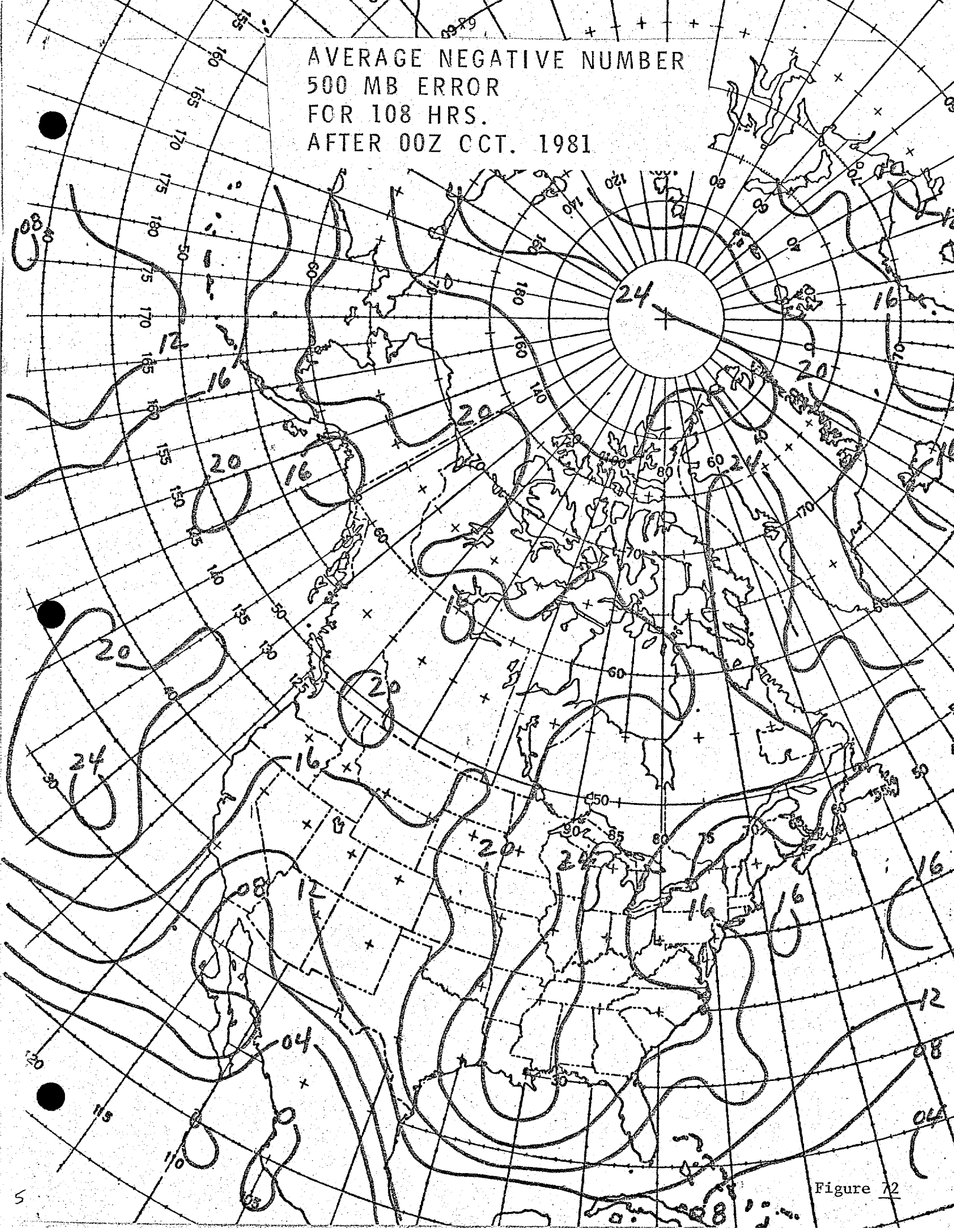
AVERAGE NEGATIVE NUMBER
500 MB ERROR
FOR 108 HRS.
AFTER 00Z OCT. 1981

Figure 72

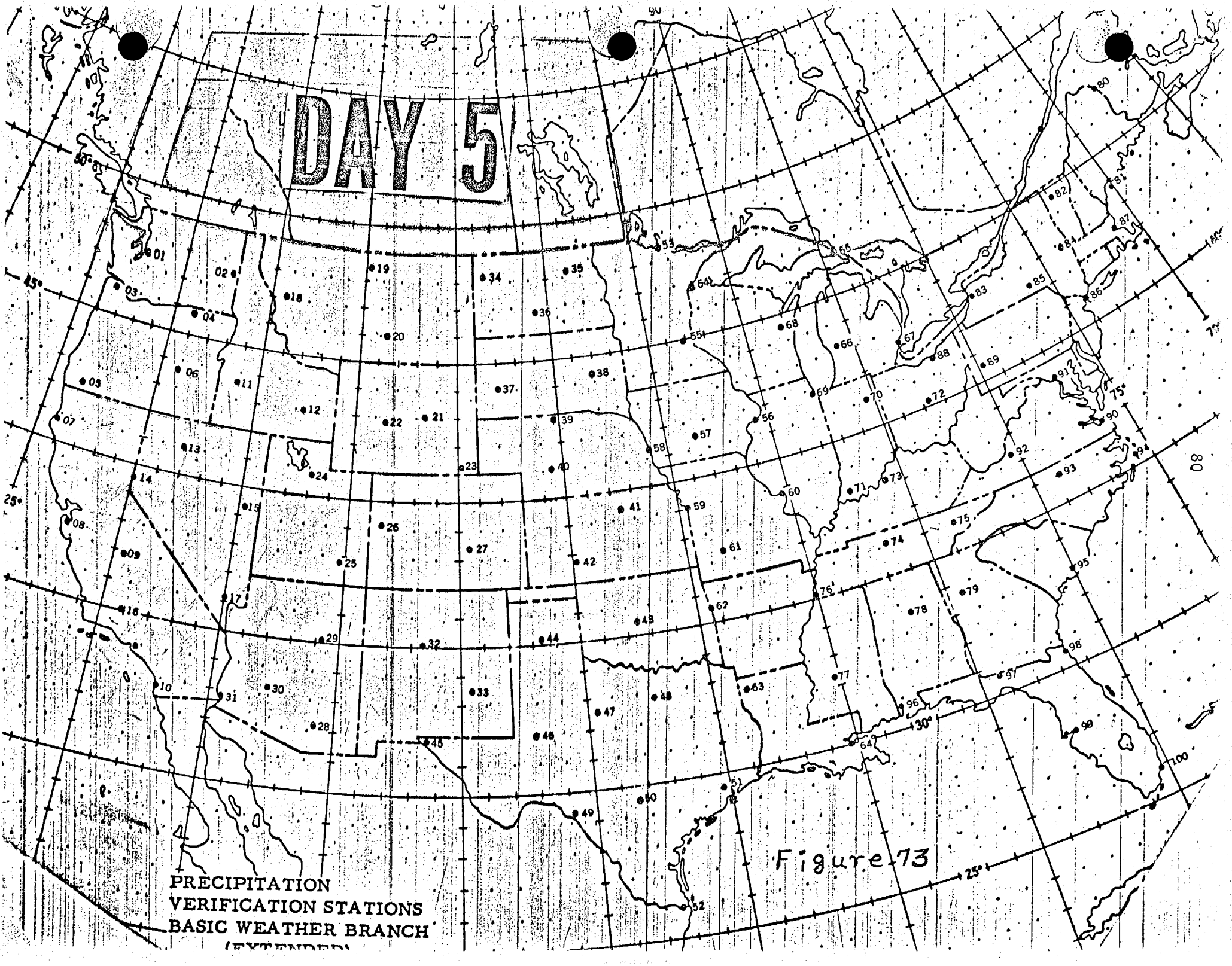
DAY 5
PRECIPITATION
VERIFICATION STATIONS
BASIC WEATHER BRANCH
(EXTENDED)

Figure 73

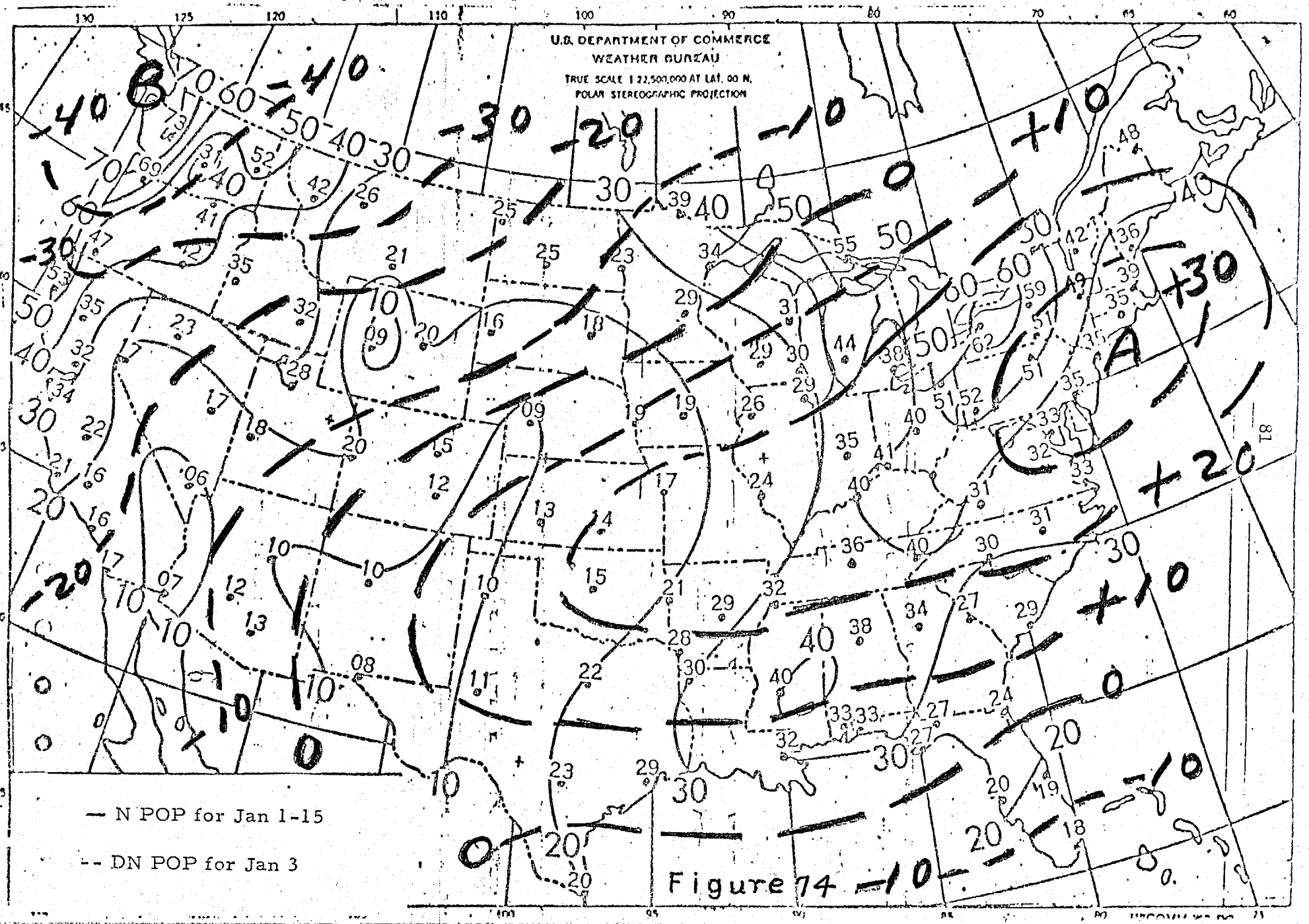
U.S. DEPARTMENT OF COMMERCE
WEATHER BUREAU
TRUE SCALE 1:22,500,000 AT LAT. 60 N.
POLAR STEREOGRAPHIC PROJECTION
— N POP for Jan 1-15
-- DN POP for Jan 3

Figure 74

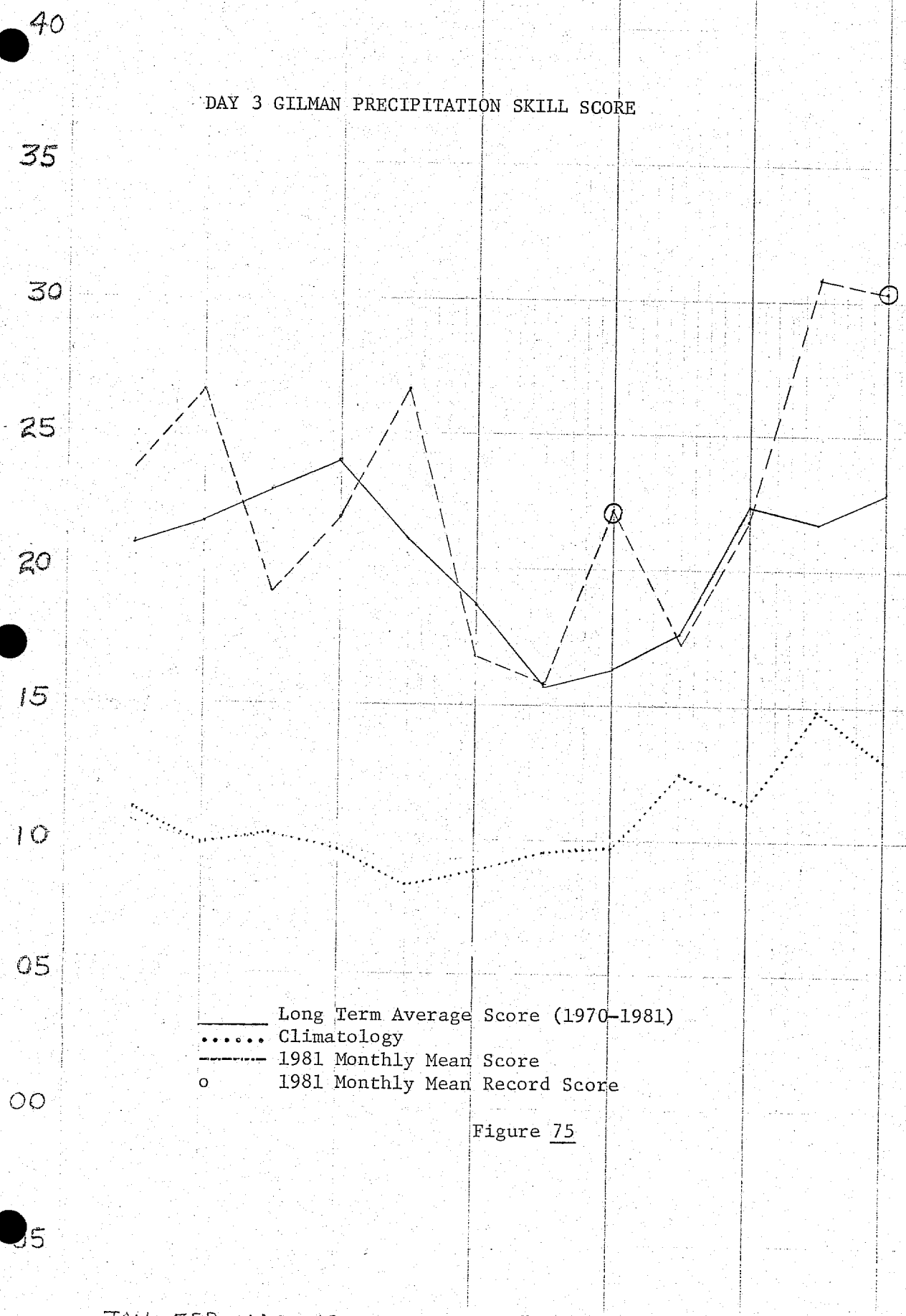
DAY 3 GILMAN PRECIPITATION SKILL SCORE
40
35
30
25
20
15
10
05
00
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
Long Term Average Score (1970-1981)
Climatology
1981 Monthly Mean Score
o 1981 Monthly Mean Record Score

Figure 75

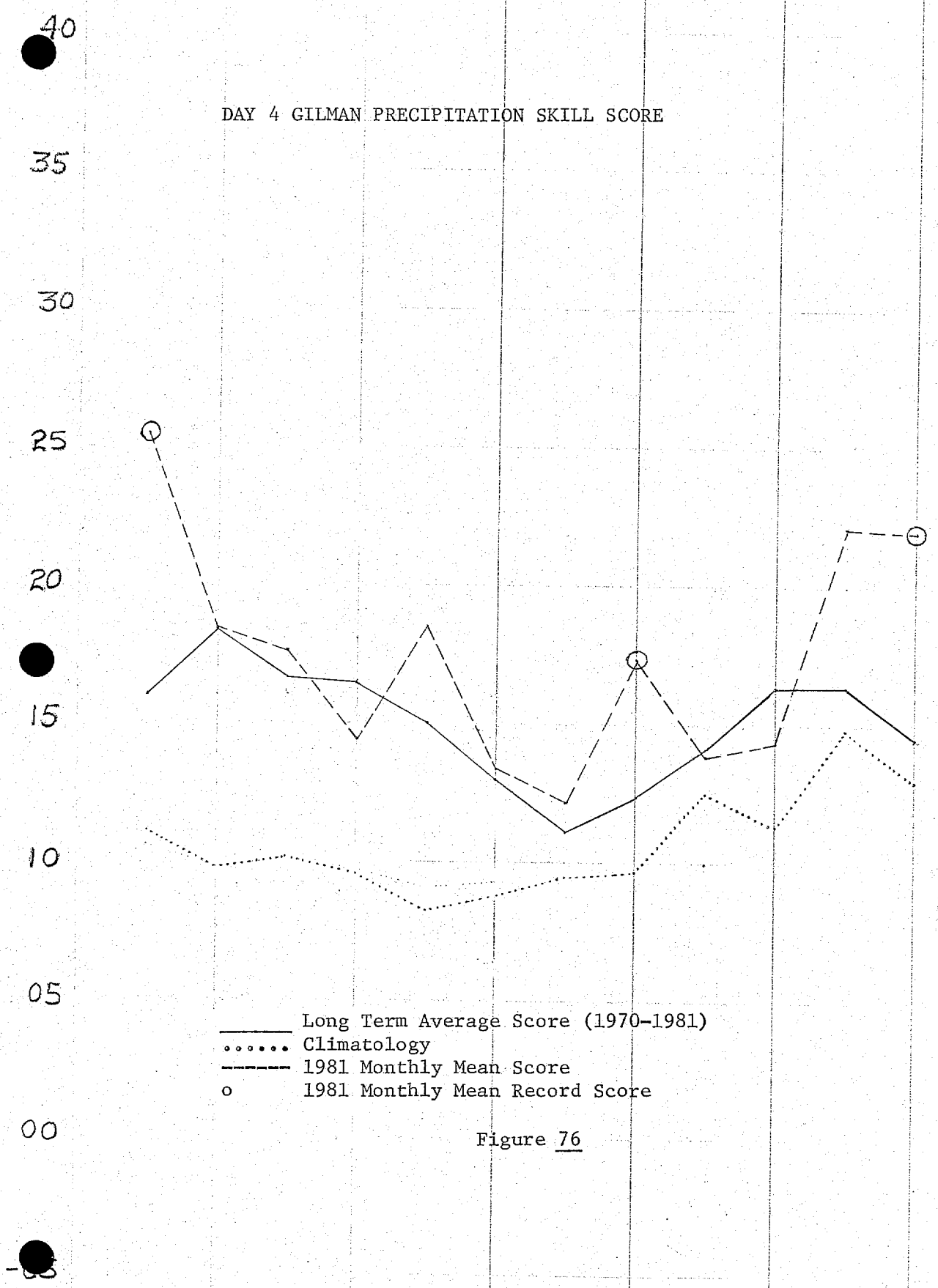
DAY 4 GILMAN PRECIPITATION SKILL SCORE
40
35
30
25
20
15
10
05
00
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
Long Term Average Score (1970-1981)
Climatology
1981 Monthly Mean Score
1981 Monthly Mean Record Score

Figure 76

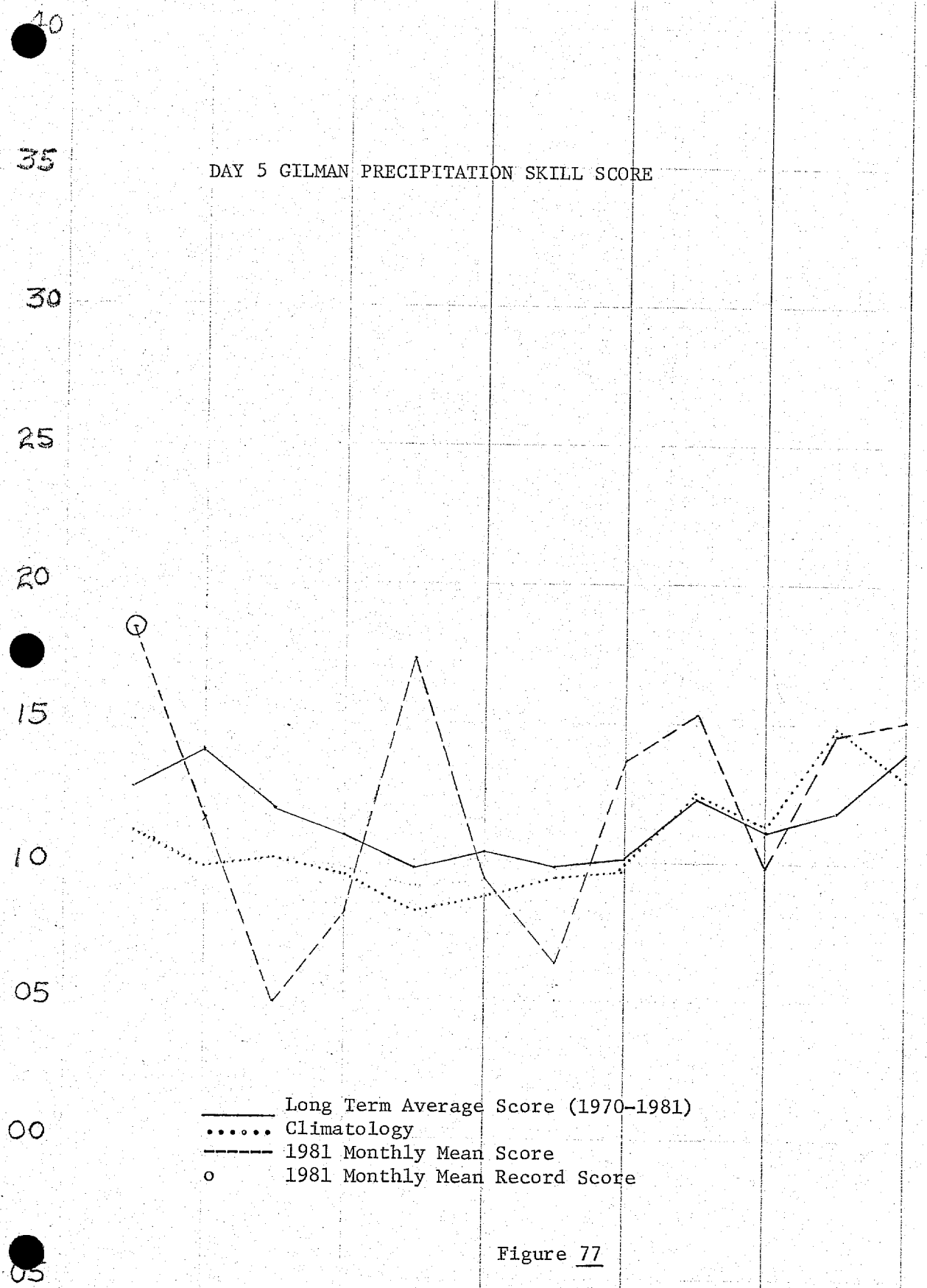
DAY 5 GILMAN PRECIPITATION SKILL SCORE
40
35
30
25
20
15
10
05
00
05
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
Long Term Average Score (1970-1981)
Climatology
1981 Monthly Mean Score
o 1981 Monthly Mean Record Score

Figure 77

DAY 3 HUGHES PRECIPITATION SKILL SCORE

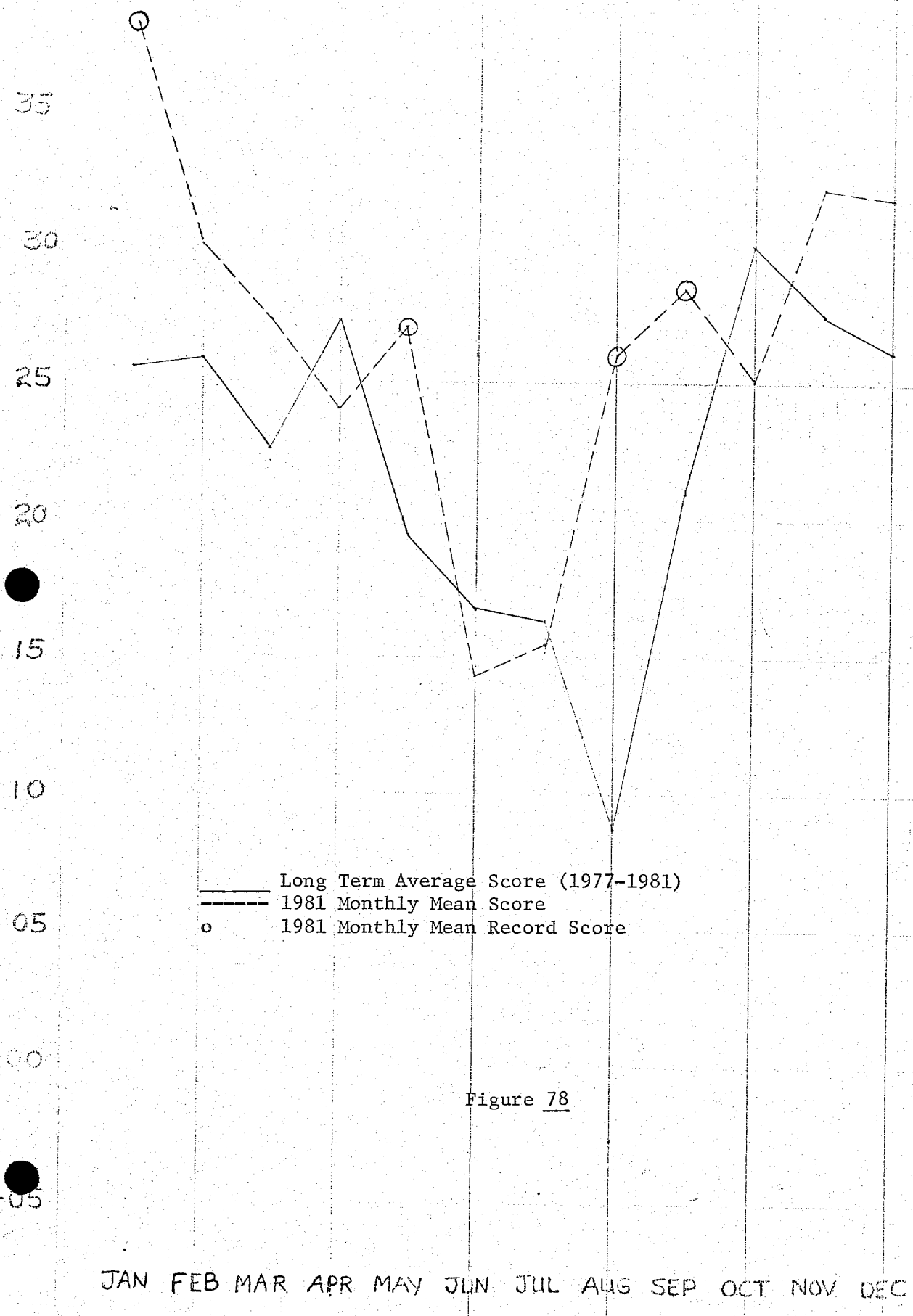

Figure 78

DAY 4 HUGHES PRECIPITATION SKILL SCORE

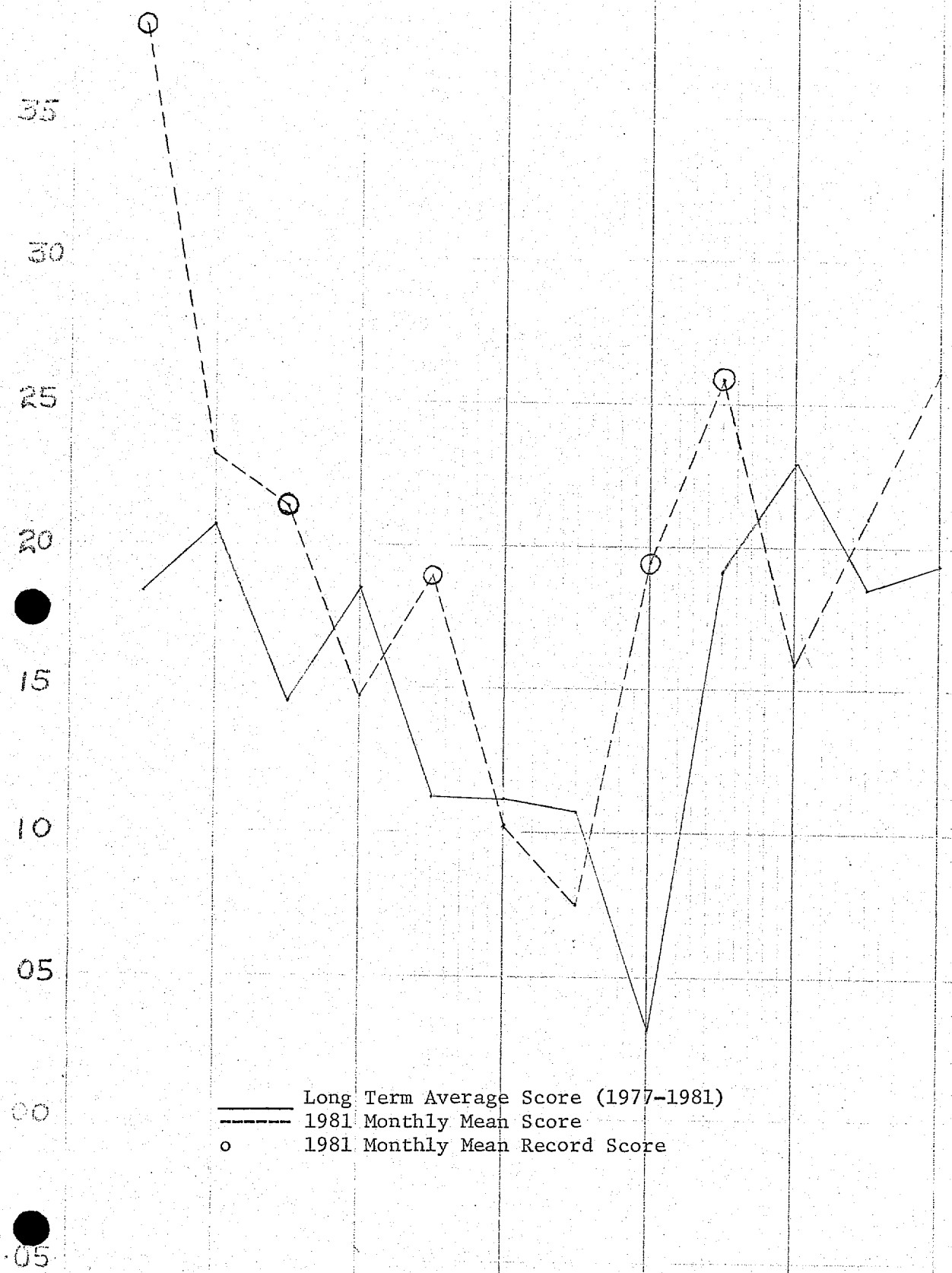

Figure 79

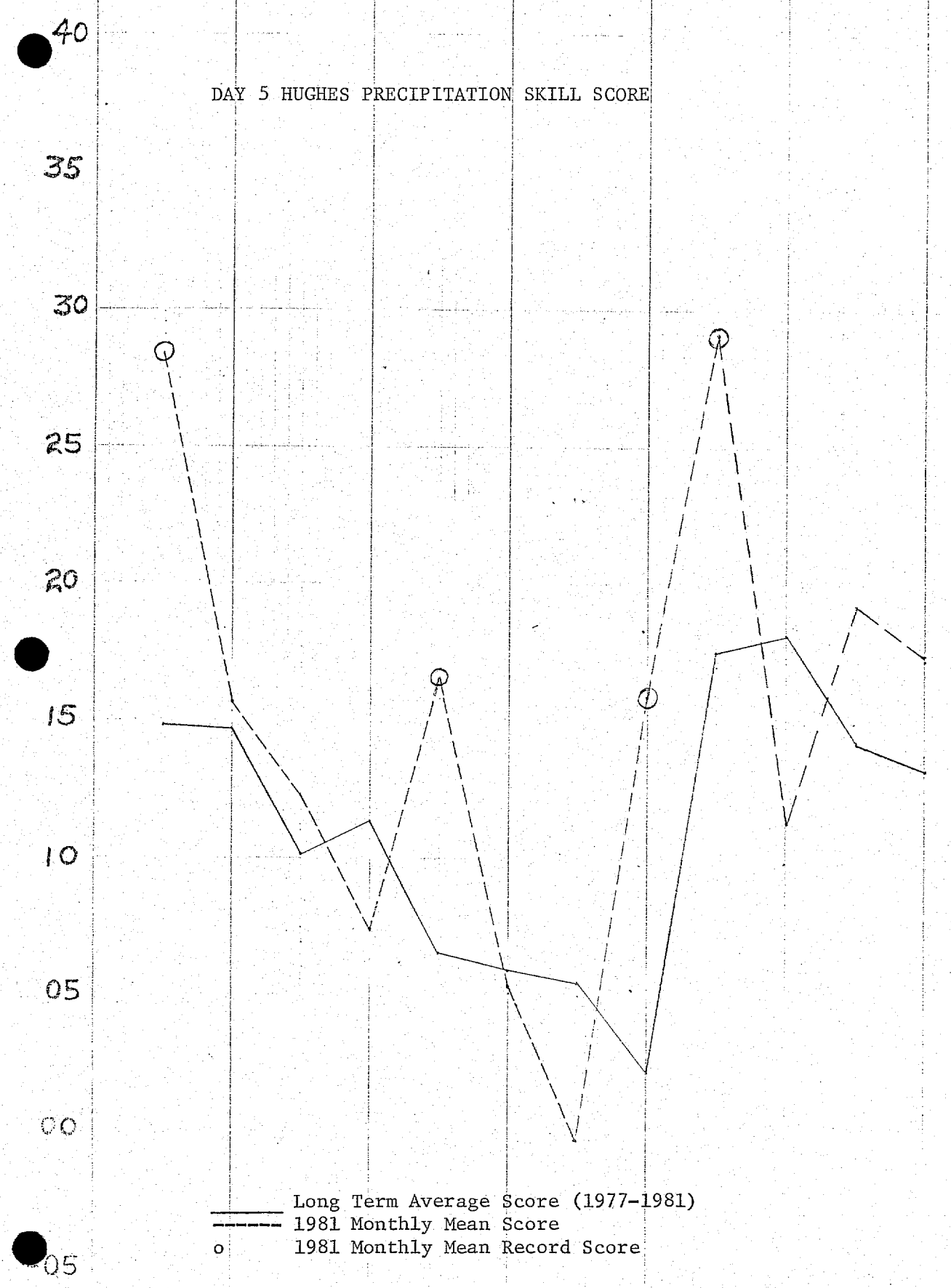
DAY 5 HUGHES PRECIPITATION SKILL SCORE
40
35
30
25
20
15
10
05
00
-05
Long Term Average Score (1977-1981)
1981 Monthly Mean Score
o 1981 Monthly Mean Record Score
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

Figure 80

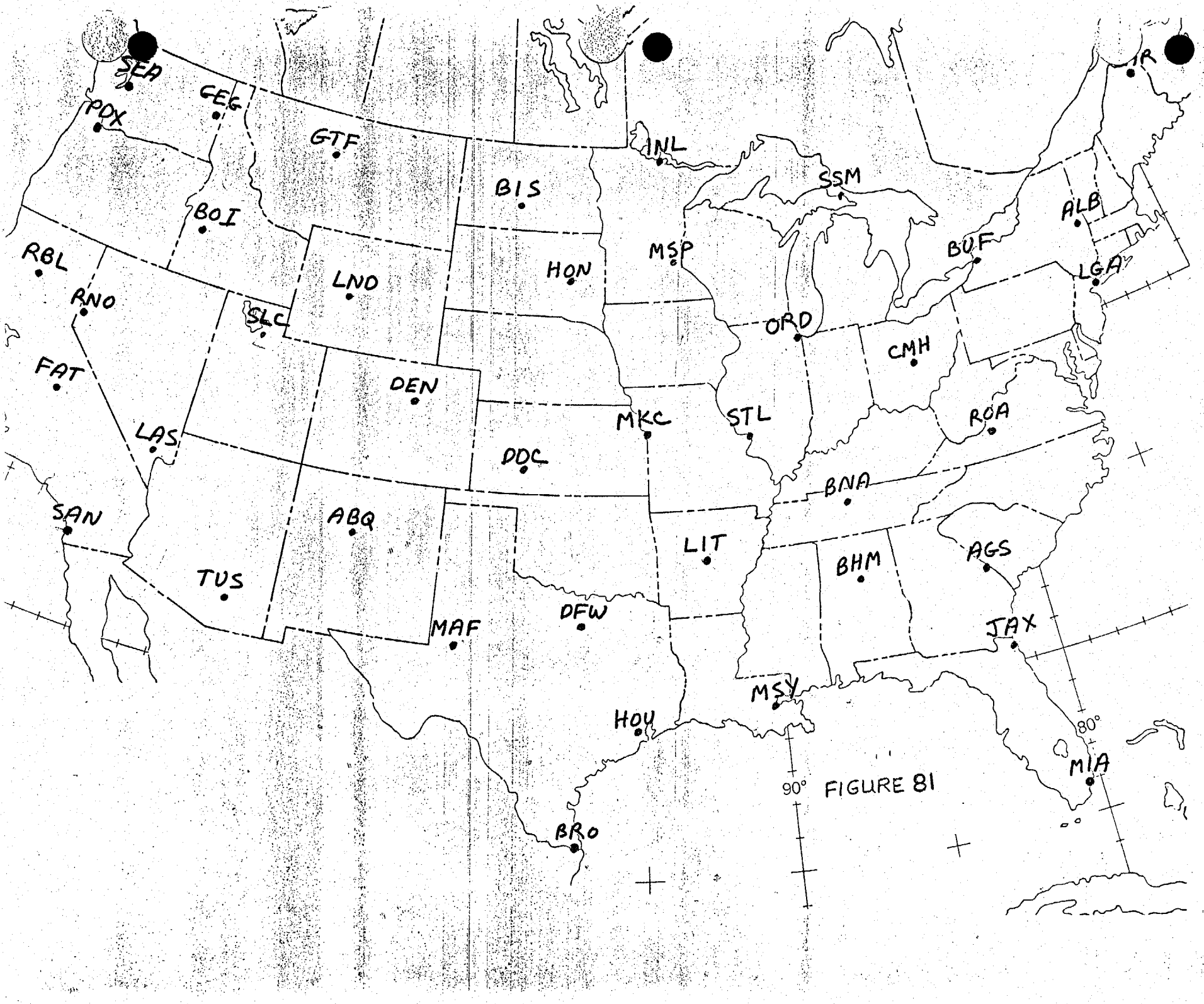
SEA
GEG
PDX
GTF
INL
BIS
SSM
BOI
ALB
RBL
MSP
BUF
LGA
HON
LND
RNO
SLC
ORD
CMH
FAT
DEN
MKC
STL
ROA
LAS
DDC
BNA
SAN
ABQ
LIT
AGS
BHM
TUS
DFW
MAF
JAX
MSY
HOU
80°
MIA
90°
BRO

FIGURE 81

DAY 3 MAN MINIMUM TEMPERATURE ABSOLUTE ERROR SCORE

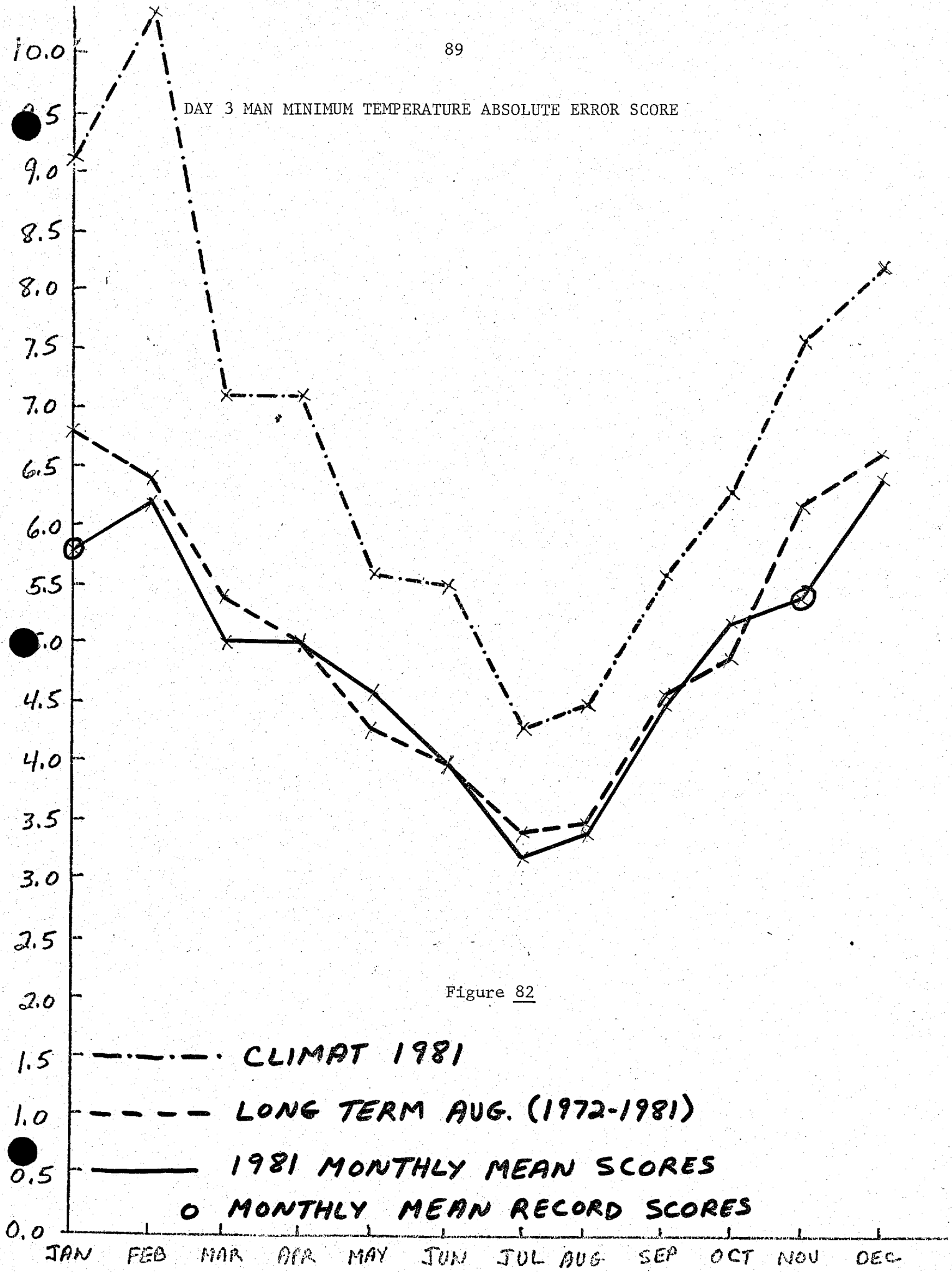

Figure 82

DAY 3 MAN MAXIMUM TEMPERATURE ABSOLUTE ERROR SCORE

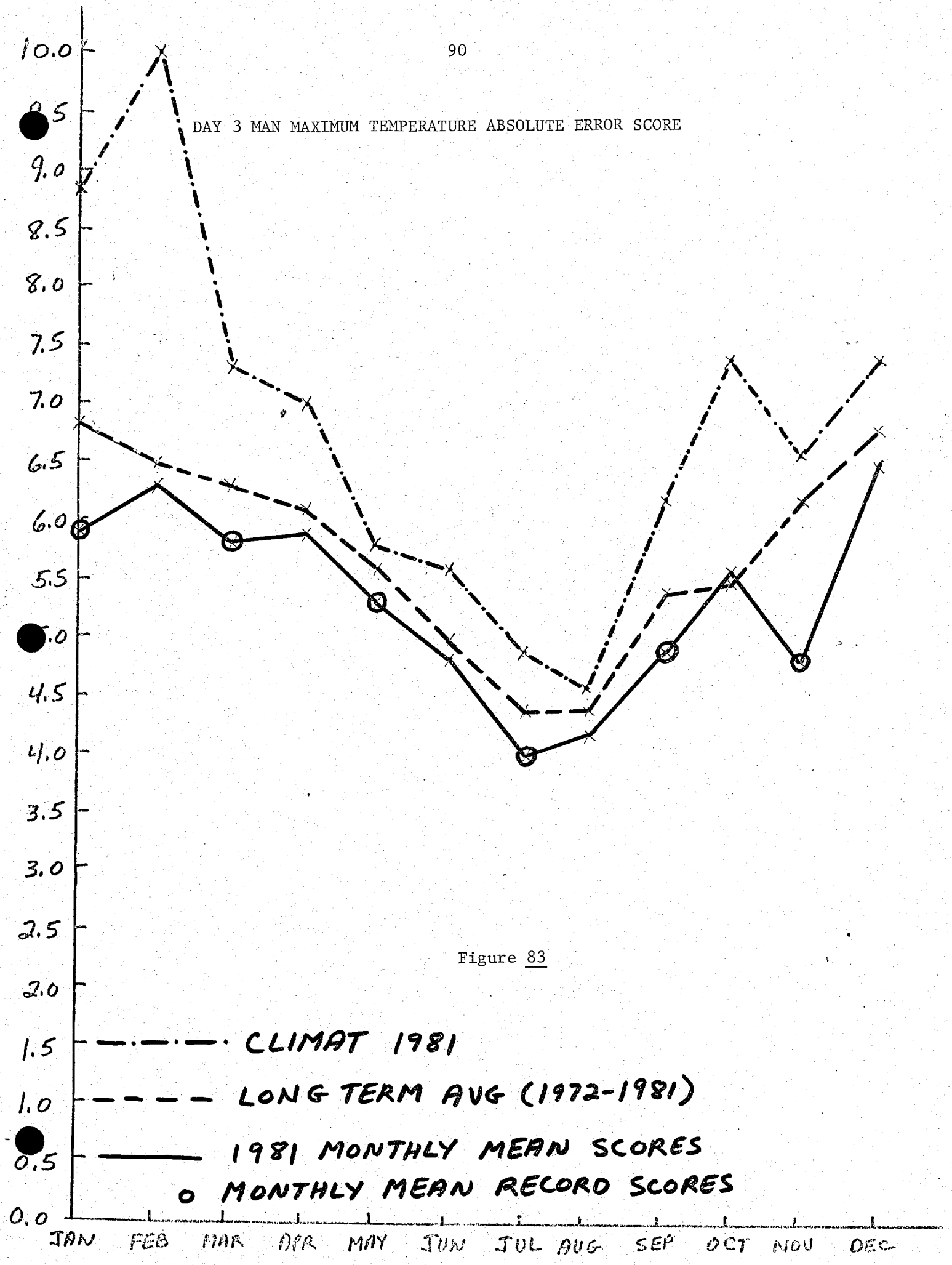

Figure 83

DAY 4 MAN MINIMUM TEMPERATURE ABSOLUTE ERROR SCORE

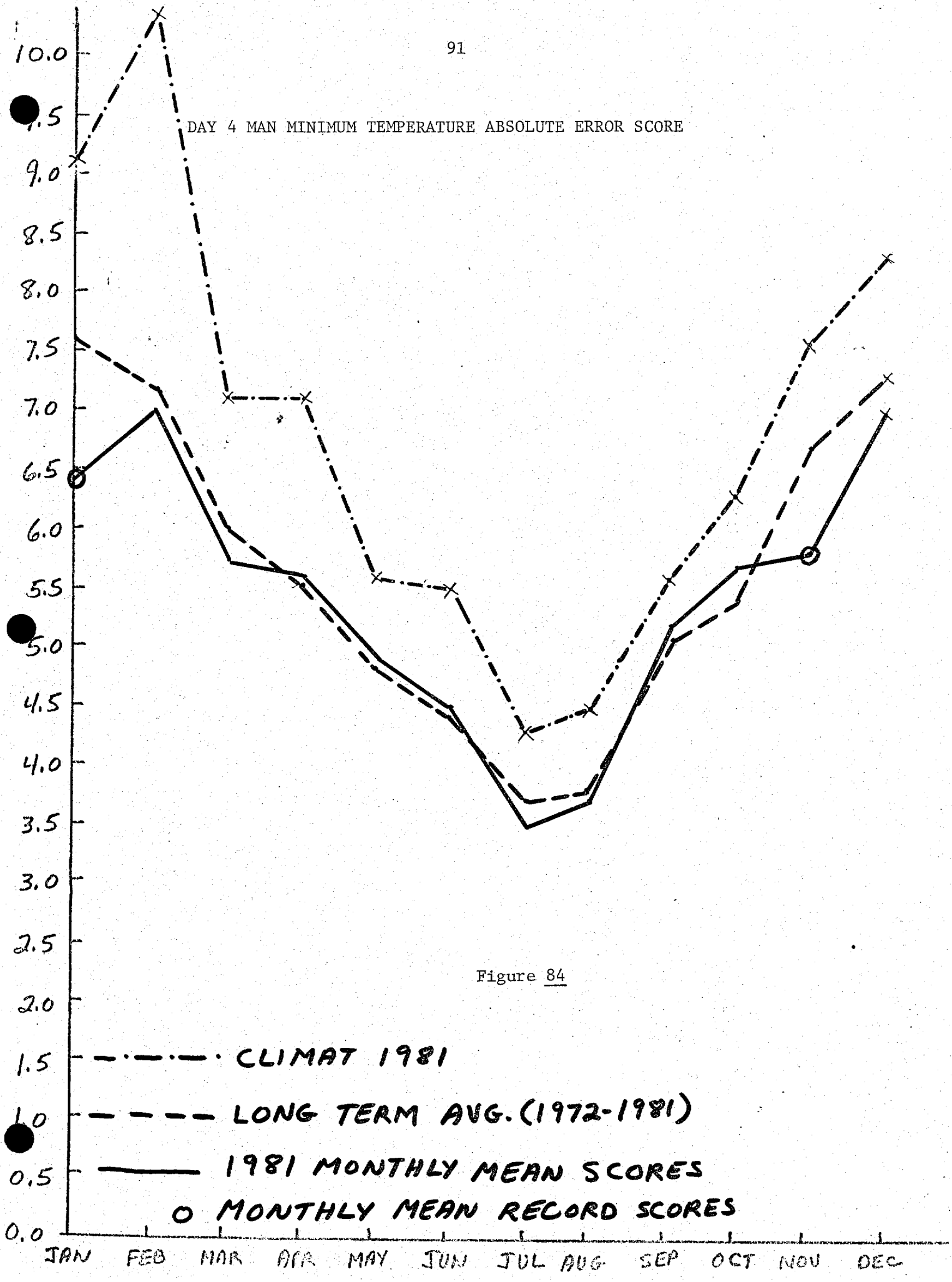

Figure 84

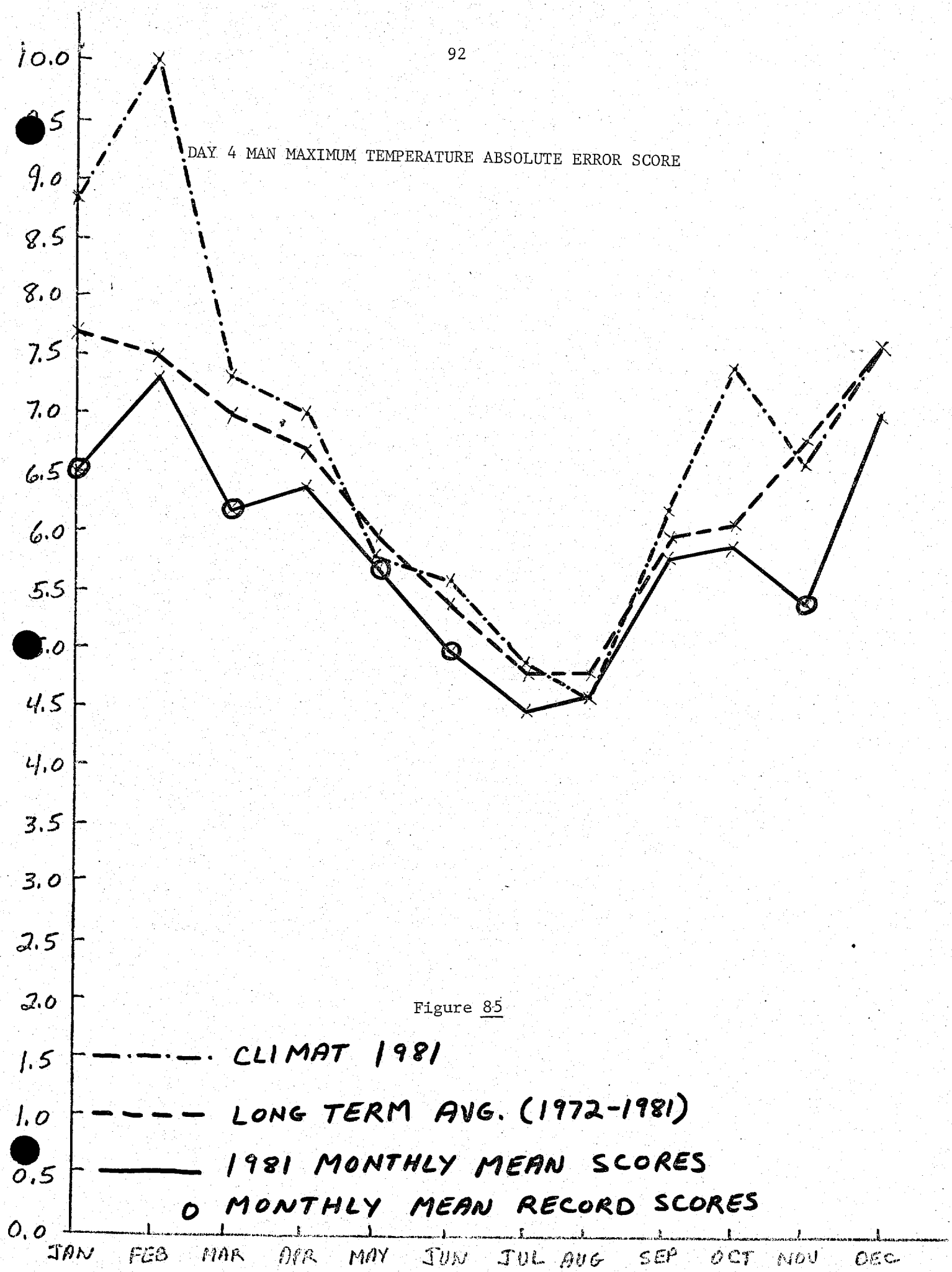
DAY 4 MAN MAXIMUM TEMPERATURE ABSOLUTE ERROR SCORE
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
CLIMAT 1981
LONG TERM AVG. (1972-1981)
1981 MONTHLY MEAN SCORES
O MONTHLY MEAN RECORD SCORES
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

Figure 85

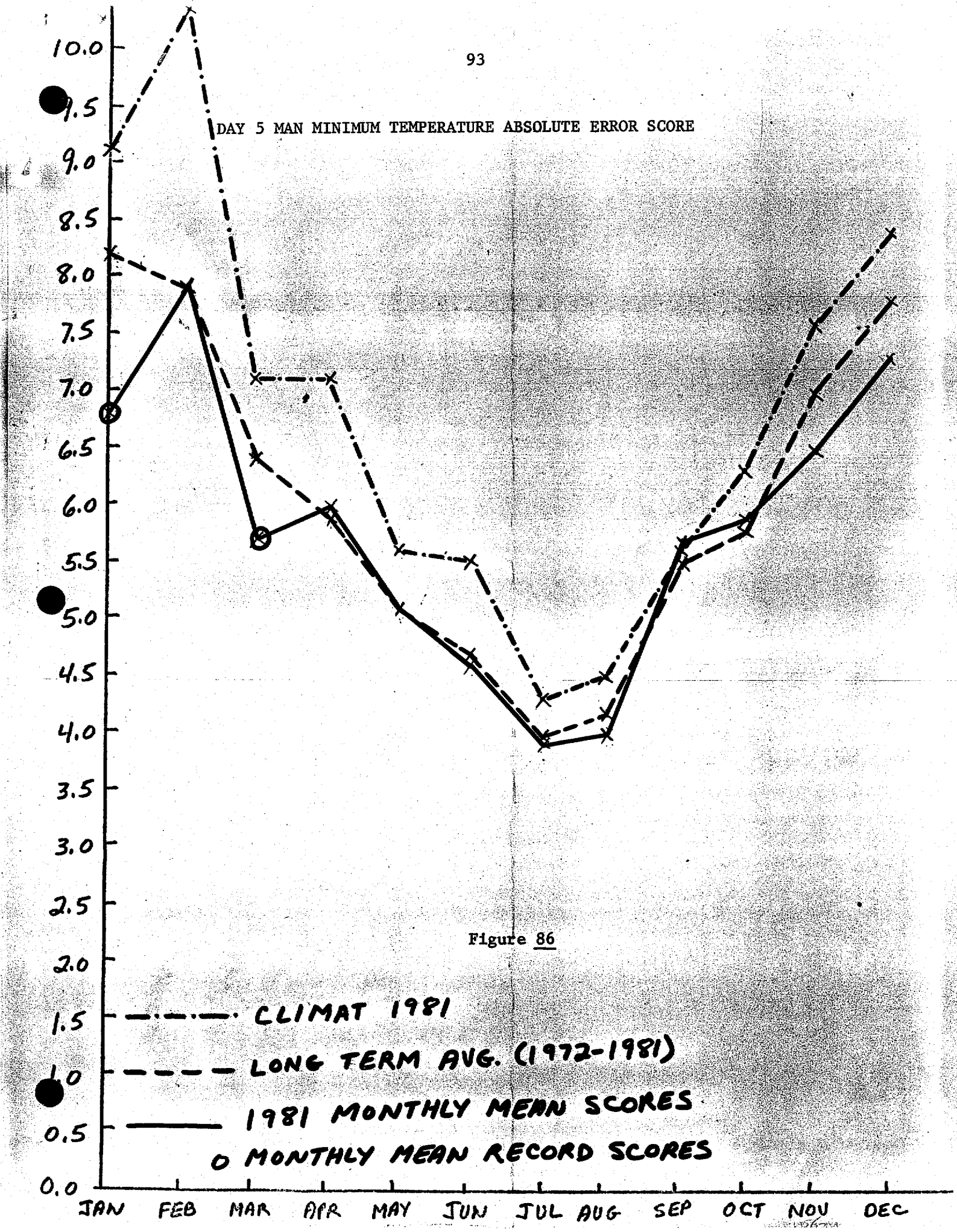
DAY 5 MAN MINIMUM TEMPERATURE ABSOLUTE ERROR SCORE
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
CLIMAT 1981
LONG TERM AVG. (1972-1981)
1981 MONTHLY MEAN SCORES
O MONTHLY MEAN RECORD SCORES

Figure 86

DAY 5 MAN MAXIMUM TEMPERATURE ABSOLUTE ERROR SCORE

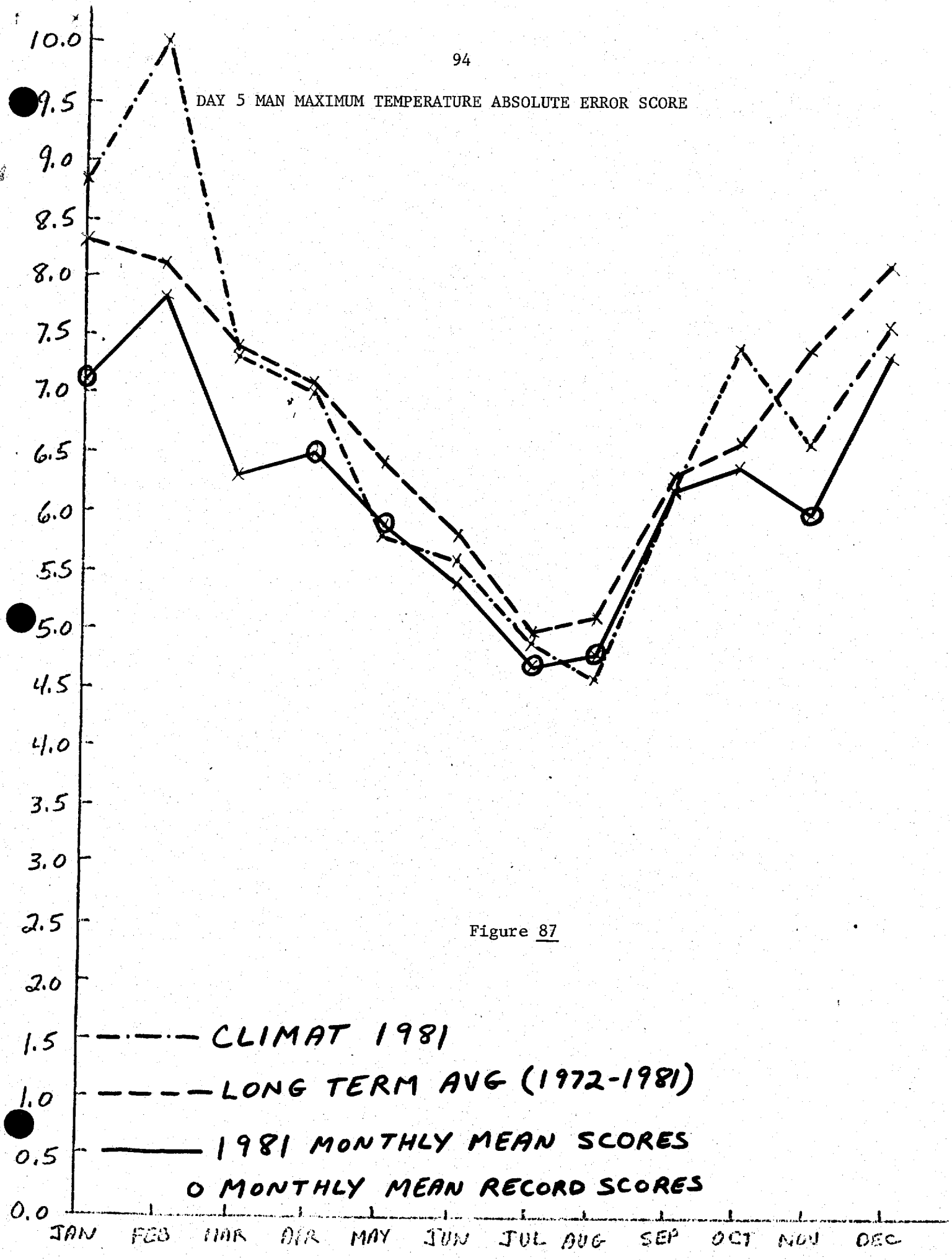

Figure 87

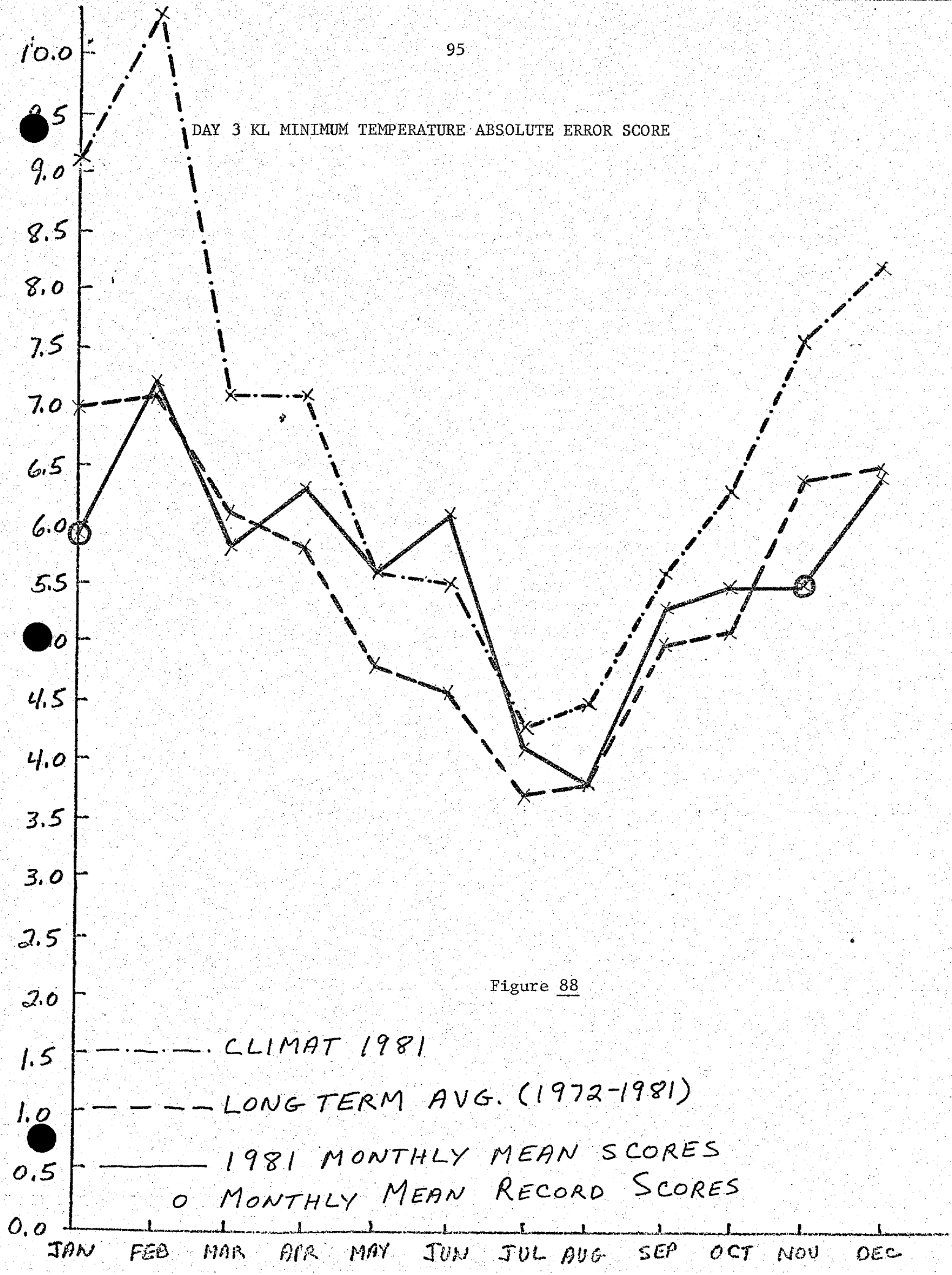
DAY 3 KL MINIMUM TEMPERATURE ABSOLUTE ERROR SCORE
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
CLIMAT 1981
LONG TERM AVG. (1972-1981)
1981 MONTHLY MEAN SCORES
o MONTHLY MEAN RECORD SCORES

Figure 88

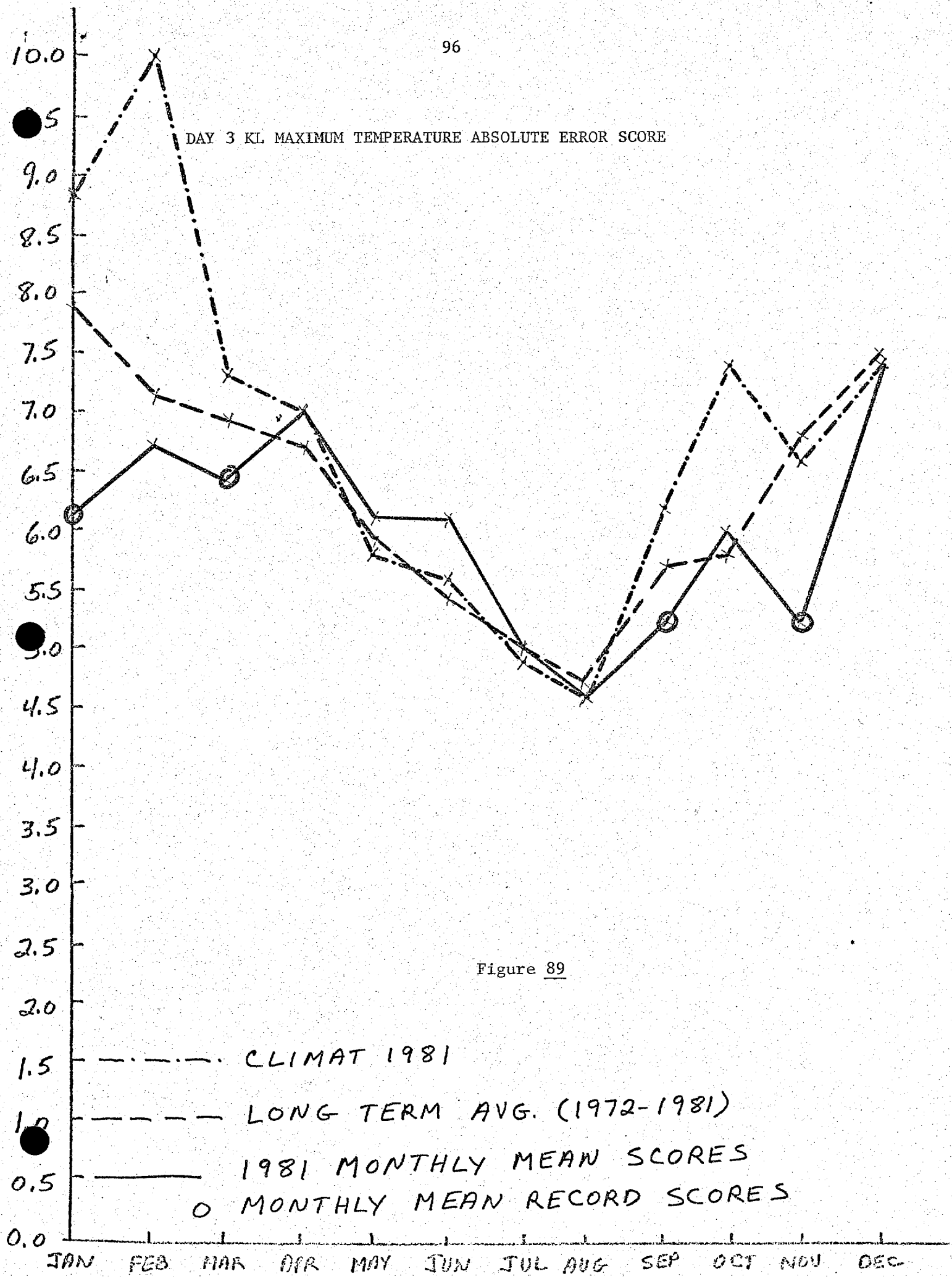
DAY 3 KL MAXIMUM TEMPERATURE ABSOLUTE ERROR SCORE
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
CLIMAT 1981
LONG TERM AVG. (1972-1981)
1981 MONTHLY MEAN SCORES
O MONTHLY MEAN RECORD SCORES
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

Figure 89

DAY 4 KL MINIMUM TEMPERATURE ABSOLUTE ERROR SCORE

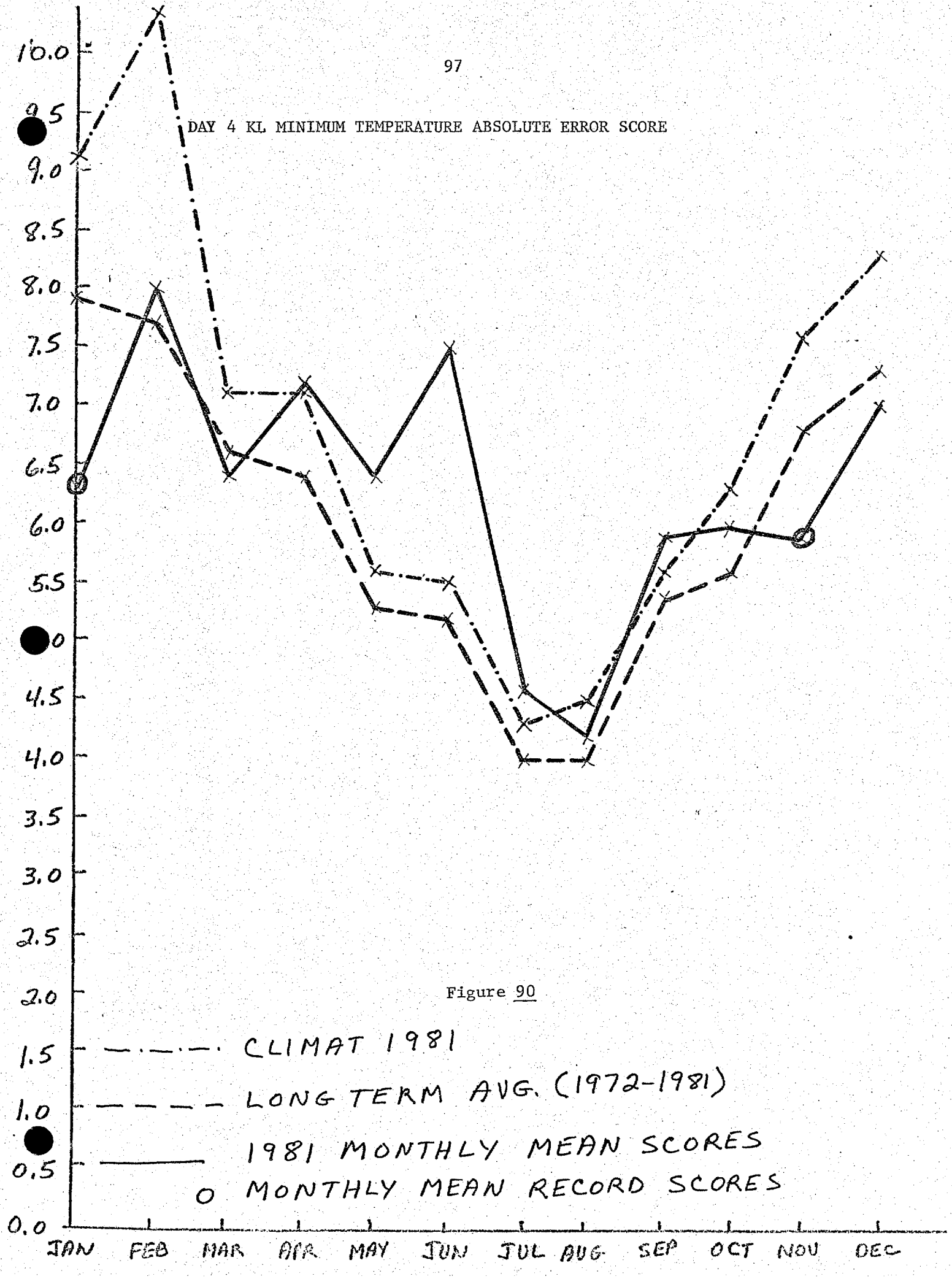

Figure 90

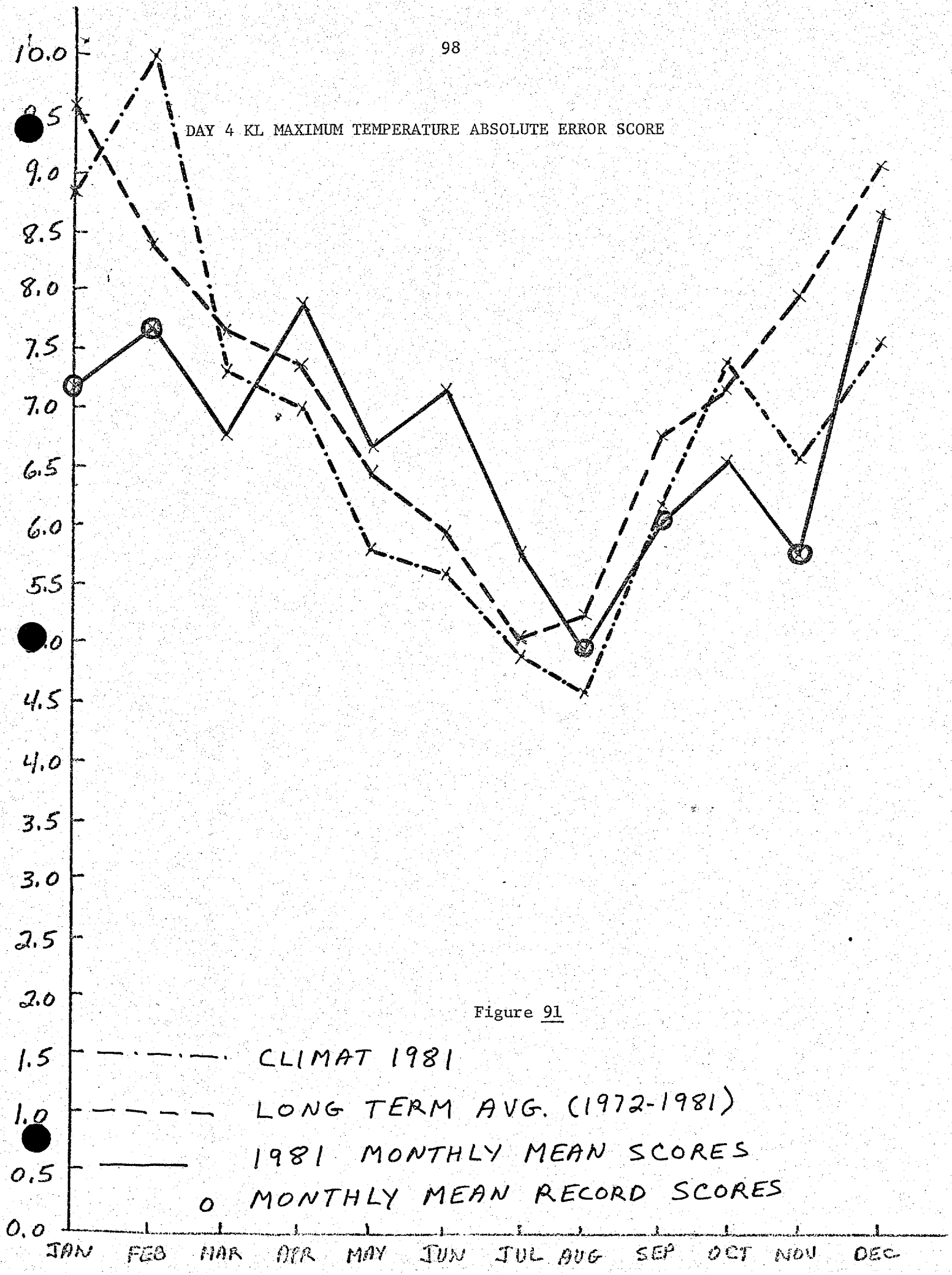
DAY 4 KL MAXIMUM TEMPERATURE ABSOLUTE ERROR SCORE
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
CLIMAT 1981
LONG TERM AVG. (1972-1981)
1981 MONTHLY MEAN SCORES
MONTHLY MEAN RECORD SCORES
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

Figure 91

DAY 5 KL MINIMUM TEMPERATURE ABSOLUTE ERROR SCORE

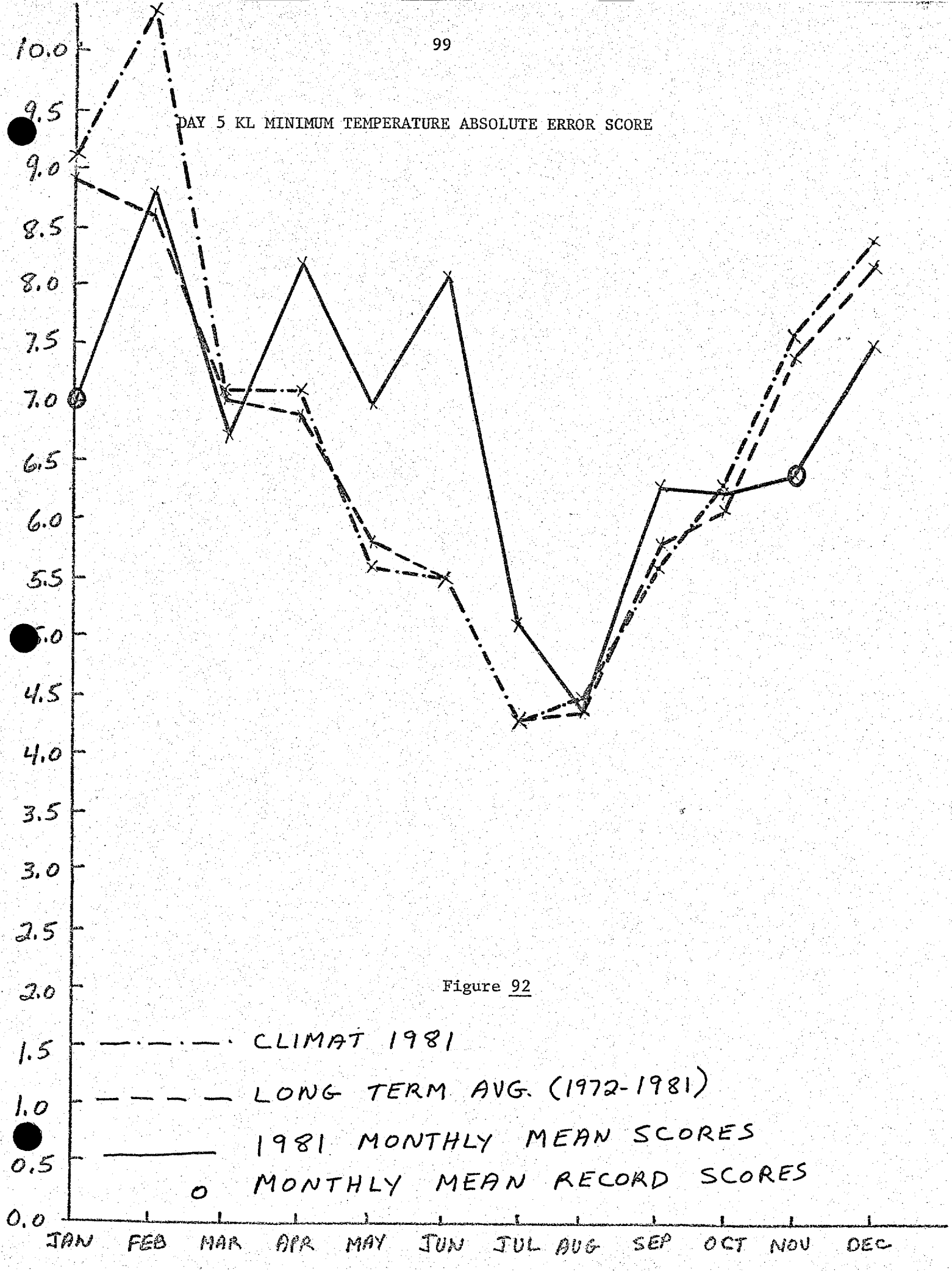

Figure 92

DAY 5 KL MAXIMUM TEMPERATURE ABSOLUTE ERROR SCORE

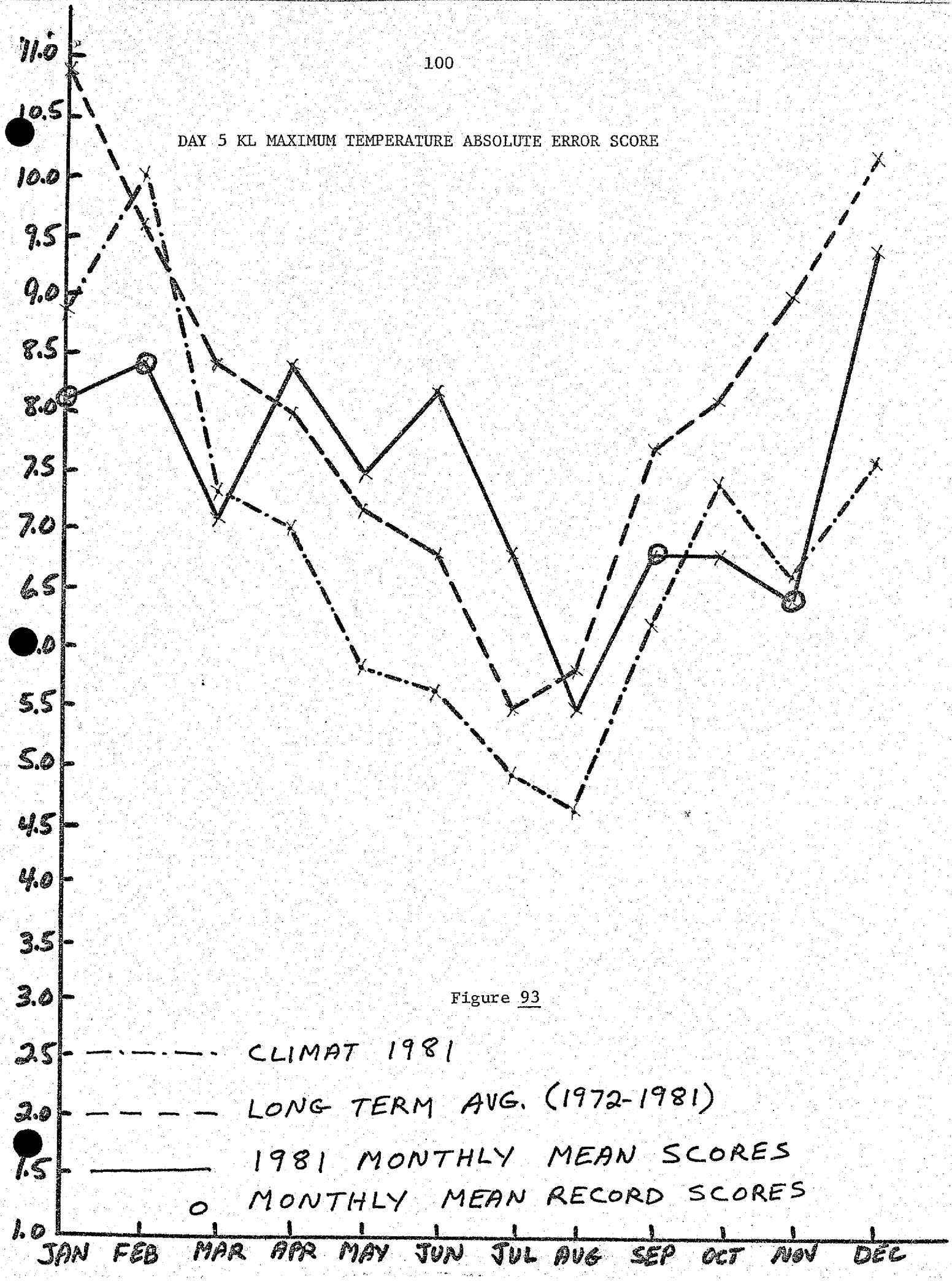

Figure 93

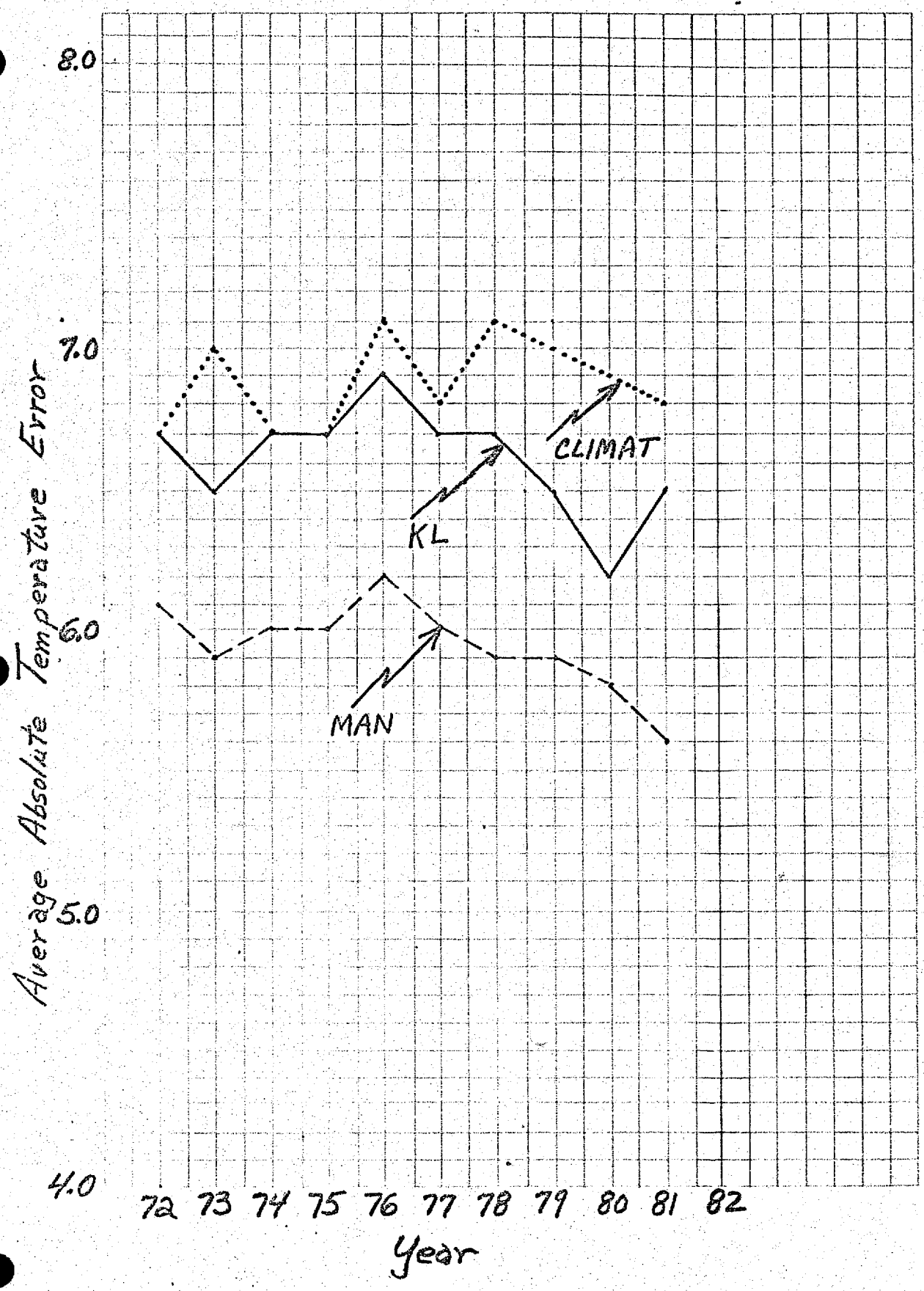
8.0
7.0
6.0
5.0
4.0
Average Absolute Temperature Error
CLIMAT
KL
MAN
72 73 74 75 76 77 78 79 80 81 82
Year

Figure 94

Comments

It is quite obvious that the skill of the days 3, 4, and 5 forecasts of the MRFG was quite good in calendar year 1981. The days 3, 4, and 5 mean sea level pressure correlation and precipitation skill scores generally were better than the long term average and several new monthly mean record scores were established. With regard to the MSLP the improvement over the long term average was most pronounced during the cooler months of the year though this, for the most part, reflected the better than average guidance received during these months. However, to get an appreciation of the increase in the MSLP skill of the man over the machine compare figures 20 through 22 to figures 23 through 25.

Perhaps the big story of the year is with regard to the days 3, 4, and 5 temperature forecasts. In general, the KL objective temperature forecasts were not as good as last year. However, the KL did have several good months in which it set 19 new monthly mean records out of a possible 72 chances. Unfortunately, poor forecasts made during April through July and in December outweighed the good ones. In spite of the decrease in skill of the KL guidance the man forecasts set 23 new monthly mean records. The man also had the lowest ever annual average absolute error temperature scores for the 96, 108, 120, 132 and 144-hour forecasts (i.e., day 3 max; day 4 min and max; day 5 min and max) and tied the 84-hour (day 3 min) score from last year which was a record.

Appendix A

The standardized mean sea level pressure correlation score is used to determine the skill of the man and machine days 3, 4 and 5 mean sea level pressure forecasts. The correlation score is employed because the phasing instead of the intensity of systems primarily determines how well the various weather parameters can be forecast. The standardizing procedure prevents the contribution of the high variability (higher latitude) grid points from overwhelming the low variability grid points (lower latitude).

f = forecast mean sea level pressure at a grid point

o = observed mean sea level pressure at a grid point

σ = standard deviation at a grid point

n = normal mean sea level pressure at a grid point

$$F = \frac{f-n}{\sigma} \qquad 0 = \frac{o-n}{\sigma}$$

$\overline{F}$ = average standardized forecast across n grid points

$\overline{0}$ = average standardized observed across n grid points

$$\text{RMS } F = \sqrt{\overline{F}^2} \qquad \text{RMS } 0 = \sqrt{\overline{0}^2}$$

$$\text{RMS Error} = \sqrt{\overline{(F-0)^2}}$$

$$\text{Average Absolute Error} = \overline{|F-0|}$$

$$\text{Correlation} = \frac{\overline{FO} - \overline{F}\,\overline{0}}{\sqrt{(\overline{F^2} - \overline{F}^2)\,(\overline{0^2} - \overline{0}^2)}} \times 100$$

Since the normal mean sea level pressure is subtracted from the forecast/observed pressure at each grid point, it is assumed that the correlation of the normal to the observed is always zero. Therefore, any positive score is considered

to have skill over the normal. Some doubts have been raised about this assumption, however, and for the past 5 years the unstandardized correlation score also has been calculated. This procedure allows a correlation score to be computed for the normal. This score then is simply the correlation of the forecast to the observed mean sea level pressure.

Appendix B

The Gilman skill score is a generalization of the Heidke skill score where the expected values are derived from a randomized version of the precipitation forecast.

$$\text{Heidke Skill} = \frac{C-E}{N-E}$$

C = total correct (hits)

N = total number of forecasts (100)

E = expected number of hits

However, for a randomized forecast allowance must be made for stations having far different precipitation climate (N POP) across the United States. Therefore, to compute and score an expected chance forecast, climatology must be considered. The procedure for this is as follows:

First, the actual number of forecasts of precipitation are distributed randomly taking into account station climatology. The expected number of chance hits is then given by:

$$E = \sum^{N} (p_i\, r_i + (1 - p_i)(1 - r_i)) \text{ or}$$

$$E = 2\sum^{N} p_i\, r_i + N - \sum^{N} p_i - \sum^{N} r_i \quad (a)$$

where $r_i = 1$ for precipitation ($\geq .01$ inch) and 0 for no precipitaiton ($< .01$ inch). Now an expression for p_i, which is the probability that after the forecast precipitation events are redistributed randomly a forecast precipitation event will fall at point "i" is given approximately by $p_i \approx F\frac{a_i}{\sum^{N} a_i}$ (b). Here F = total number of forecasted precipitation events and a_i = climatic precipitation probability (N POP). This approximate value for p_i is most valid for small values of F and $(a_i / \sum a_i)$ and is unstable at times. Because of this instability the less sophisticated but more stable Hughes skill score was developed.

Substituting the expression (b) into (a) gives $E = \frac{2F\sum^{N} a_i r_i}{\sum^{N} a_i} + N-F-R$, where E = the approximate expected value of a randomized forecast, R = total precipitation cases, and N = total number of stations. If the climatic probabilities are uniform ($a_i = a_j = a$), then the approximate value of E reduces to the standard Heidke value given by: $E = \frac{(N-F)(N-R)+FR}{N}$.

Appendix C

The Hughes skill score is a generalization of the Heidke skill score where the expected values are derived from the observed precipitation:

$$\text{Heidke Skill} = \frac{C-E}{N-E}$$

C = total correct (hits)
N = total number of forecasts (100)
E = expected number of hits

If the average precipitation climate (NPOP) of 12 stations having precipitation is 25, then the expected (precipitation) is simply 12 x .25 or 3 stations. If the average NPOP of the (100-12) stations not having precipitation is also 25 then the expected (no precipitation) is simply 88 x (1.0-.25) or 66 stations. The total expected (E) then is 69 stations. If the forecaster hit (C) 75 stations correctly, his skill score then is (75-69)/(100-69) x 100 or 19.