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

OFFICE NOTE 364

Skill of Medium Range Forecasts

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PURPOSE

This paper depicts in a graphical manner the skill of the Medium Range (3-10 day) man and machine (numerical model guidance) forecasts. It will be updated each February in order to present the latest scores for each of the several forecast categories in the medium range forecast program (MRFP). Only scores with at least a 5-year period of record are presented. This paper contains the standardized and unstandardized mean sea level pressure and 500mb correlation; the Gilman, Hughes and experimental precipitation skill; the minimum/maximum average absolute temperature error; and the 5-day mean normalized 500mb correlation, temperature, and precipitation skill scores.

Numerical Model Guidance (Past to Present)

1. Acronyms

   a. Baro - Reed Baratropic Advection Model Hemispheric
   b. 6L PE - 6-layer Primitive Equation Model Hemispheric
   c. CM - Course Mesh 380km FM - Fine Mesh 190km
   d. SMG26 - Spectral Model Global 24 modes 6-layers
   e. SMG2C - Spectral Model Hemispheric 24 modes 12-layers
   f. SMG3C - Spectral Model Global 30 modes 12-layers
   g. SMG4C - Spectral Model Global 40 modes 12-layers
   h. SMG4H - Spectral Model Global 40 modes 18-layers
   i. SMG8H - Spectral Model Global 80 modes 18-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 to April 15, 1981: SMG3C to 48-hours then SMH2C to 84-hours.
      (5) From April 15, 1981 through October 19, 1983: SMG3C to 48-hours then SMG2C to 84-hours.
      (6) From October 19, 1983 through December 1984: SMG4C
      (7) From January 01, 1985 through December 1986: SMG4H
      (8) From August 13, 1987 through December 1989 : SMG8H

   b. Greater then 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 April 1982: SMG26
      (5) From May 1982 through October 19, 1983: SMG2C
      (6) From October 19, 1983 through December 1984: SMG4C
      (7) From January 01, 1985 through December 1986: SMG4H
      (8) From August 13, 1987 through December 1989 : SMG8H

   c. Greater the 144-hours to 240-hours

      (1) From November 1977 through April 1981: Baro Mesh
      (2) From December 1977 through April 15, 1981: 3L PE CM
      (3) From April 15, 1981 through October 19, 1983: SMG26 to 192-hours then SMG26 to 240 hours.
      (4) From October 19, 1983 through December 1984: SMG4C to

240-hours.

(5) From January 01, 1985 through August 12, 1987: SMG4H to 240-hours.

(6) From August 13, 1987 through December 1989: SMG8H to 240-hours.

3. 12Z Guidance

a. To 60-hours

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

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

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

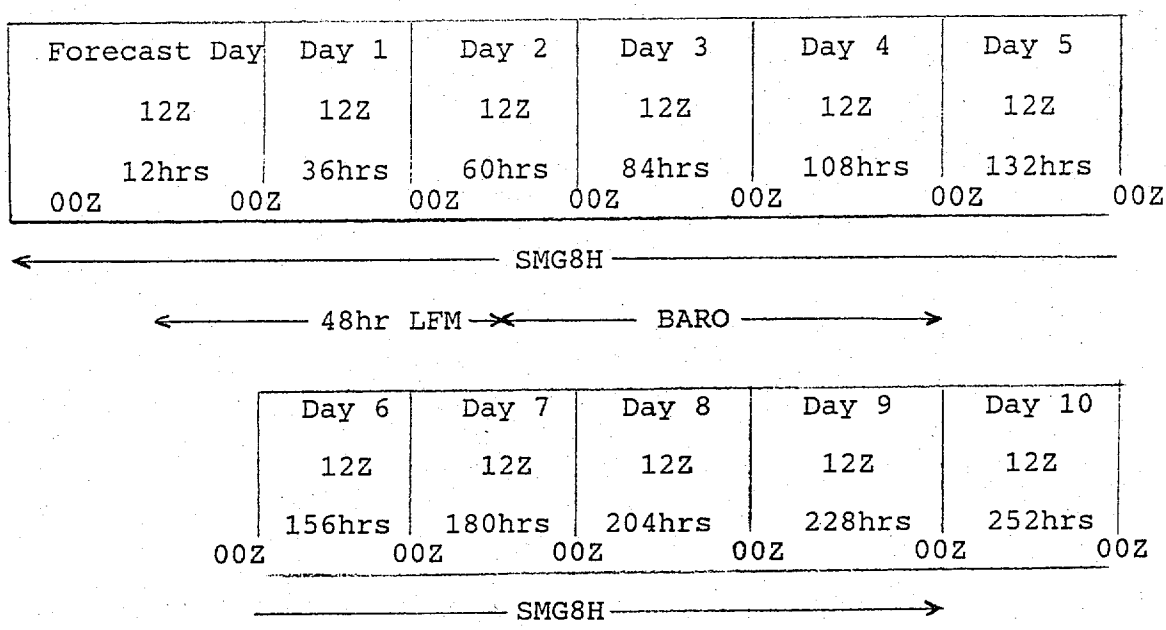
c. To 48-hours

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

(2) From September 1977 through 1987: 7L PE LFM (127km)

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

(1) From 1978 through 1989: Baro run from the 48-hour LFM inserted into the 60-hour SMG8H from 00Z.



*Note OI analysis replaced the HUF in late July 1984.

Figure 1 depicts the North American (NOAM, 130 grid points) mean sea level pressure (MSLP) and 500mb correlation score verification area.

Figures 2-13 are plots of the calendar year 1989 monthly mean correlation scores for the man and NMC/NWP/MRF model NOAM area MSLP progs verifying on days 1-9 after forecast day.

Figures 14-25 are plots of the calendar year 1989 monthly mean standardized correlation scores for the man and NMC/NWP/MRF model NOAM area MSLP progs verifying on days 1-9 after forecast day. (See Appendix A for an explanation of this score).

Figures 26-37 are plots of the calendar year 1989 monthly mean standardized correlation scores for the NMC/NWP/MRF model NOAM area 500mb progs verifying on days 1-9 after forecast day.

Figures 38-49 are plots of the calendar year 1989 monthly mean standardized correlation scores for the NMC/NWP/(AVN, NGM, LFM) models NOAM area MSLP progs verifying on days 1-(3,2,2) after forecast day.

Figures 50-61 are plots of the calendar year 1989 monthly mean standardized correlation scores for the NMC/NWP/(AVN, NGM, LFM) model NOAM area 500mb progs verifying on days 1-(3,2,2) after forecast day.

Figure 62 is a plot of the 1968/70-1989 calendar year standardized correlation scores for the man and NMC/NWP model NOAM area MSLP progs verifying on days 3, 4 and 5 after forecast day.

Figure 63 is a plot of the 1970-89 calendar year standardized correlation scores for the NMC/NWP model NOAM area 500mb progs verifying on days 3, 4 and 5 after forecast day.

Figure 64 is a plot of the 1979-89 calendar year normalized correlation scores for the man, NMC/NWP model, and ECMWF model (82-89) NOAM area 500mb mean progs verifying 6-10 days after forecast day.

Figure 65 depicts the 41 stations in the United States where the temperature forecasts are verified.

Figures 66-77 are plots of the calendar year 1989 monthly mean absolute error minimum/maximum temperature scores for the man, Klein-Lewis (KL) Perfect Prog, MOS, linear regression corrected Perfect Prog, and climatology U.S. area temperature forecasts verifying on days 1-9 after forecast day.

Figure 78 is a plot of the 1971-89 calendar year average absolute error minimum temperature scores for the man and KL Perfect Prog U.S. area temperature forecast verifying on days 3 and 5 after forecast day.

Figure 79 is a plot of the 1971-89 calendar year average absolute error maximum temperature scores for the man and KL Perfect Prog U.S. area temperature forecasts verifying on days 3 and 5 after forecast day.

Figure 80 is a plot of the 1971-89 calendar year average absolute error (minimum + maximum) - 2 temperature scores for the man, KL Perfect Prog, and climatology U.S. area temperature forecasts verifying on days (3+4+5) - 3 after forecast day.

Figure 81 is a plot of the 1978-89 5-class and 3-class temperature skill scores for the man U.S. area categorical temperature forecasts verifying 6-10 days after forecast day. (See Appendix B for an explanation of this score.)

Figure 82 depicts the 100 stations in the United States where the precipitation forecasts are verified.

Figure 83 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 "yes" forecast of precipitation ($\geq$ 0.01 inch). All stations with an (NPOP) $\geq$ 30 are considered as a "yes" climatological forecast of precipitation.

Figures 84-95 are plots of the calendar year 1989 monthly mean Gilman, Hughes, and Probability precipitation skill scores for the man and climatology U.S. area precipitation forecasts verifying on days 1-9 after forecast day. (See Appendixes C, D and E for an explanation of these scores.)

Figure 96 is a plot of the 1970-89 Gilman precipitation skill scores for the man and climatology U.S. area precipitation forecasts verifying on days 3, 4 and 5 after forecast day.

Figure 97 is a plot of the 1978-89 3-class precipitation skill scores for the man and NMC/NWP model U.S. area categorical precipitation forecasts verifying 1-5 days after forecast day. (For an explanation of this score see Appendix F.)

Figure 98 is a plot of the 1978-89 3-class precipitation skill scores for the man and NMC/NWP model U.S. area categorical precipitation forecasts verifying 6-10 days after forecast day.

SECTION 1

Man and Machine (NMC/NWP Model Guidance)

Mean Sea Level Pressure and 500mb Correlation Scores

Fig. 1

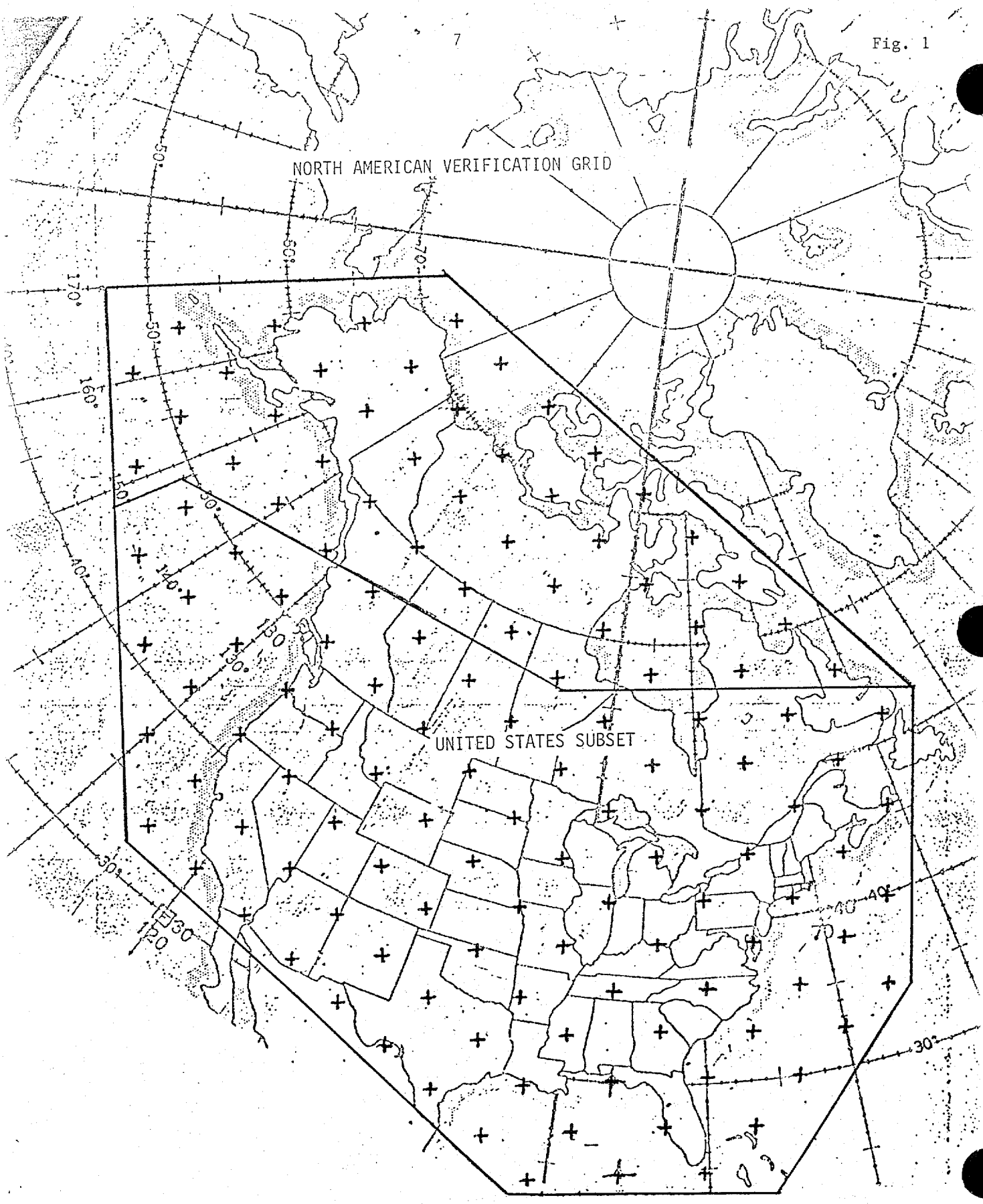

NORTH AMERICAN VERIFICATION GRID
UNITED STATES SUBSET
170°
160°
150°
140°
130°
120°
50°
40°
30°
70°

Fig. 2

DAYS 1 THROUGH 9 NORTH AMERICAN AREA MSLP
CORRELATION SCORES FOR JAN 89

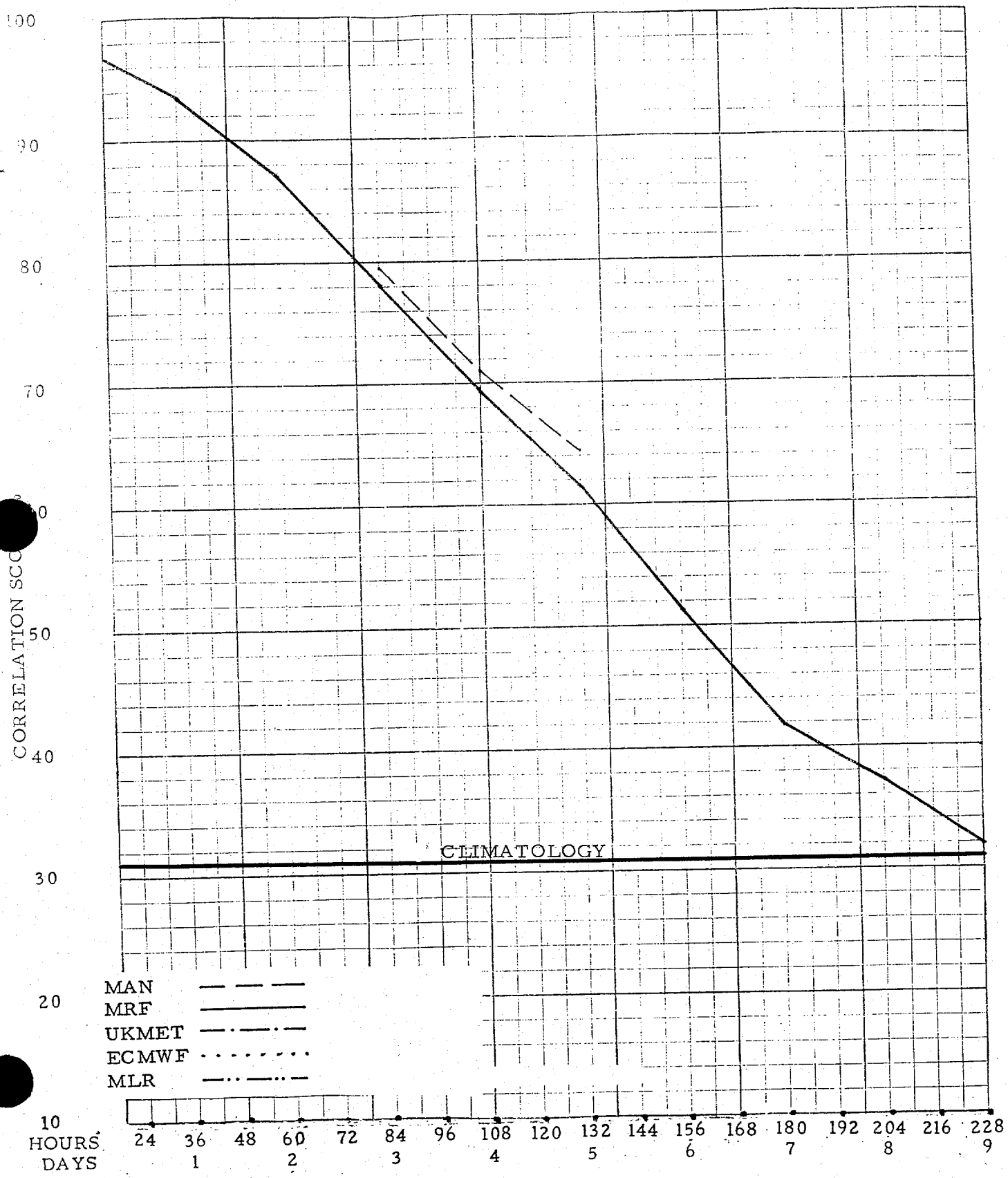


Fig. 3

DAYS 1 THROUGH 9 NORTH AMERICAN AREA MSLP
CORRELATION SCORES FOR FEB 1989

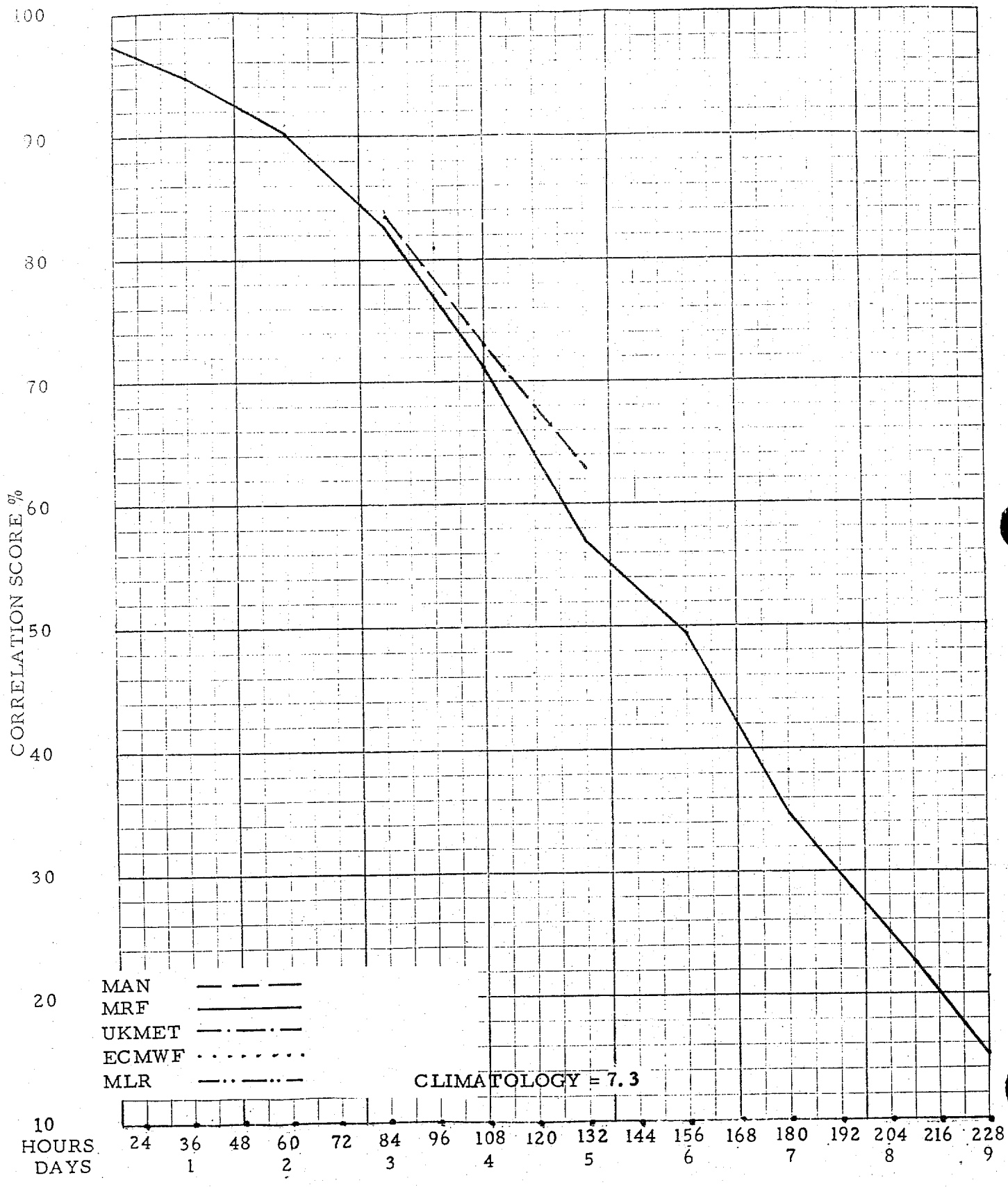


Fig. 4

DAYS 1 THROUGH 9 NORTH AMERICAN AREA MSLP
CORRELATION SCORES FOR MAR 89

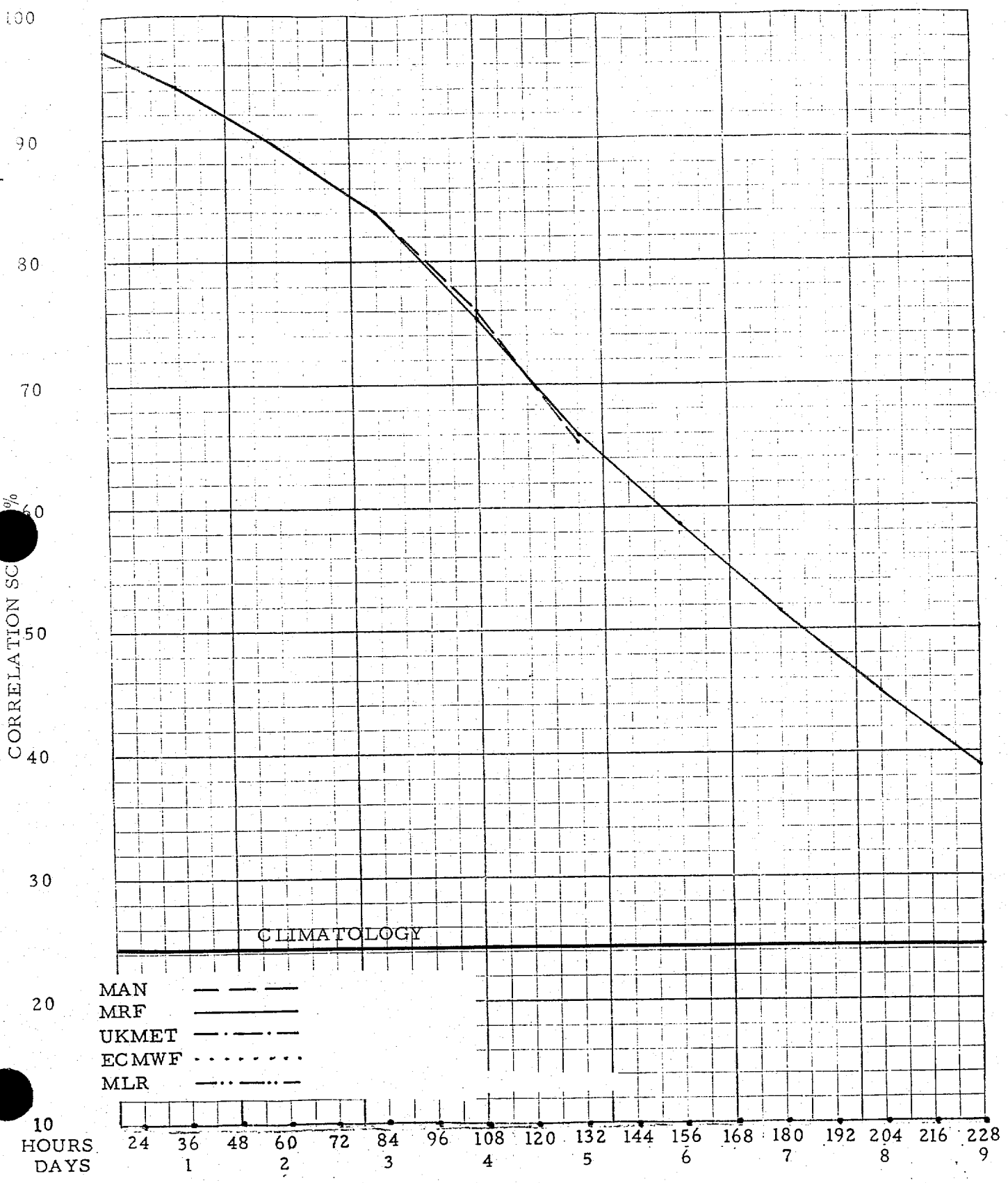


Fig. 5

DAYS 1 THROUGH 9 NORTH AMERICAN AREA MSLP
CORRELATION SCORES FOR APR 89

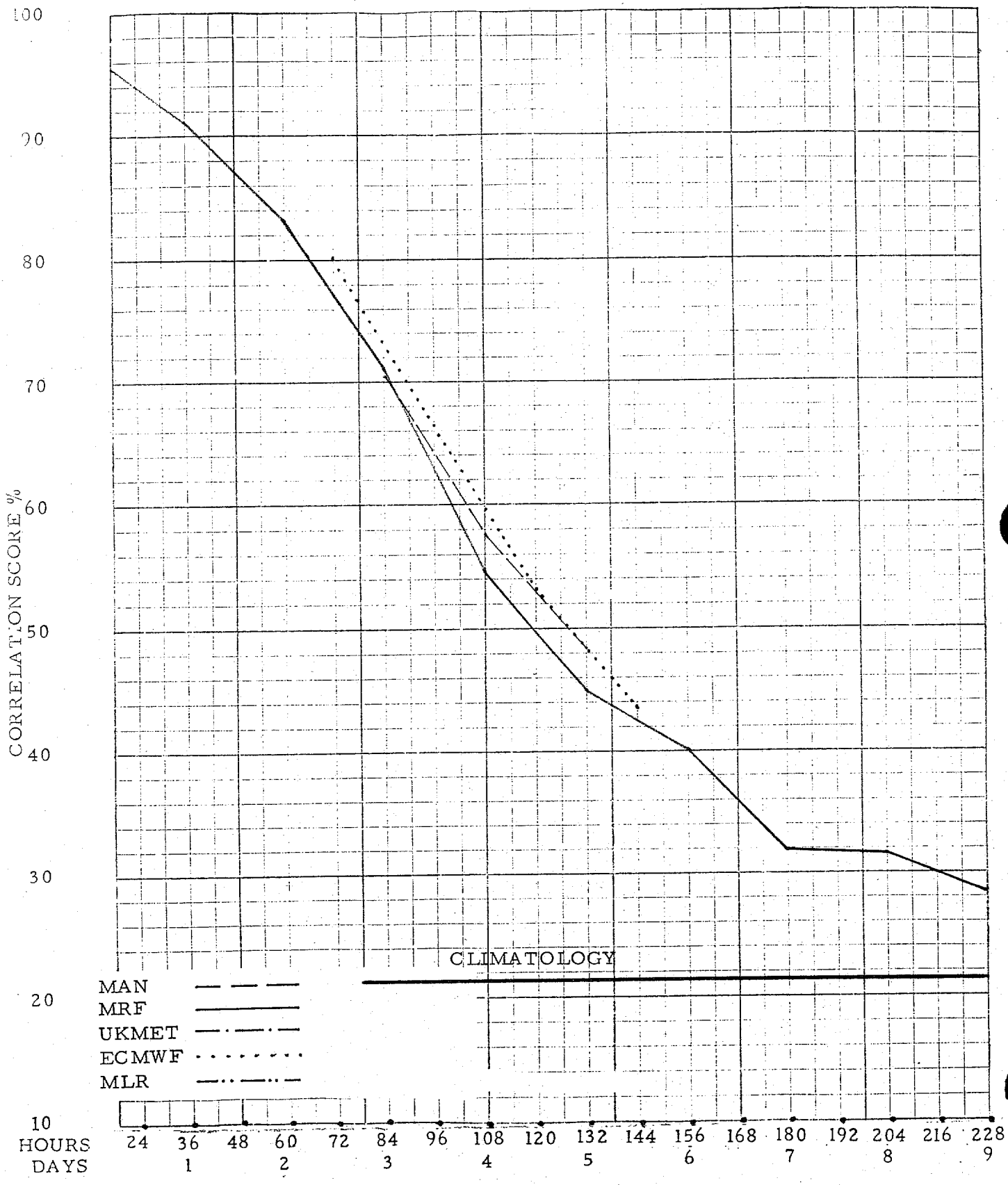


Fig. 6

DAYS 1 THROUGH 9 NORTH AMERICAN AREA MSLP
CORRELATION SCORES FOR MAY 89

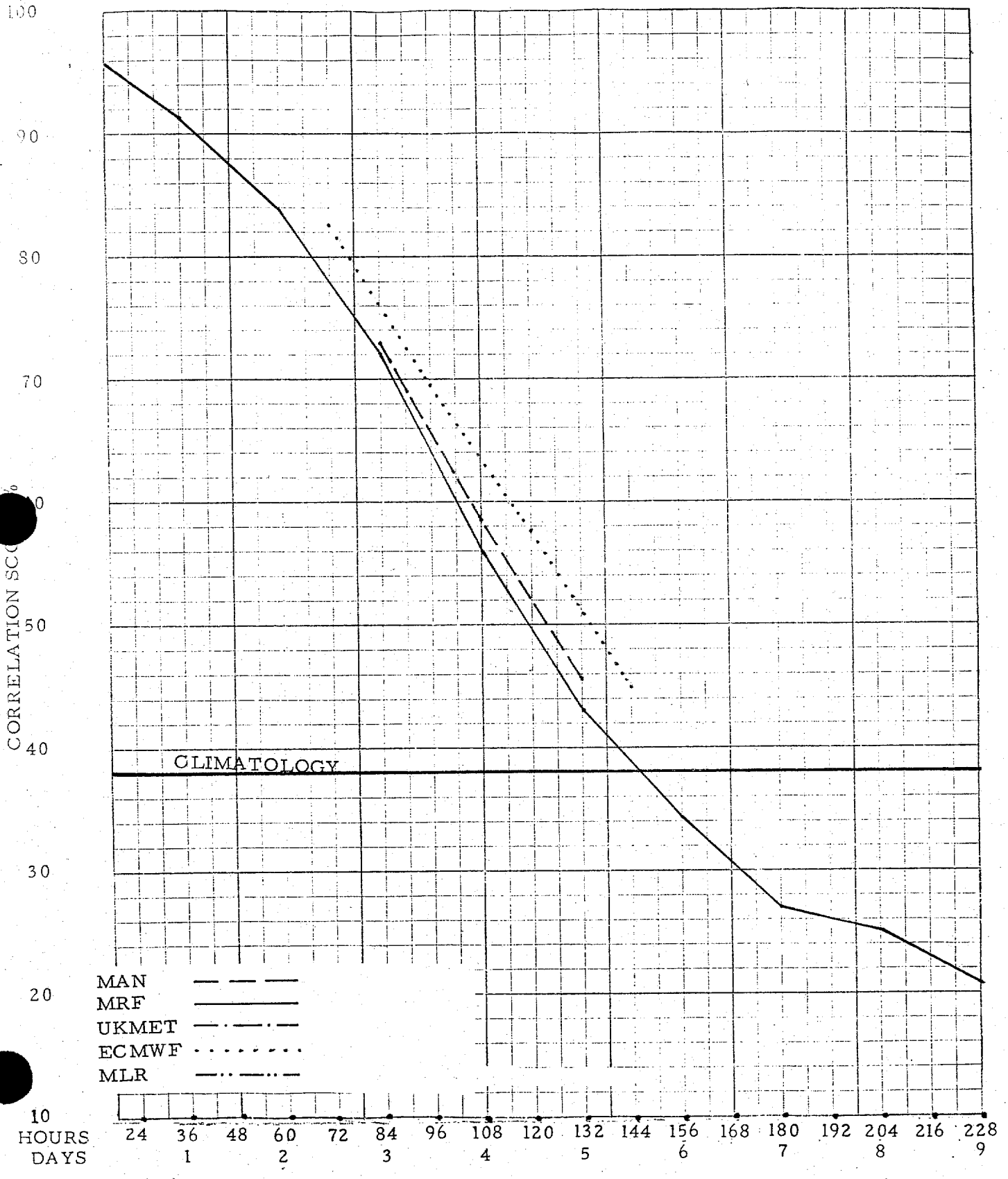


Fig. 7

DAYS 1 THROUGH 9 NORTH AMERICAN AREA MSLP
CORRELATION SCORES FOR JUN 89

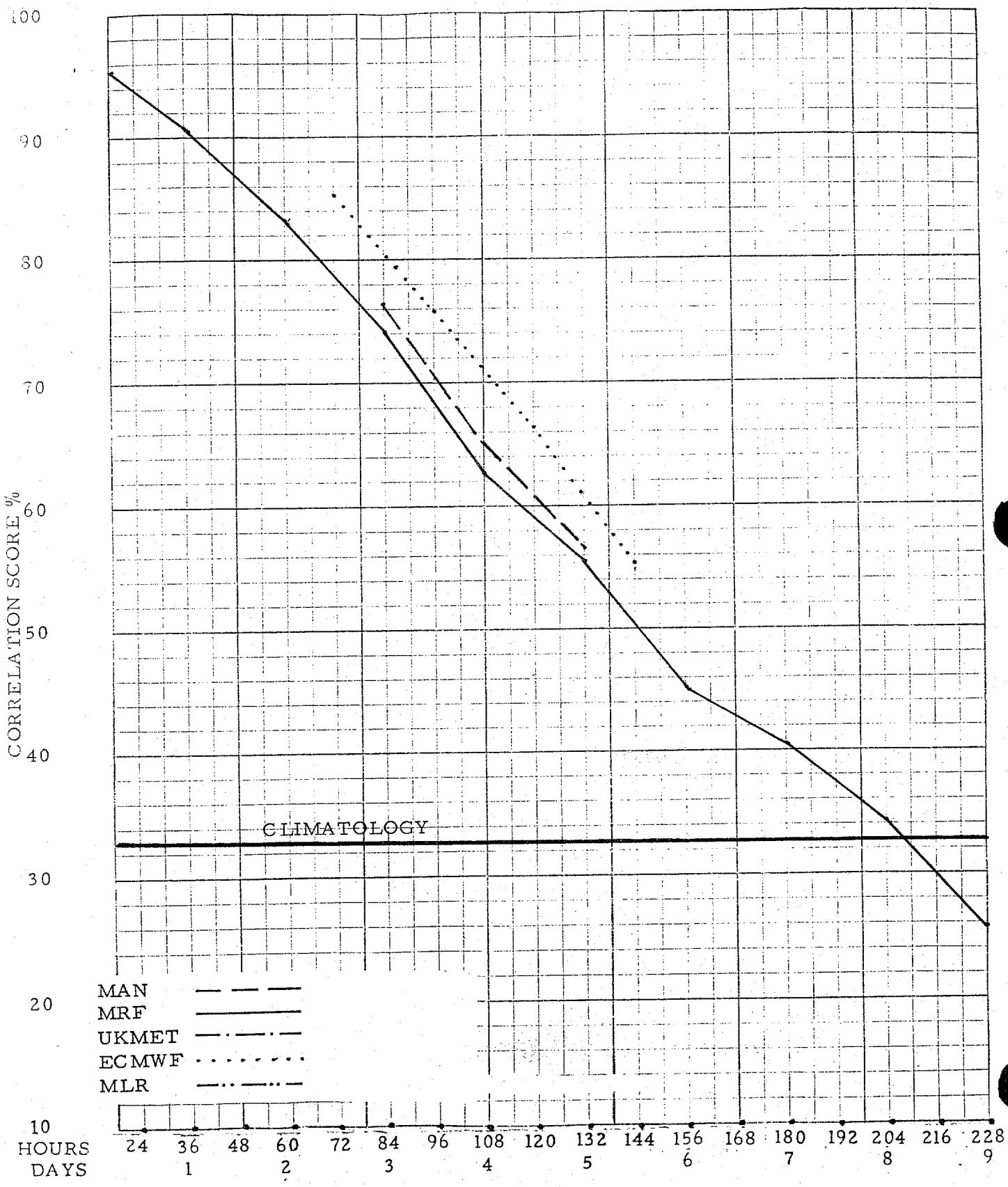


Fig. 8

DAYS 1 THROUGH 9 NORTH AMERICAN AREA MSLP
CORRELATION SCORES FOR JUL 89

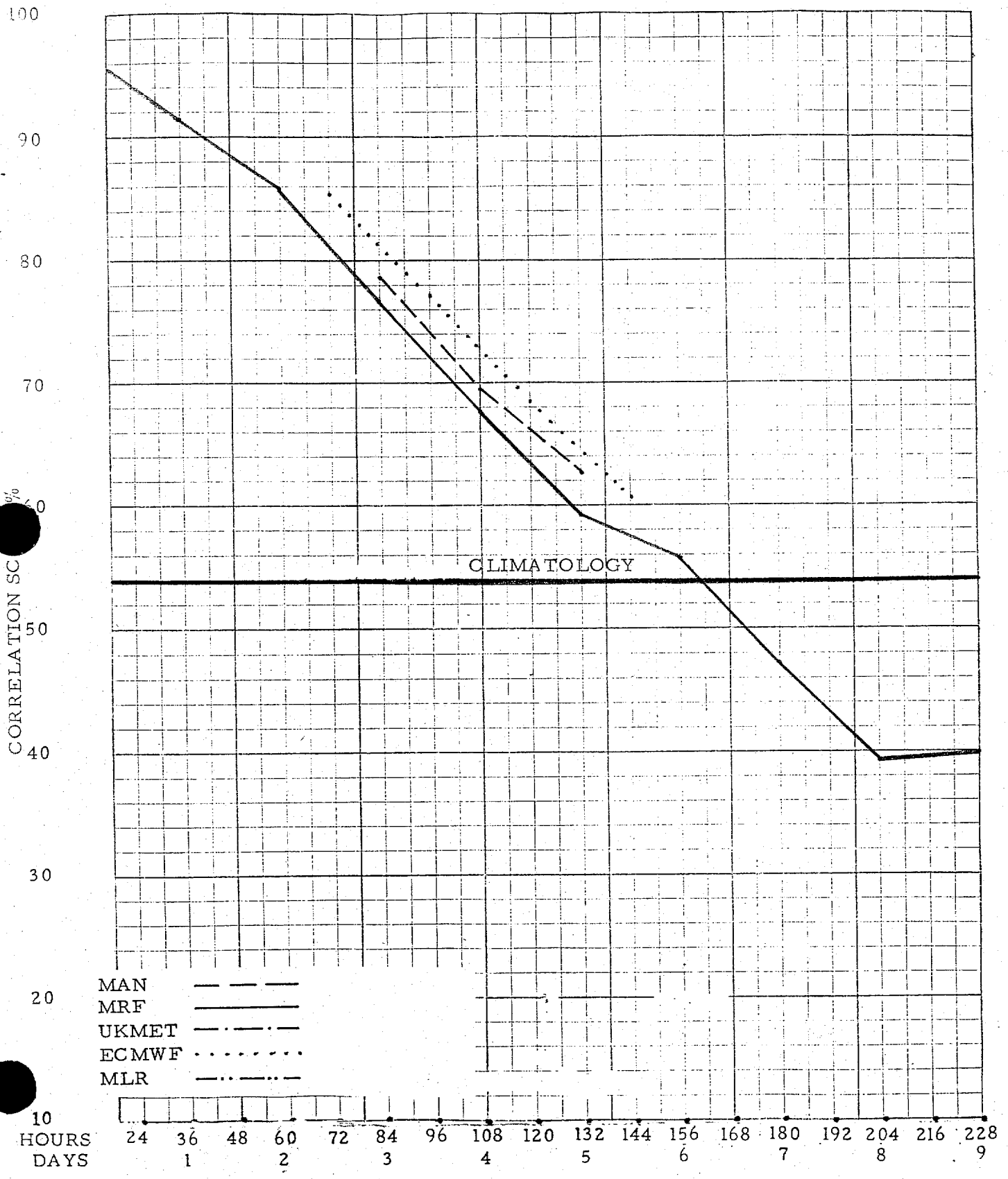


Fig. 9

DAYS 1 THROUGH 9 NORTH AMERICAN AREA MSLP
CORRELATION SCORES FOR AUG 89

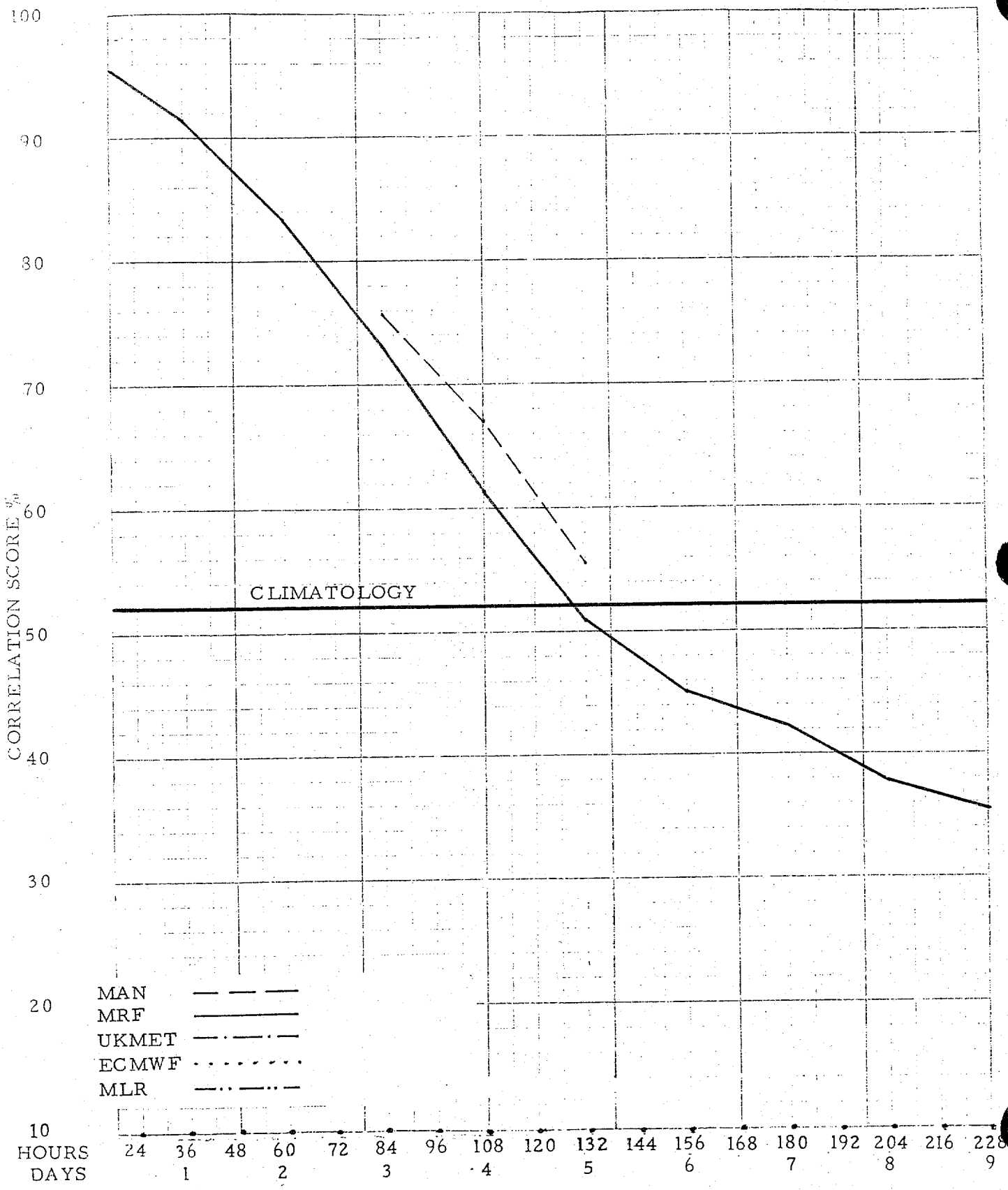


Fig. 10

DAYS 1 THROUGH 9 NORTH AMERICAN AREA MSLP
CORRELATION SCORES FOR SEP 89

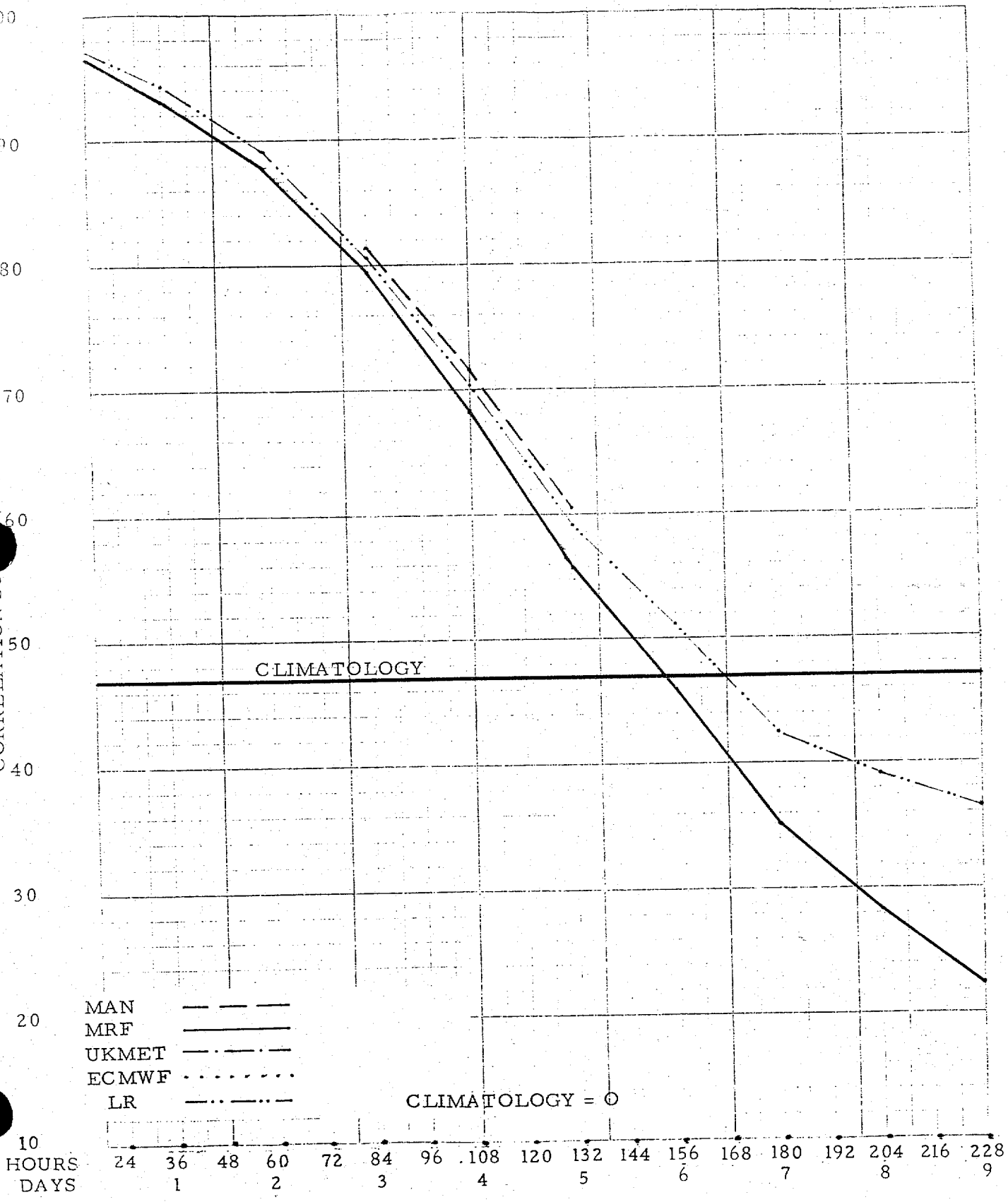


Fig. 11

DAYS 1 THROUGH 9 NORTH AMERICAN AREA MSLP
CORRELATION SCORES FOR OCT 1989

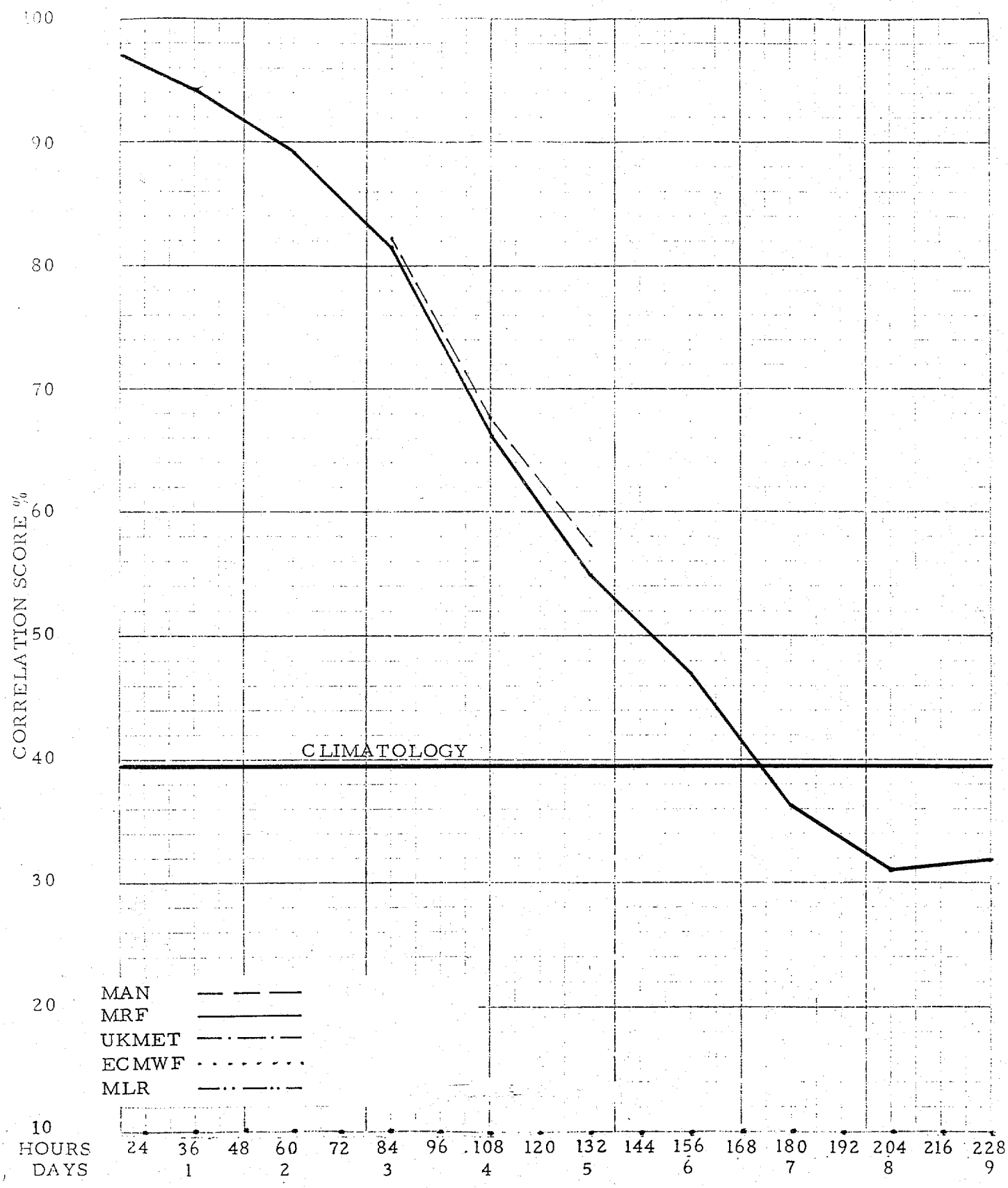


Fig. 12

DAYS 1 THROUGH 9 NORTH AMERICAN AREA MSLP
CORRELATION SCORES FOR NOV 89

Fig. 13

DAYS 1 THROUGH 9 NORTH AMERICAN AREA MSLP
CORRELATION SCORES FOR DEC 89

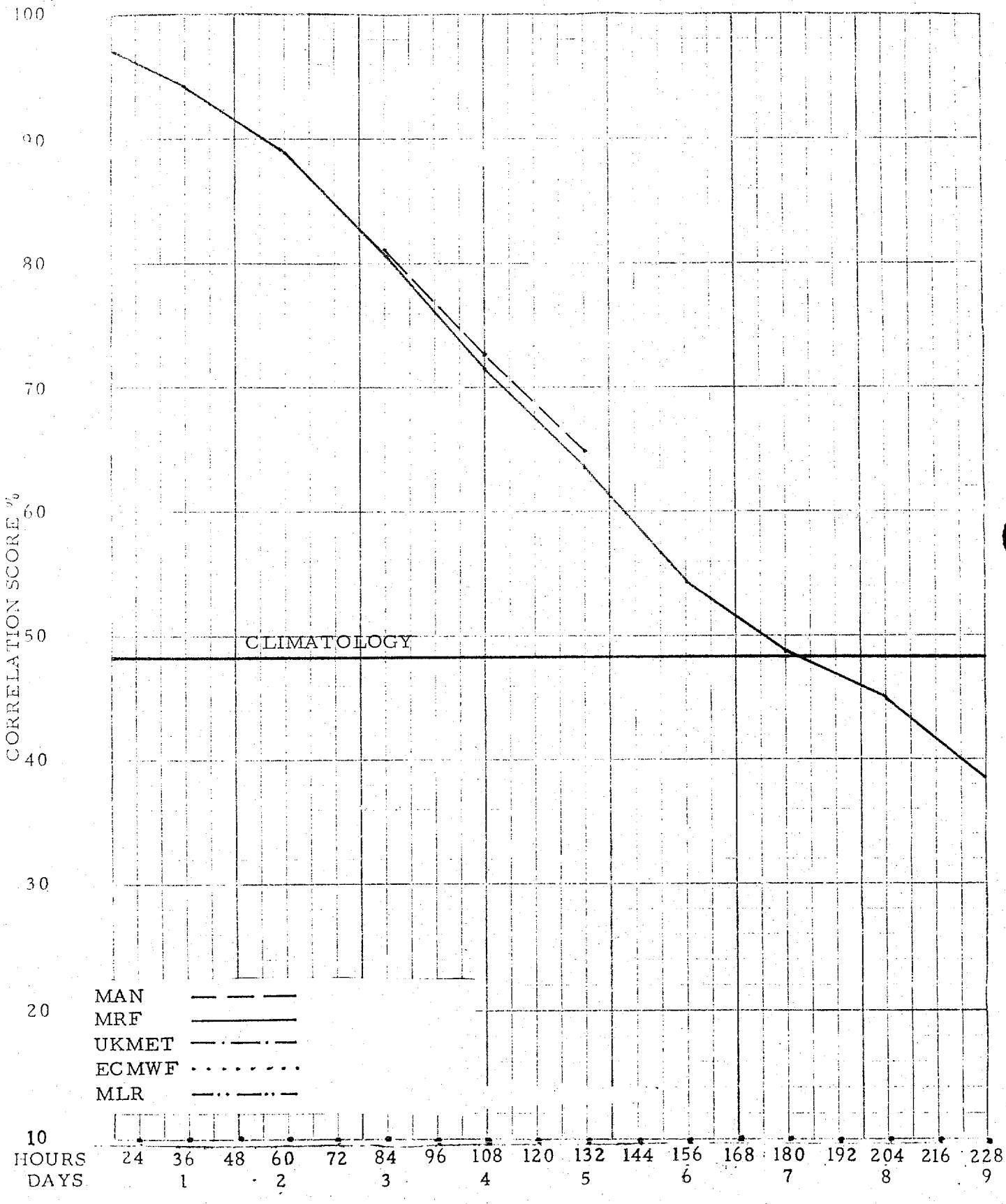


Fig. 14

DAYS 1 THROUGH 9 NORTH AMERICAN AREA MSLP
STANDARDIZED CORRELATION SCORES FOR JAN 89

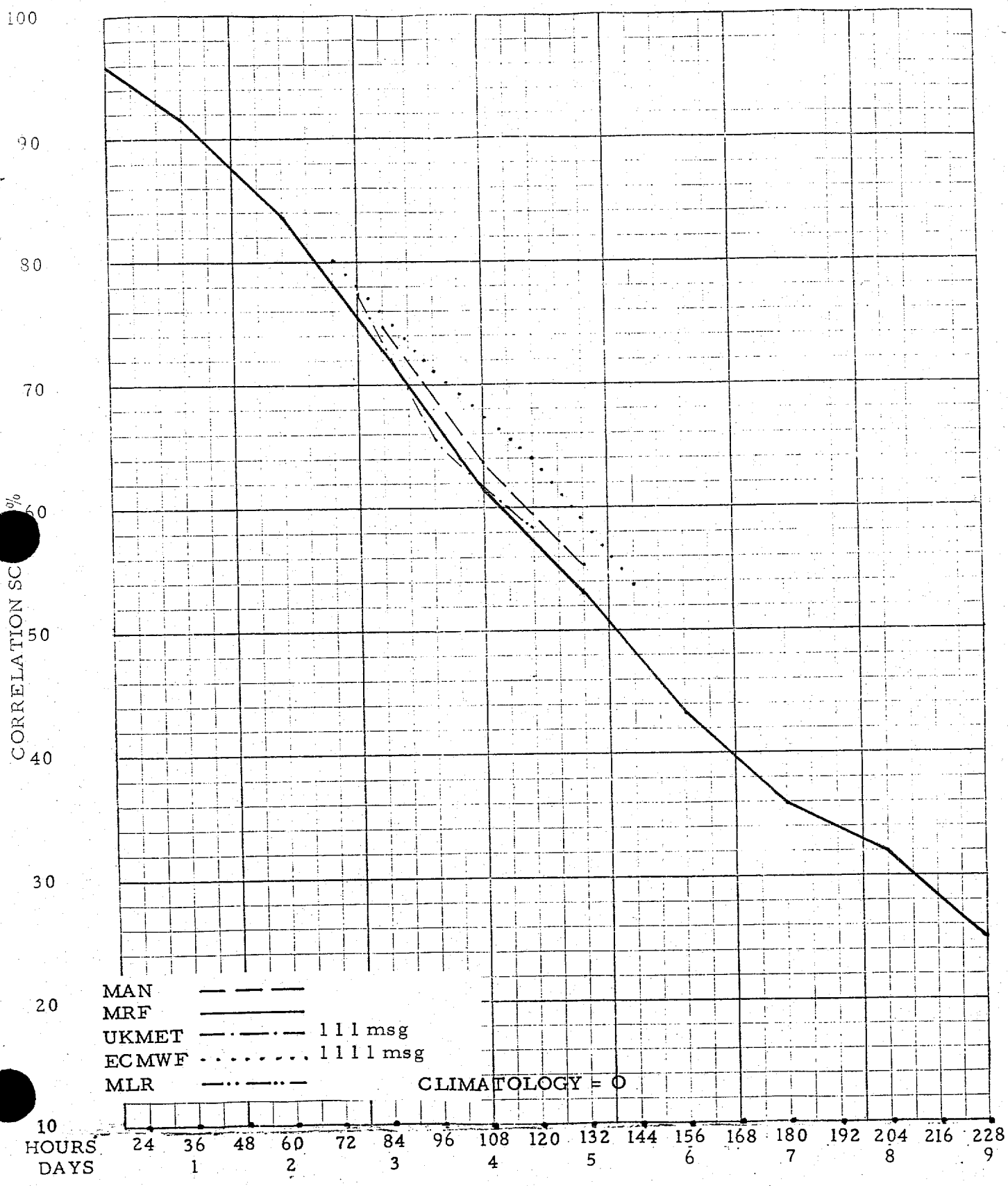


Fig. 15

DAYS 1 THROUGH 9 NORTH AMERICAN AREA MSLP
STANDARDIZED CORRELATION SCORES FOR FEB 1989

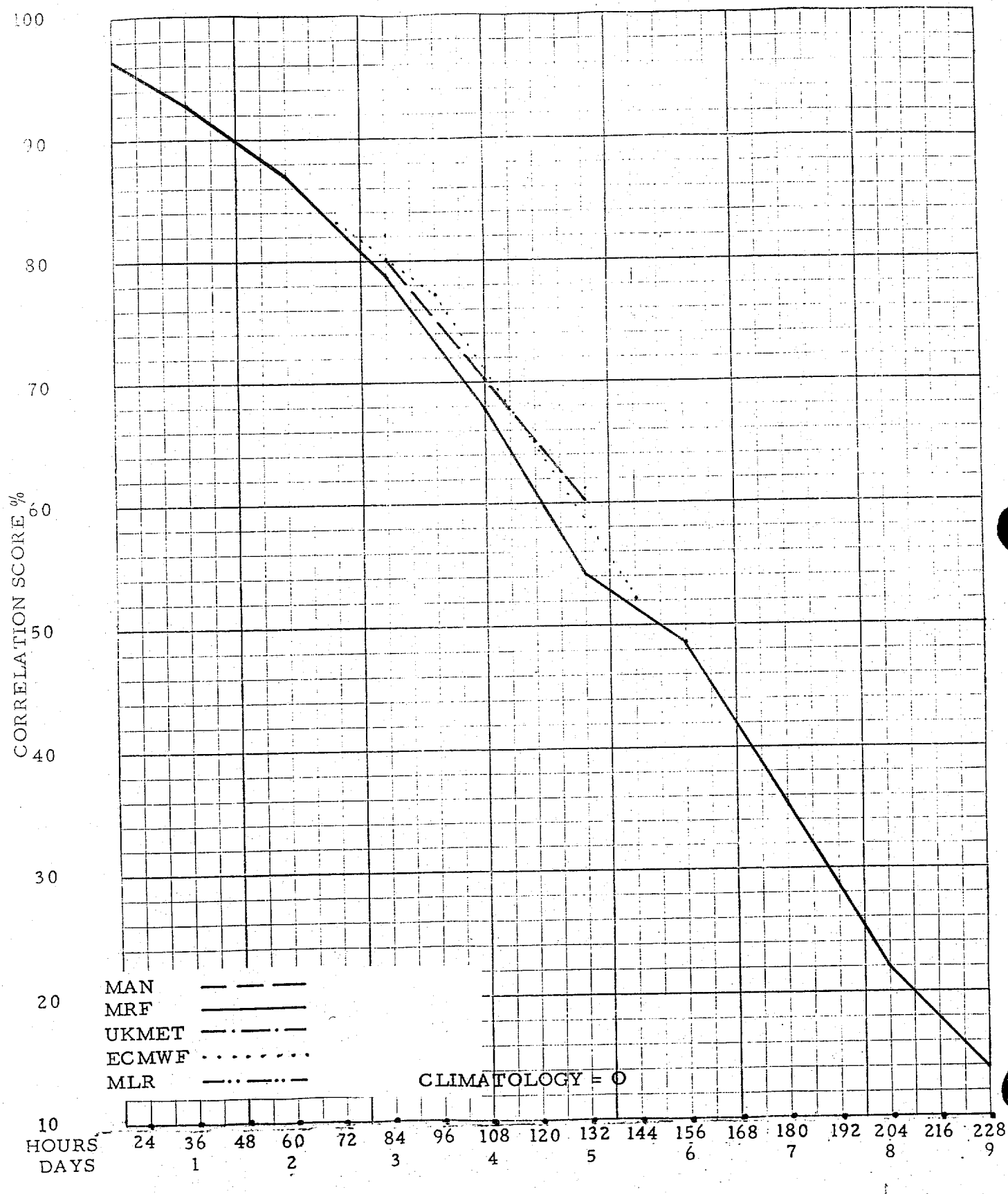


Fig. 16

DAYS 1 THROUGH 9 NORTH AMERICAN AREA MSLP
STANDARDIZED CORRELATION SCORES FOR MAR 89

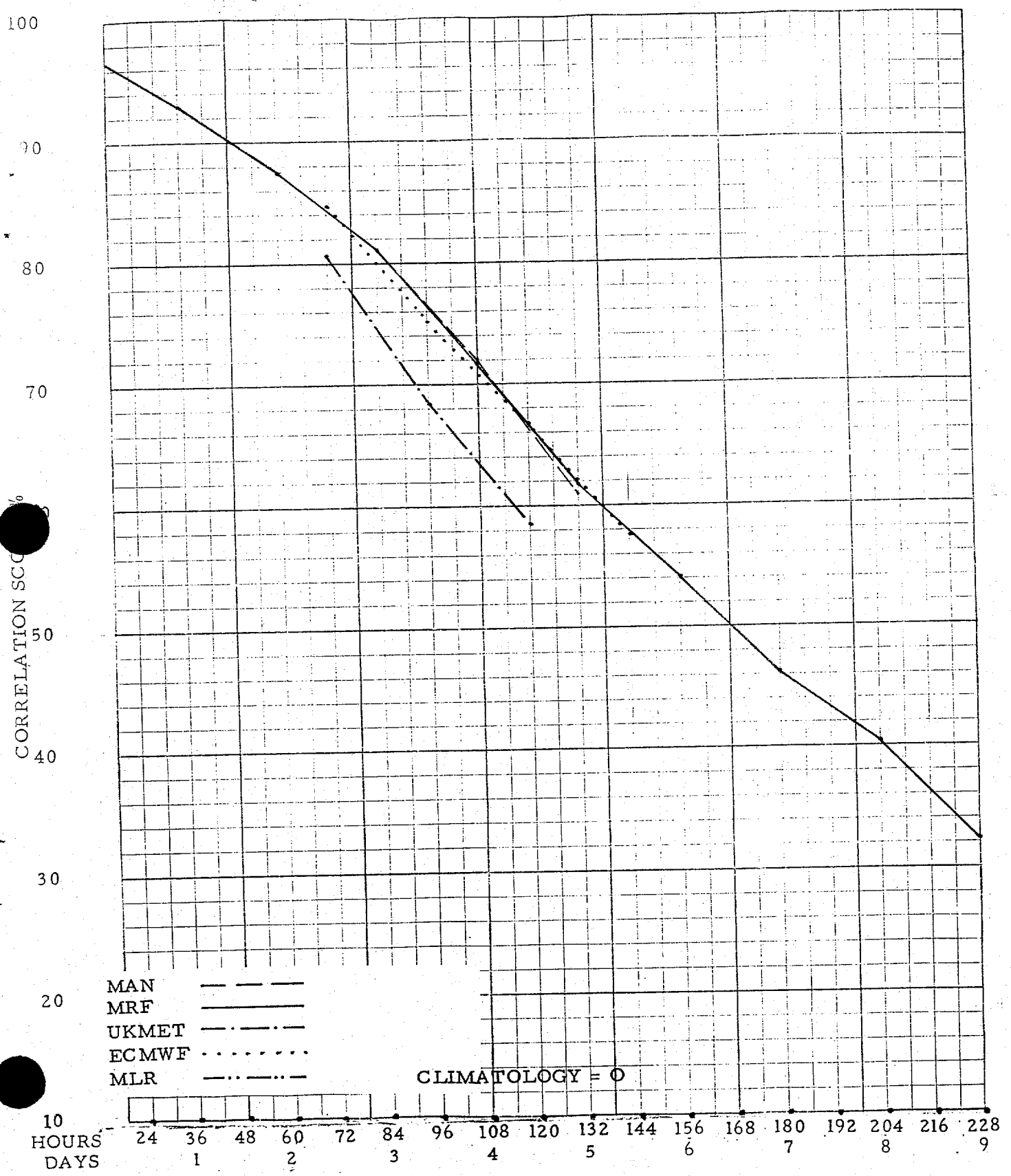


Fig. 17

DAYS 1 THROUGH 9 NORTH AMERICAN AREA MSLP
STANDARDIZED CORRELATION SCORES FOR APR 89

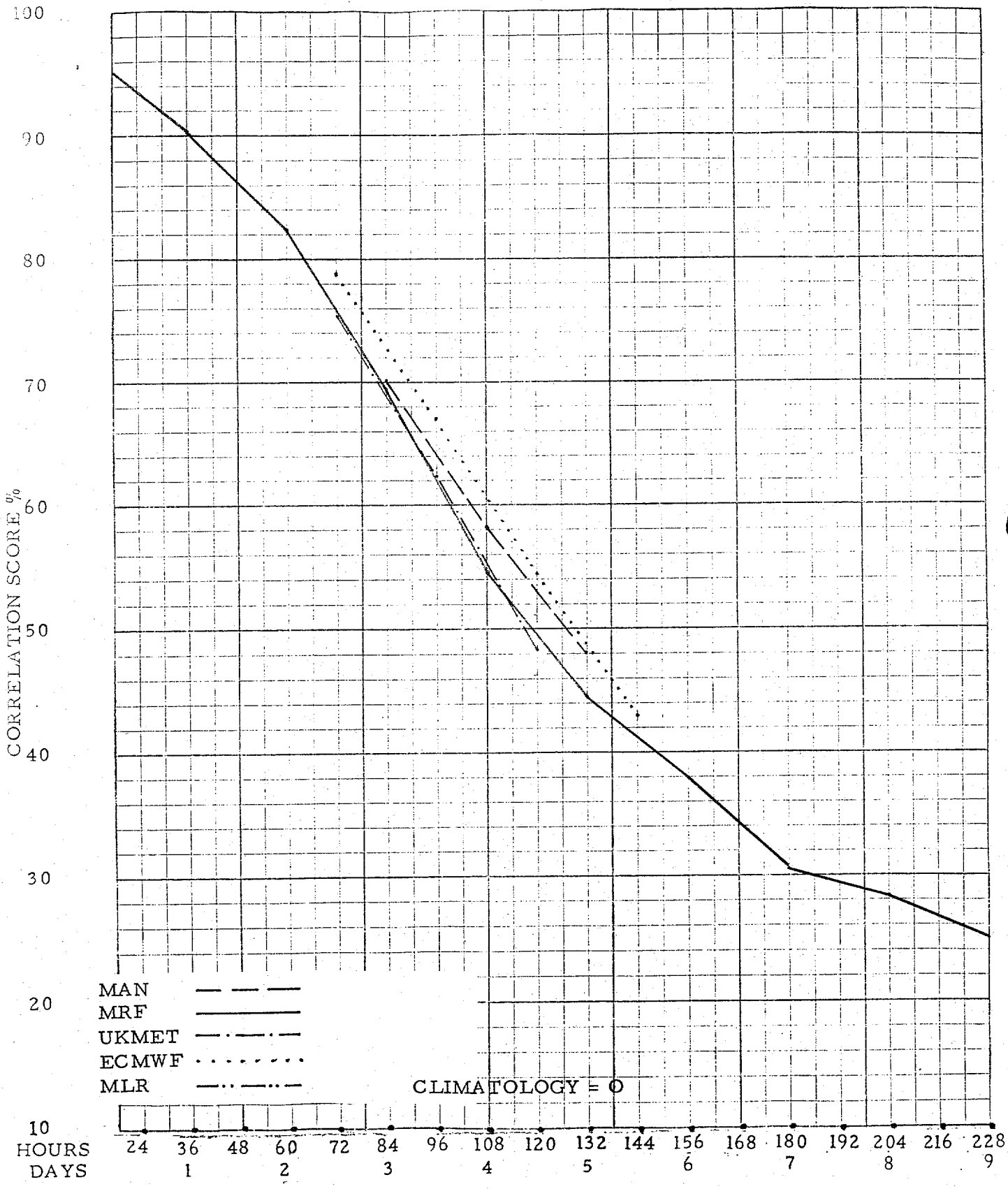


Fig. 18

DAYS 1 THROUGH 9 NORTH AMERICAN AREA MSLP
STANDARDIZED CORRELATION SCORES FOR MAY 89

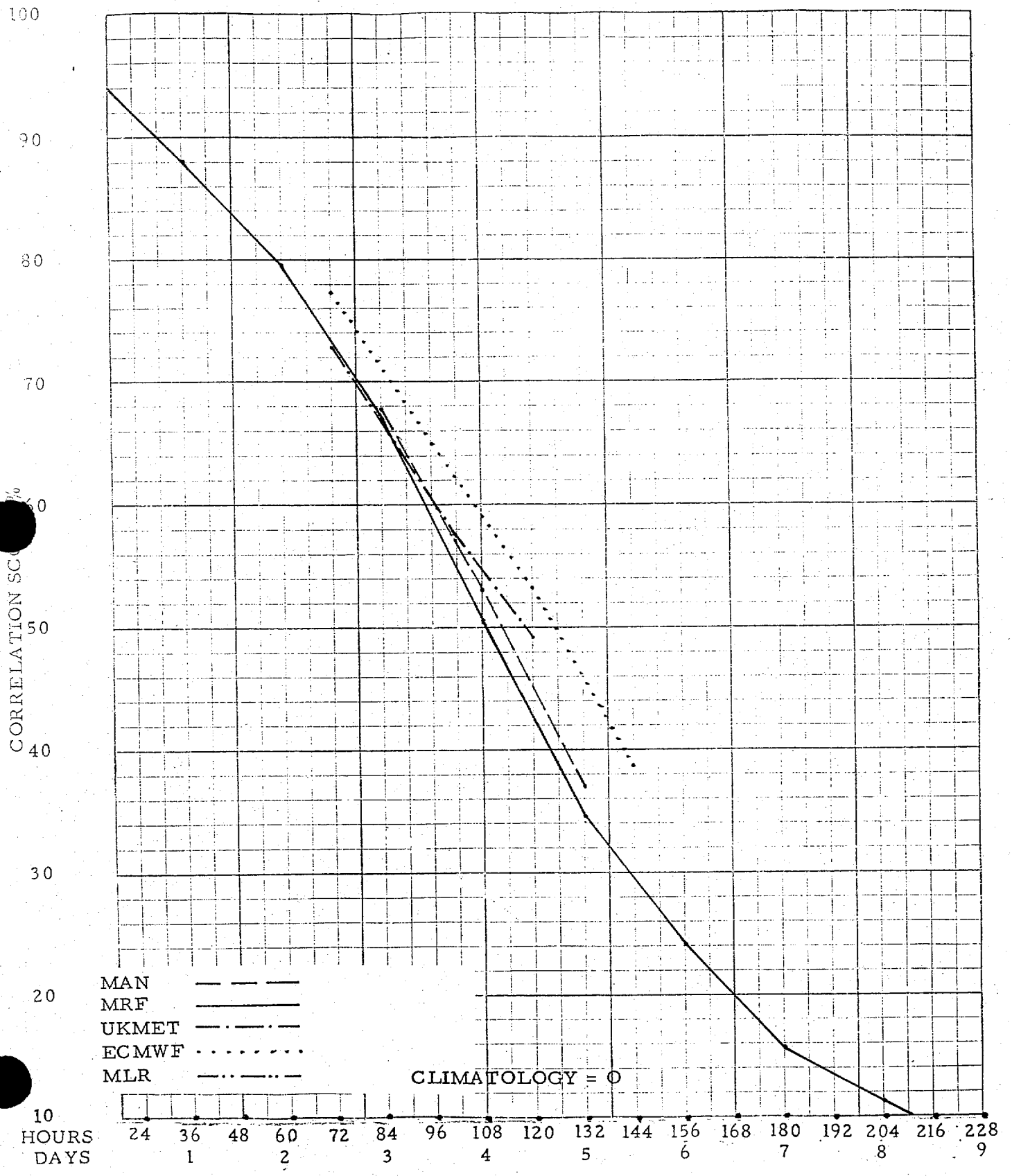


Fig. 19

DAYS 1 THROUGH 9 NORTH AMERICAN AREA MSLP
STANDARDIZED CORRELATION SCORES FOR JUN 89

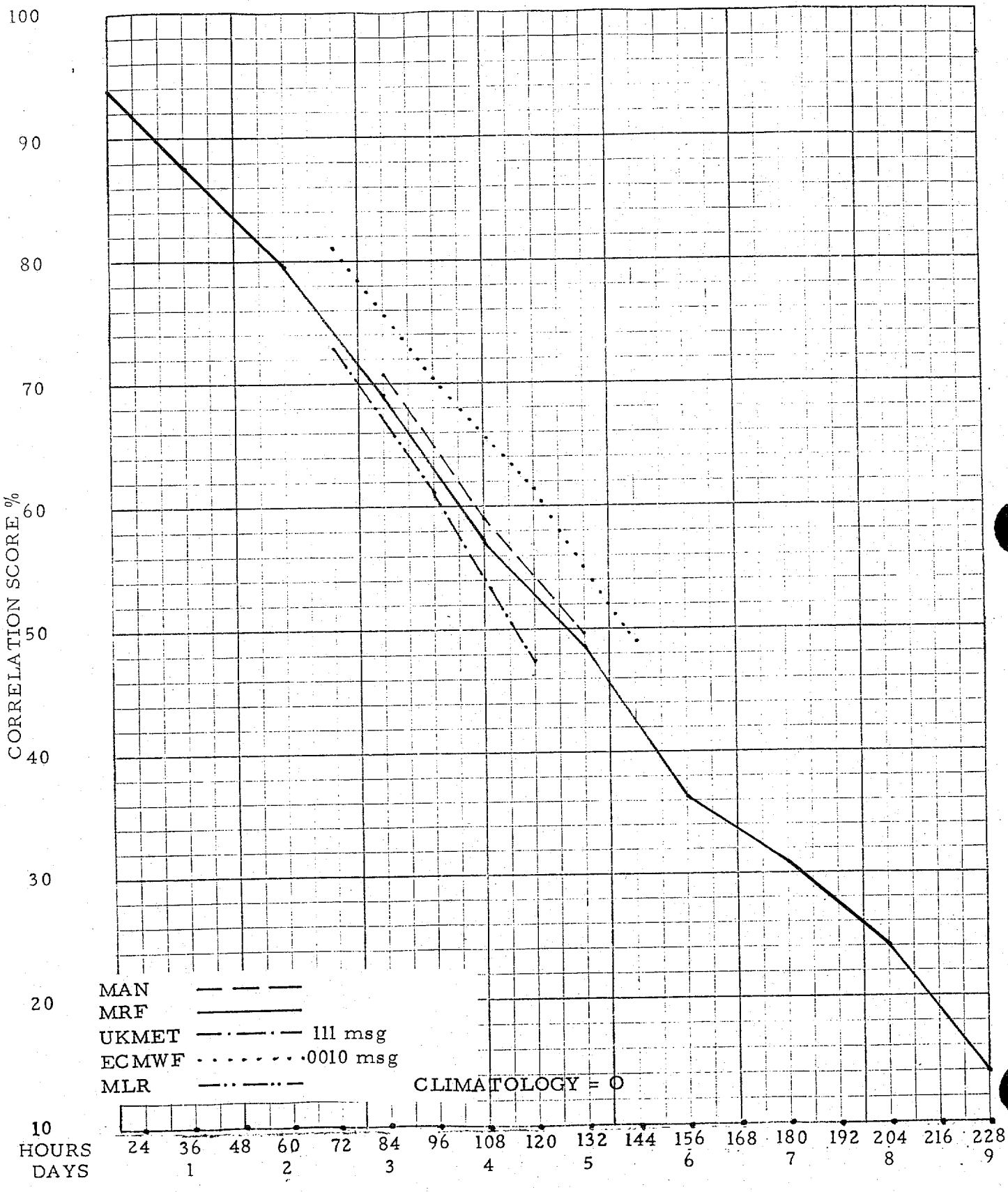


Fig. 20

DAYS 1 THROUGH 9 NORTH AMERICAN AREA MSLP
STANDARDIZED CORRELATION SCORES FOR JUL 89

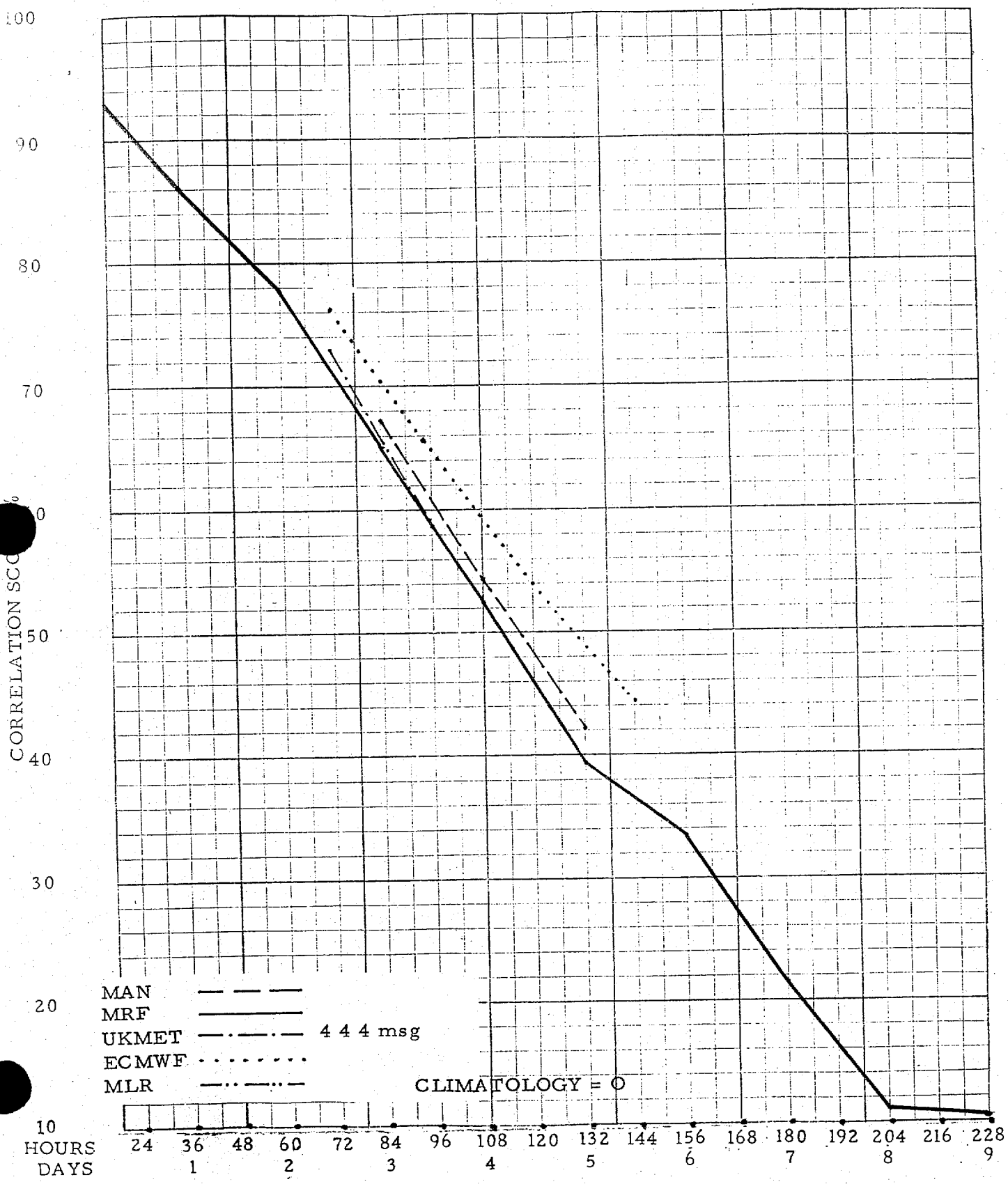


Fig. 21

DAYS 1 THROUGH 9 NORTH AMERICAN AREA MSLP
STANDARDIZED CORRELATION SCORES FOR AUG 89

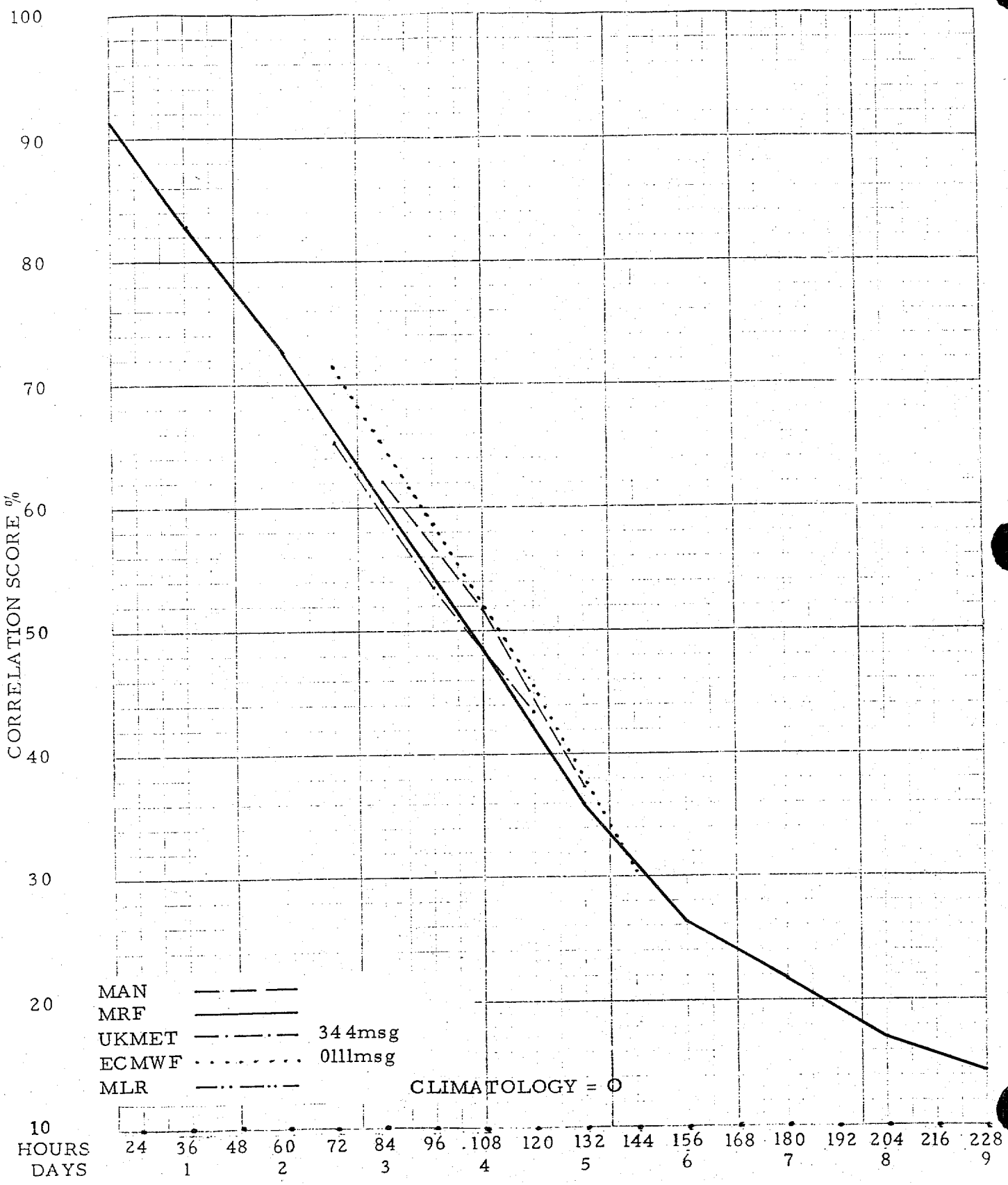


Fig. 22

DAYS 1 THROUGH 9 NORTH AMERICAN AREA MSLP
STANDARDIZED CORRELATION SCORES FOR SEP 89

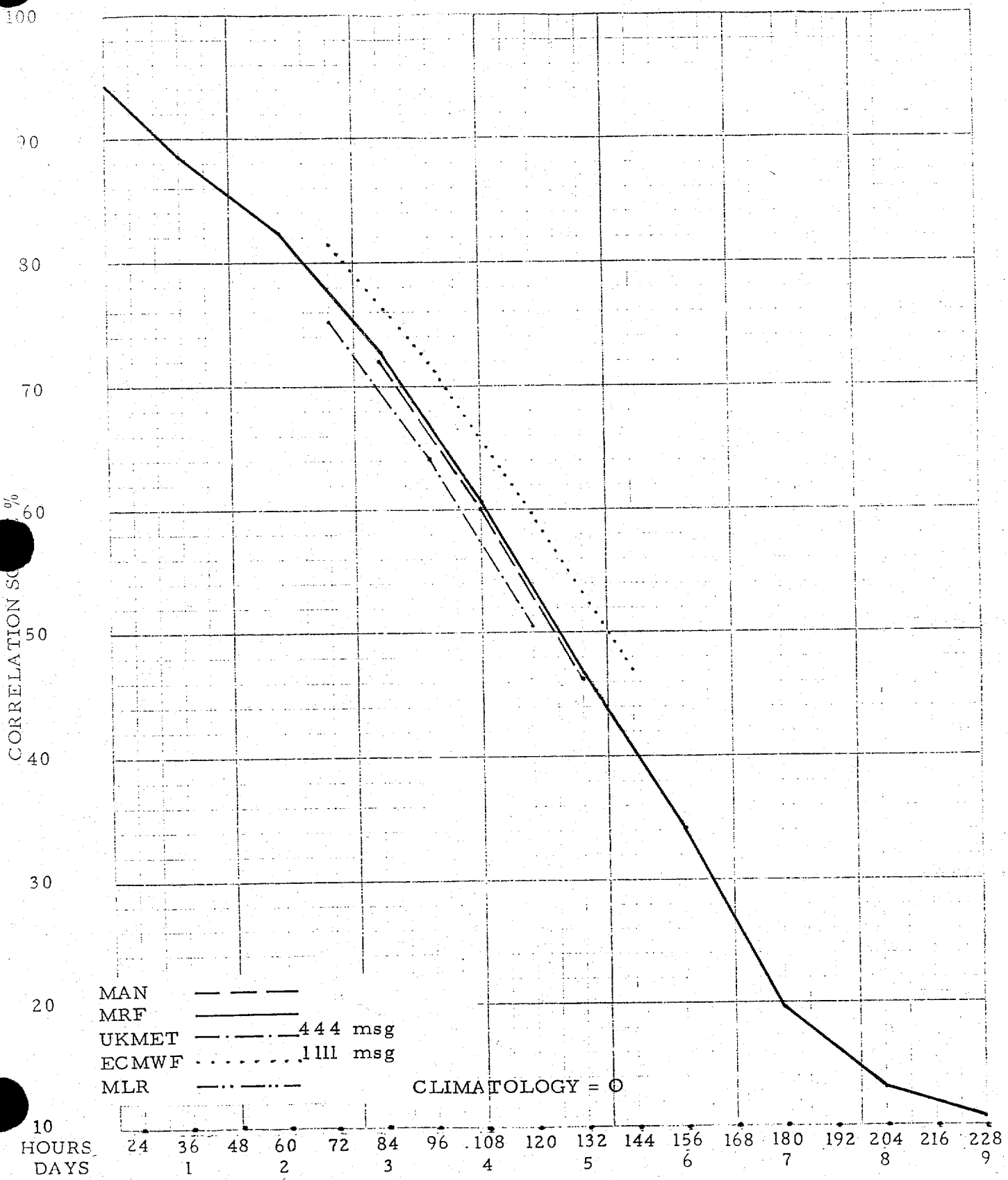


Fig. 23

DAYS 1 THROUGH 9 NORTH AMERICAN AREA MSLP
STANDARDIZED CORRELATION SCORES FOR OCT 1989

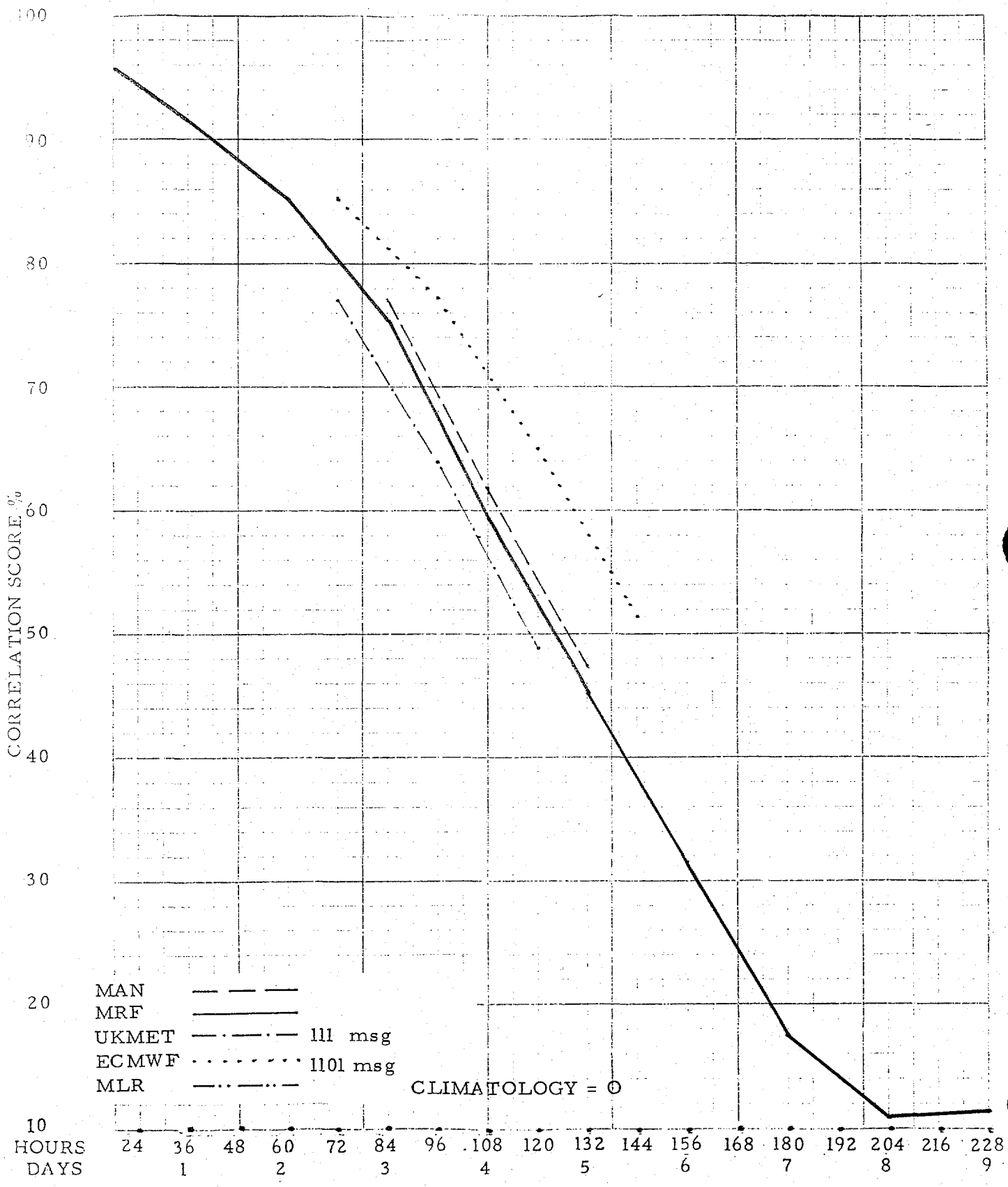


Fig. 24

DAYS 1 THROUGH 9 NORTH AMERICAN AREA MSLP
STANDARDIZED CORRELATION SCORES FOR NOV 89

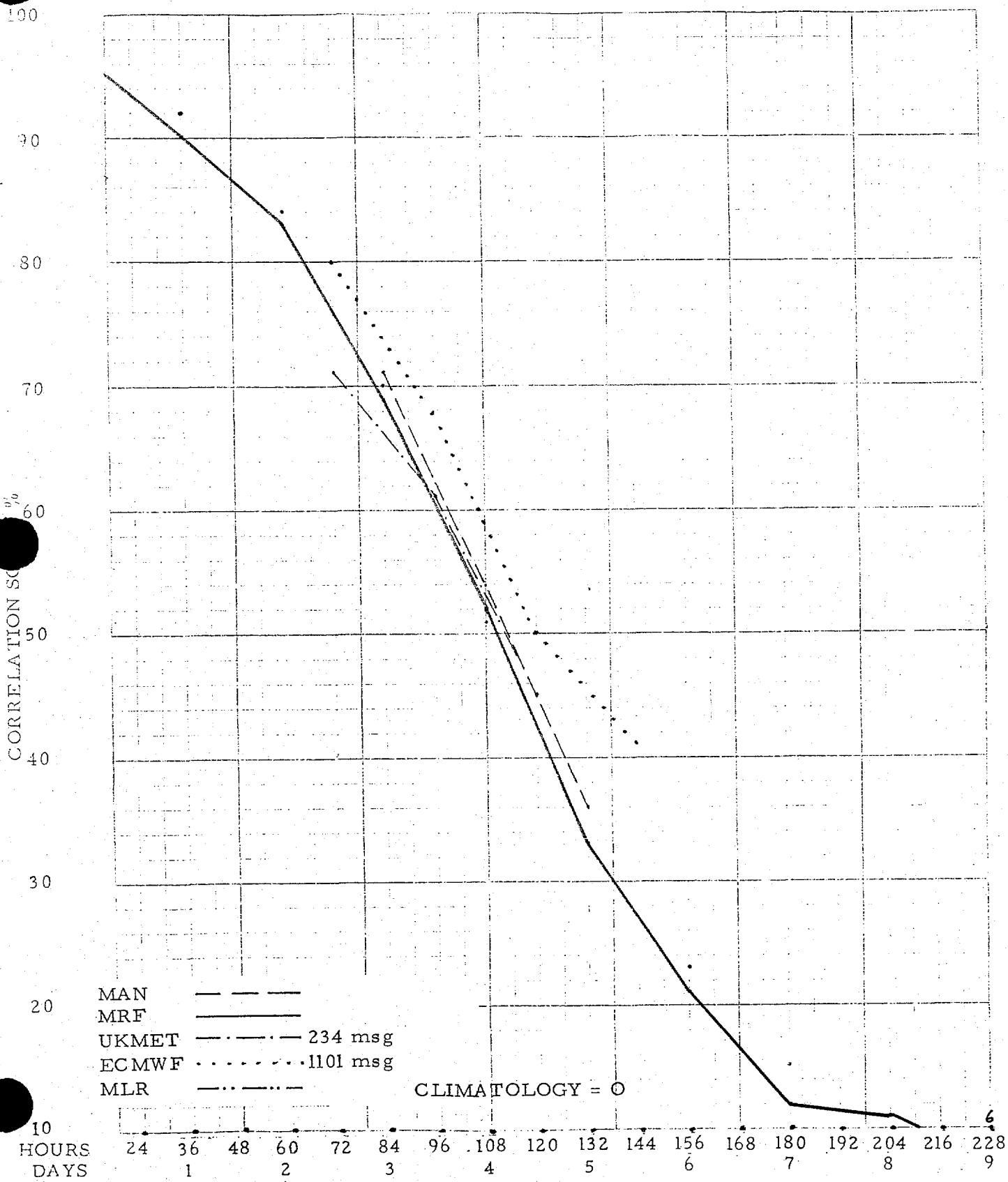


Fig. 25

DAYS 1 THROUGH 9 NORTH AMERICAN AREA MSLP
STANDARDIZED CORRELATION SCORES FOR DEC 89

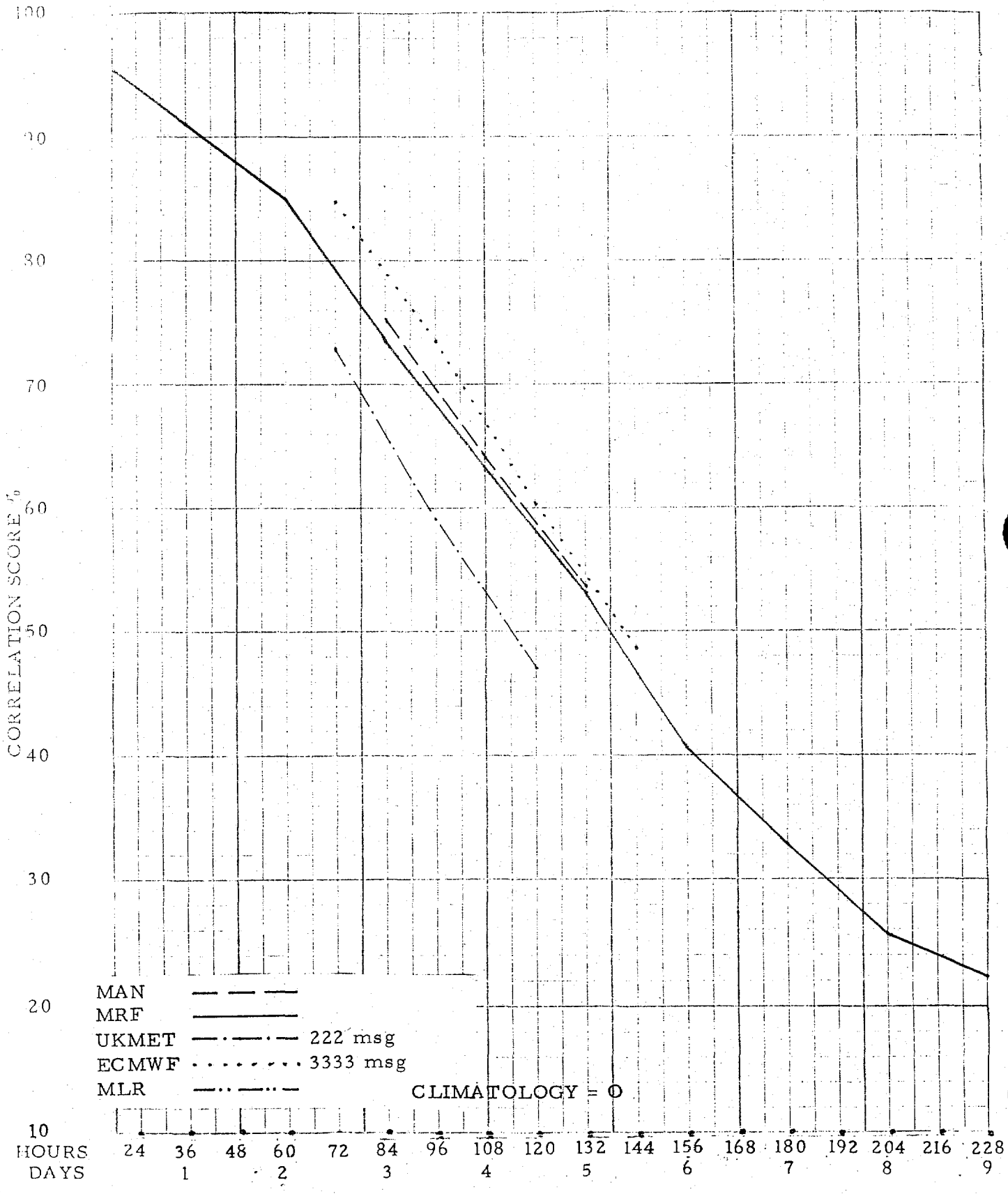


Fig. 26

DAYS 1 THROUGH 9 NORTH AMERICAN AREA 500 MB
STANDARDIZED CORRELATION SCORES FOR JAN 89

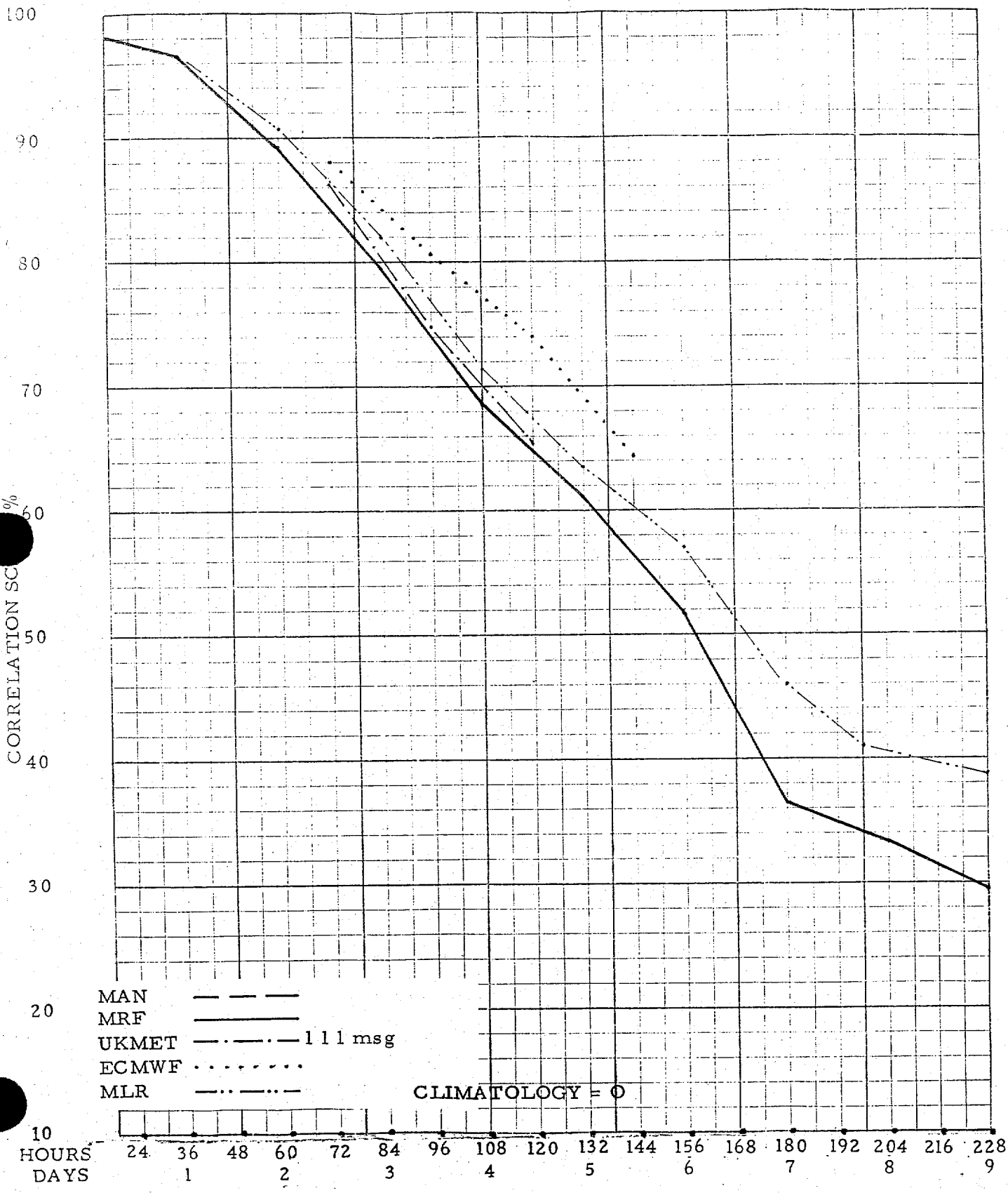


Fig. 27

DAYS 1 THROUGH 9 NORTH AMERICAN AREA 500 MB
STANDARDIZED CORRELATION SCORES FOR FEB 1989

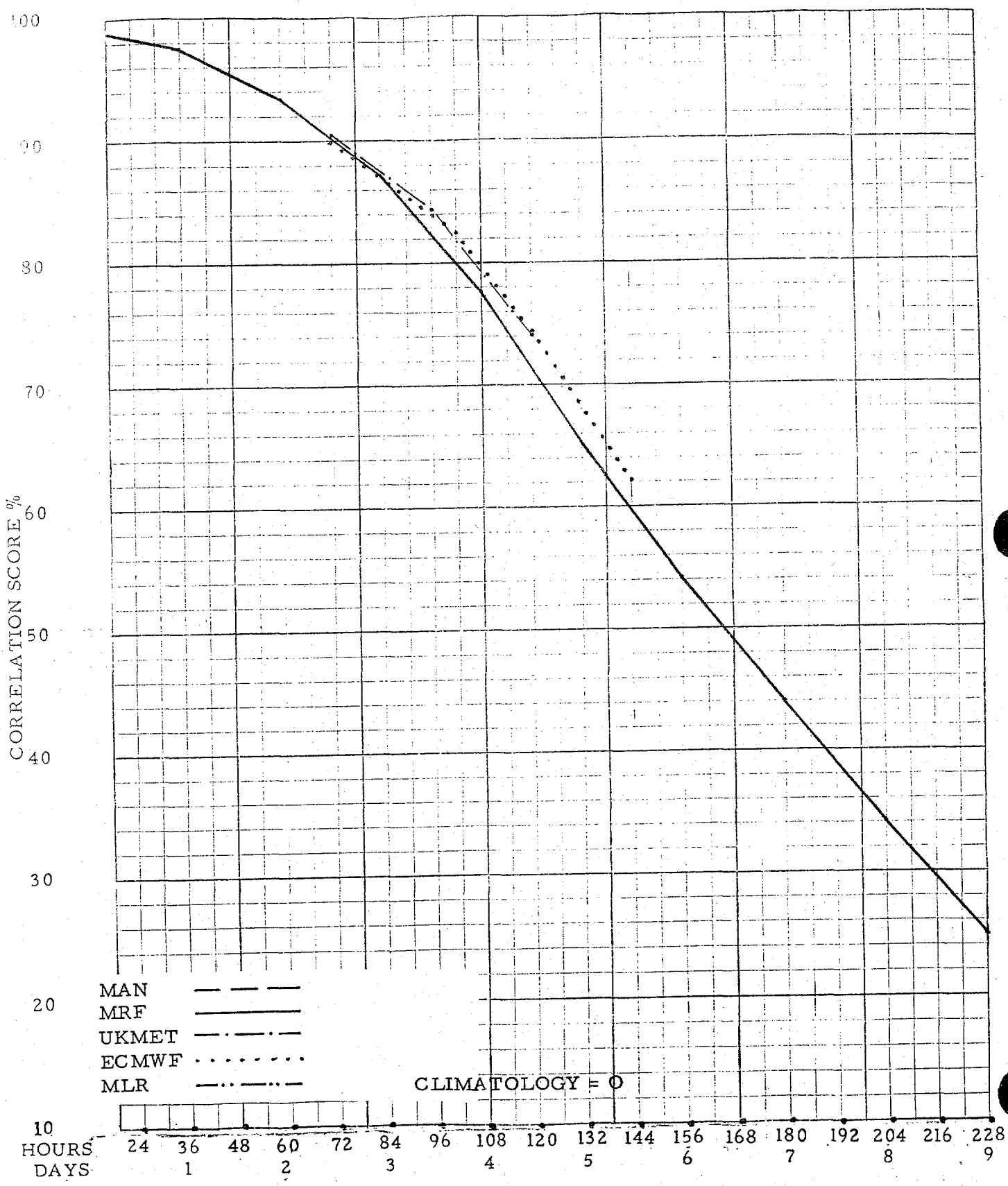


Fig. 28

DAYS 1 THROUGH 9 NORTH AMERICAN AREA 5 00 MB
STANDARDIZED CORRELATION SCORES FOR MAR 89

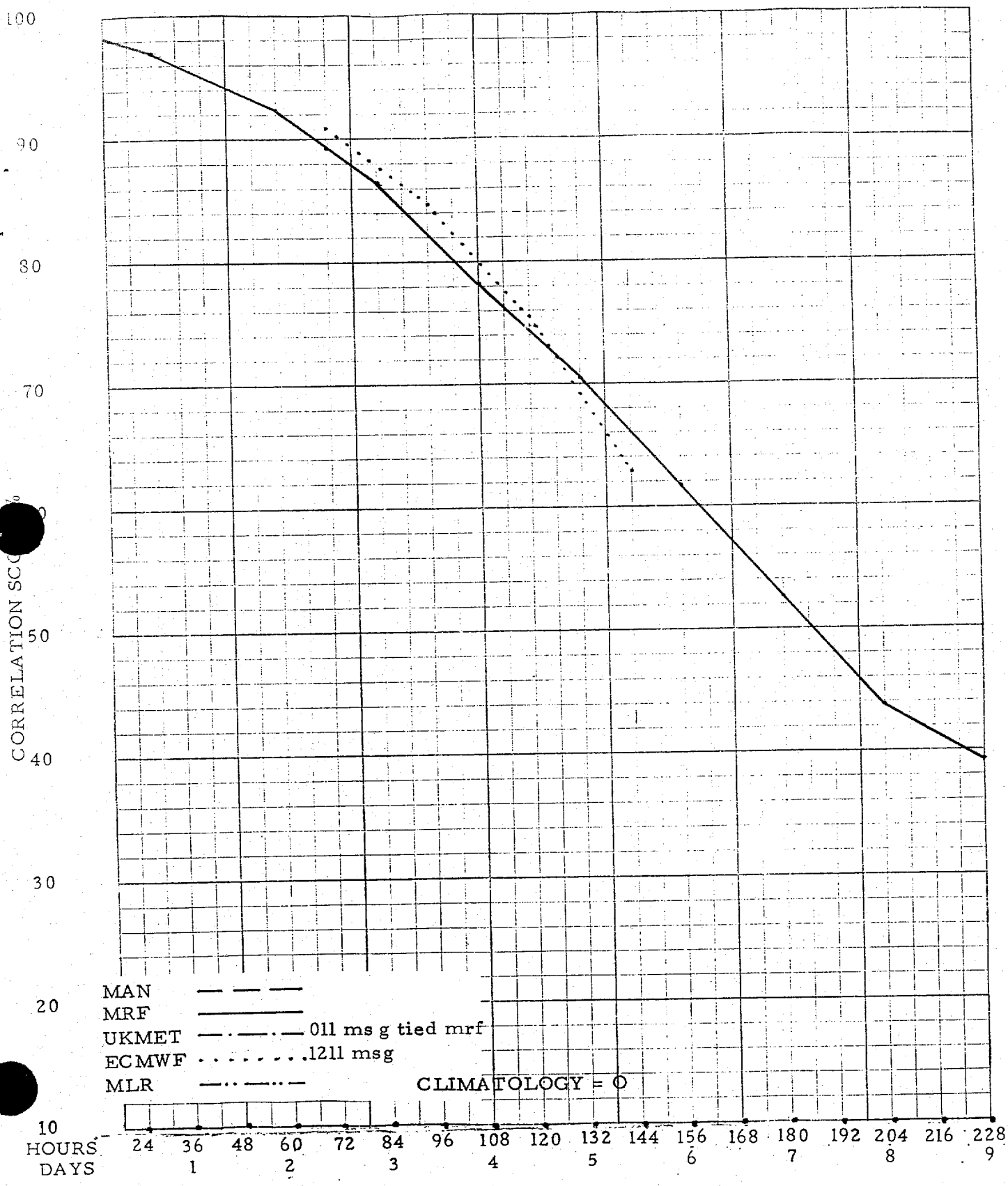


Fig. 29

DAYS 1 THROUGH 9 NORTH AMERICAN AREA 500MB
STANDARDIZED CORRELATION SCORES FOR APR 89

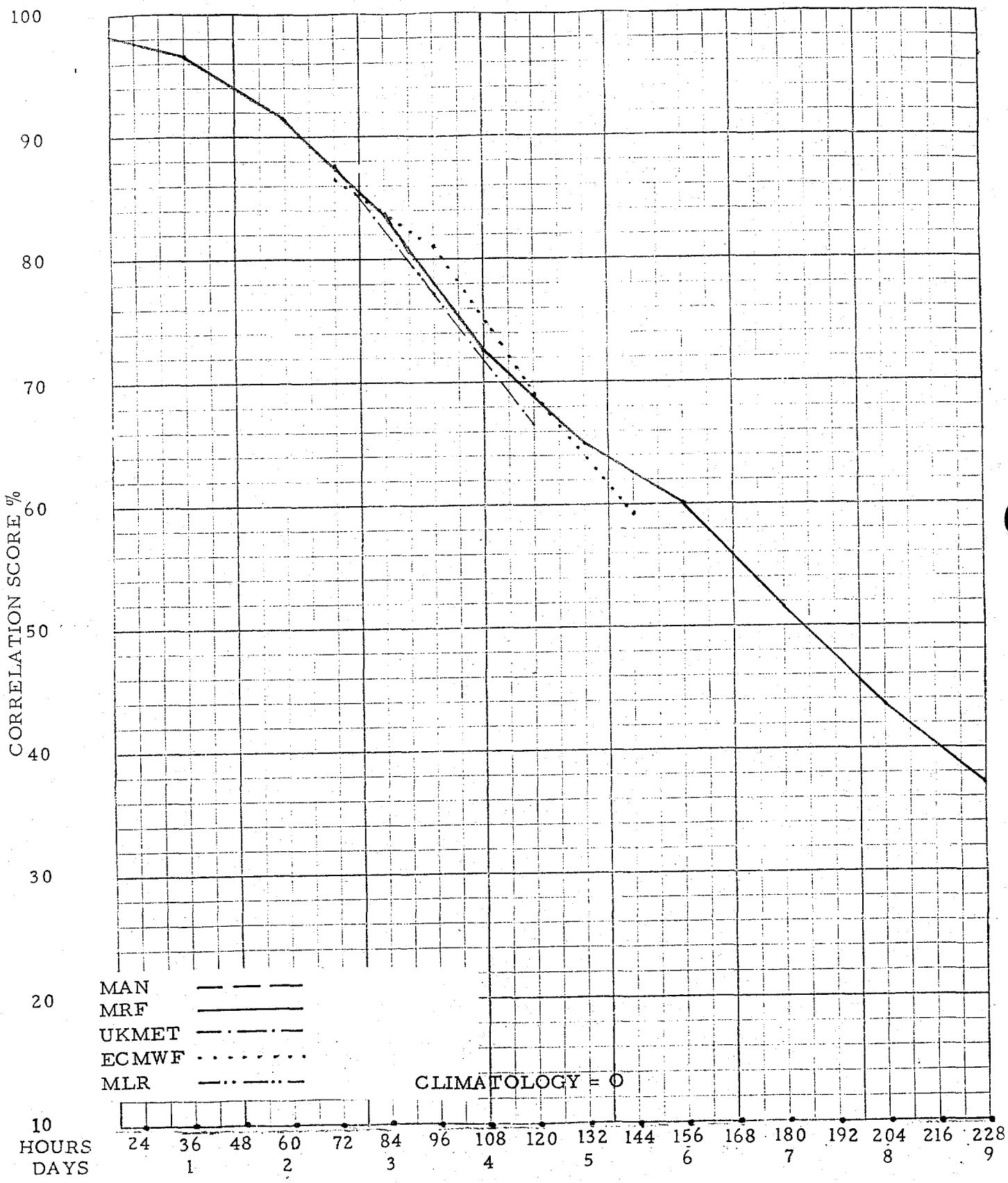


Fig. 30

DAYS 1 THROUGH 9 NORTH AMERICAN AREA 5 00 MB
STANDARDIZED CORRELATION SCORES FOR MAY 89

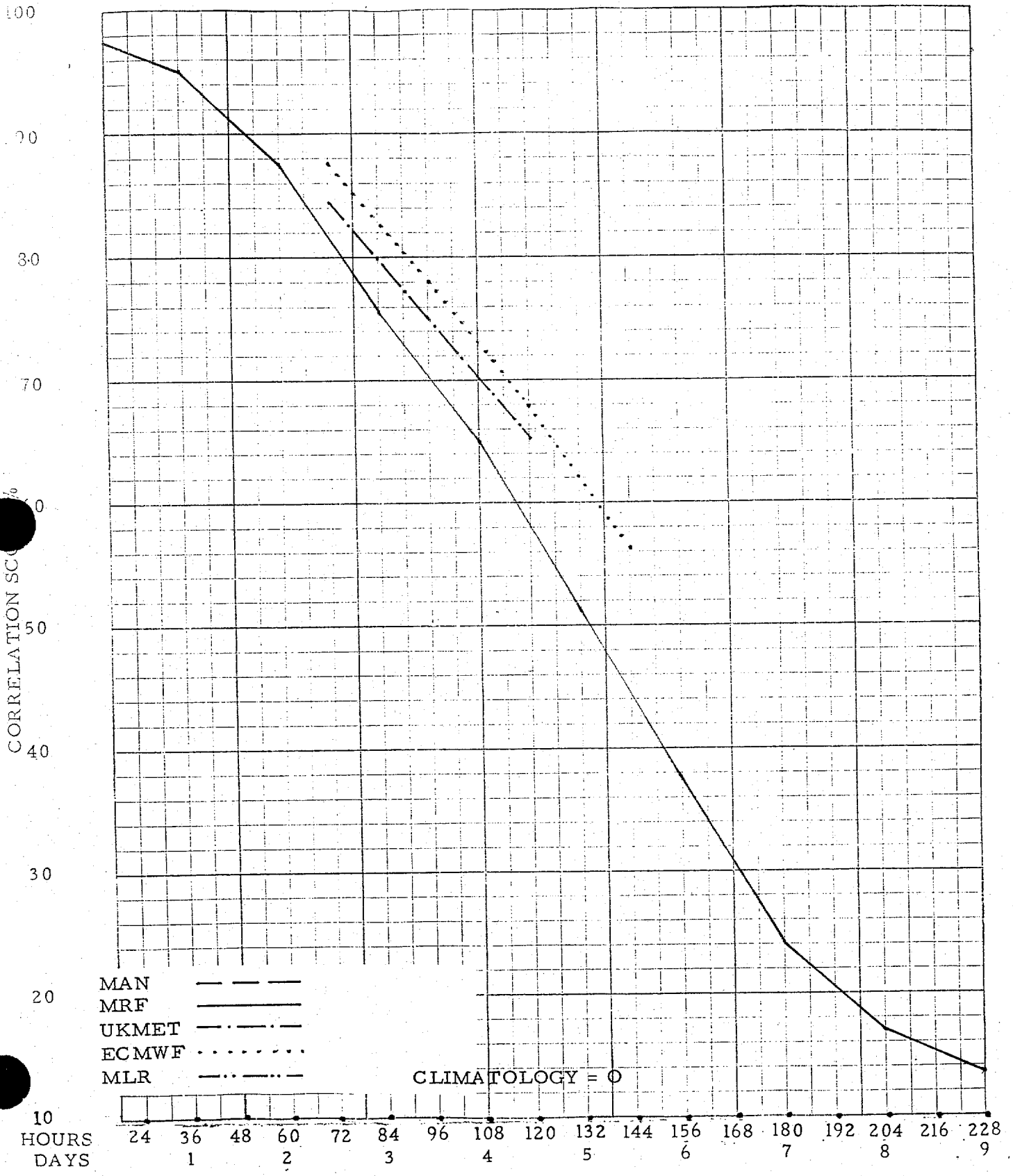


Fig. 31

DAYS 1 THROUGH 9 NORTH AMERICAN AREA 500 MB
STANDARDIZED CORRELATION SCORES FOR JUN 89

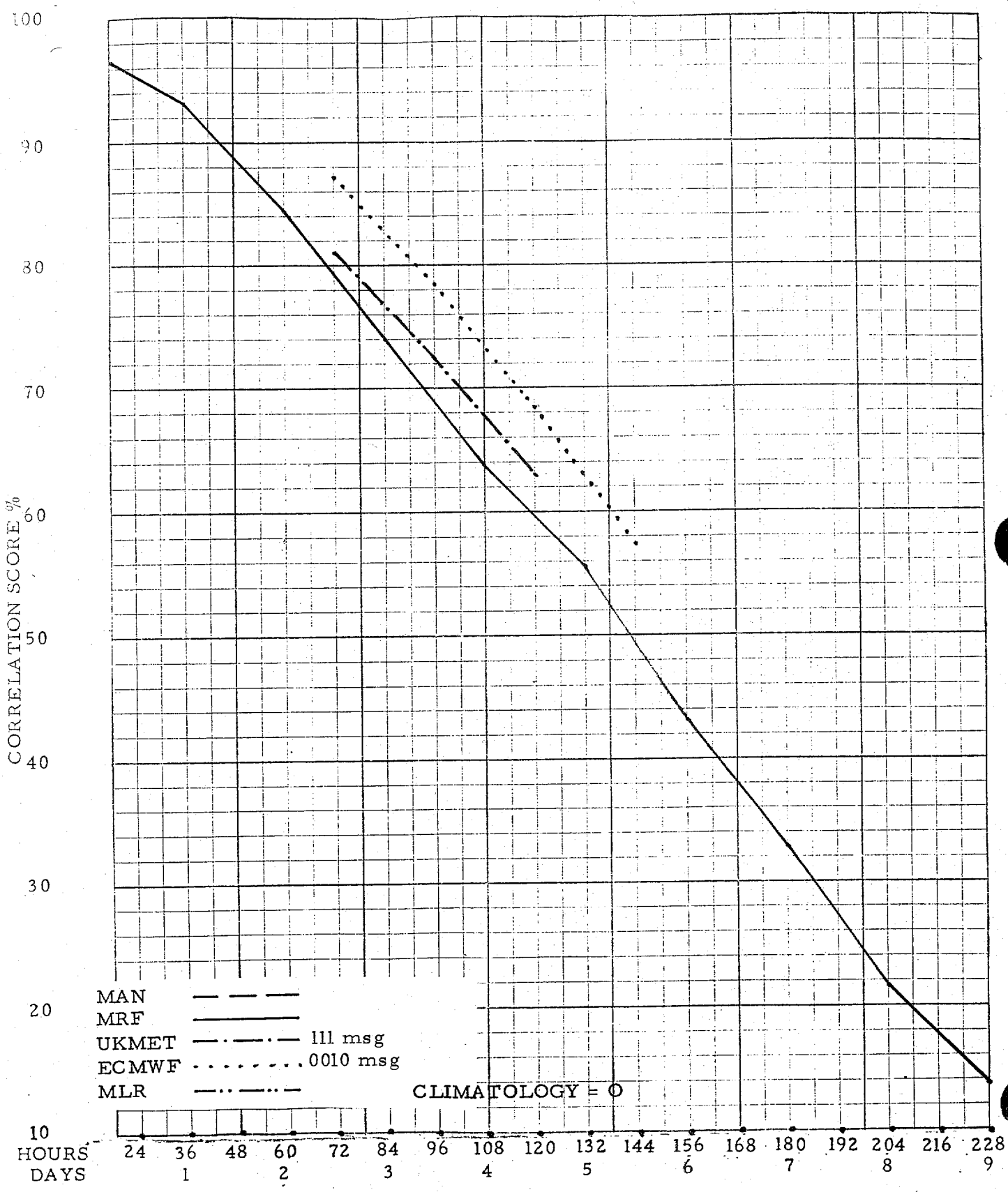


Fig. 32

DAYS 1 THROUGH 9 NORTH AMERICAN AREA 500MB
STANDARDIZED CORRELATION SCORES FOR JUL 89

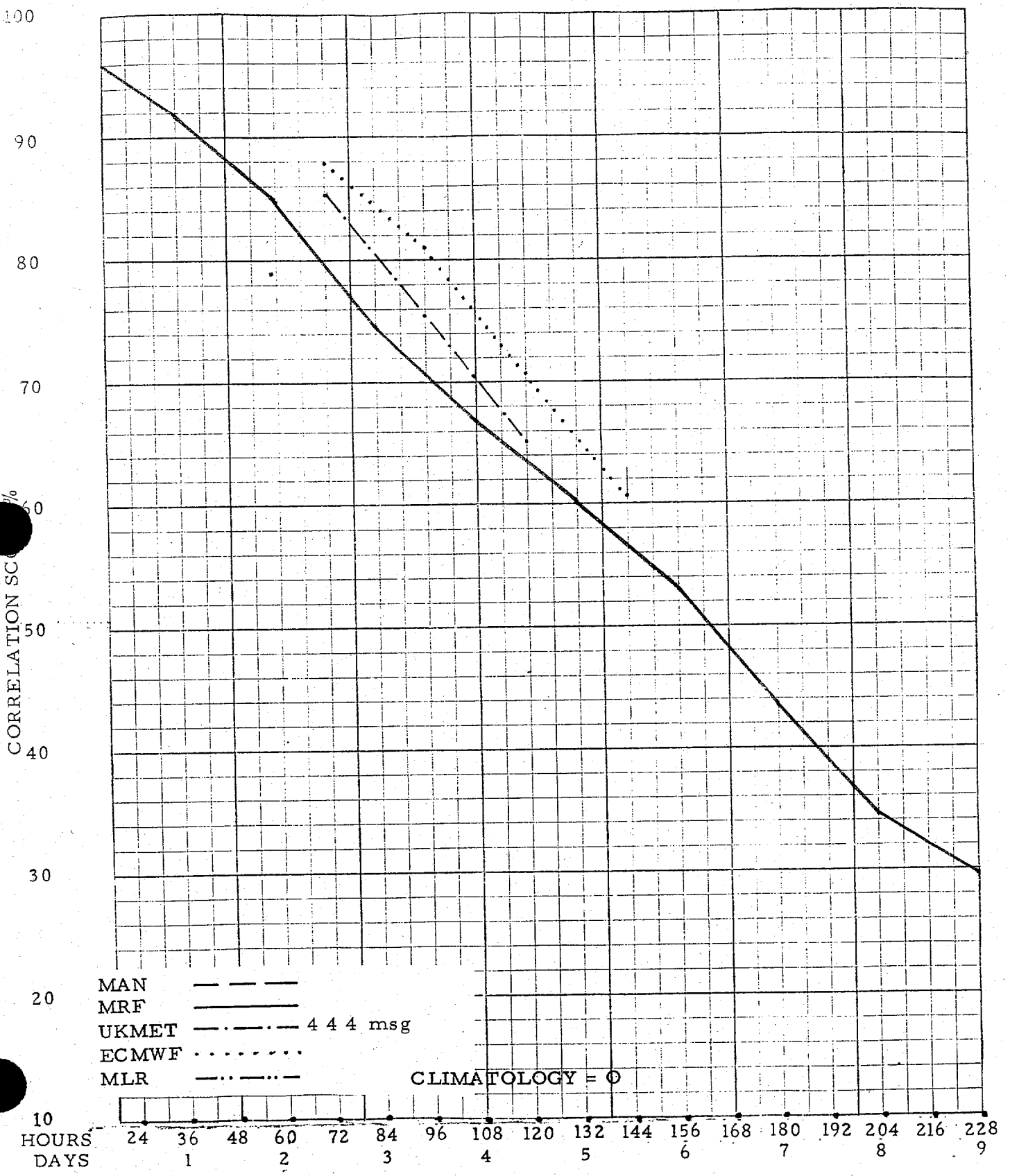


Fig. 33

DAYS 1 THROUGH 9 NORTH AMERICAN AREA 500MB
STANDARDIZED CORRELATION SCORES FOR AUG 89

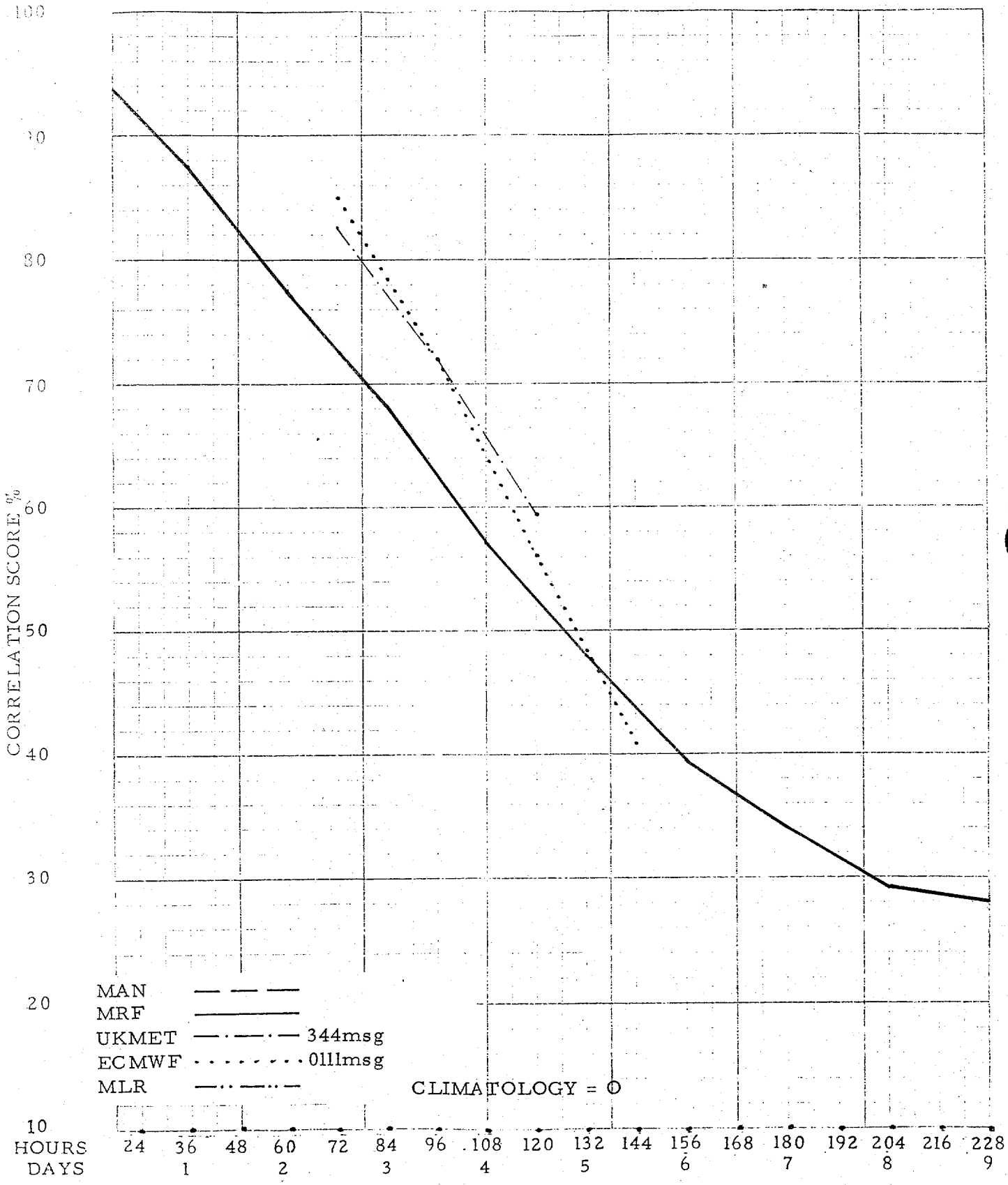


Fig. 34

DAYS 1 THROUGH 9 NORTH AMERICAN AREA 500 MB
STANDARDIZED CORRELATION SCORES FOR SEP 89

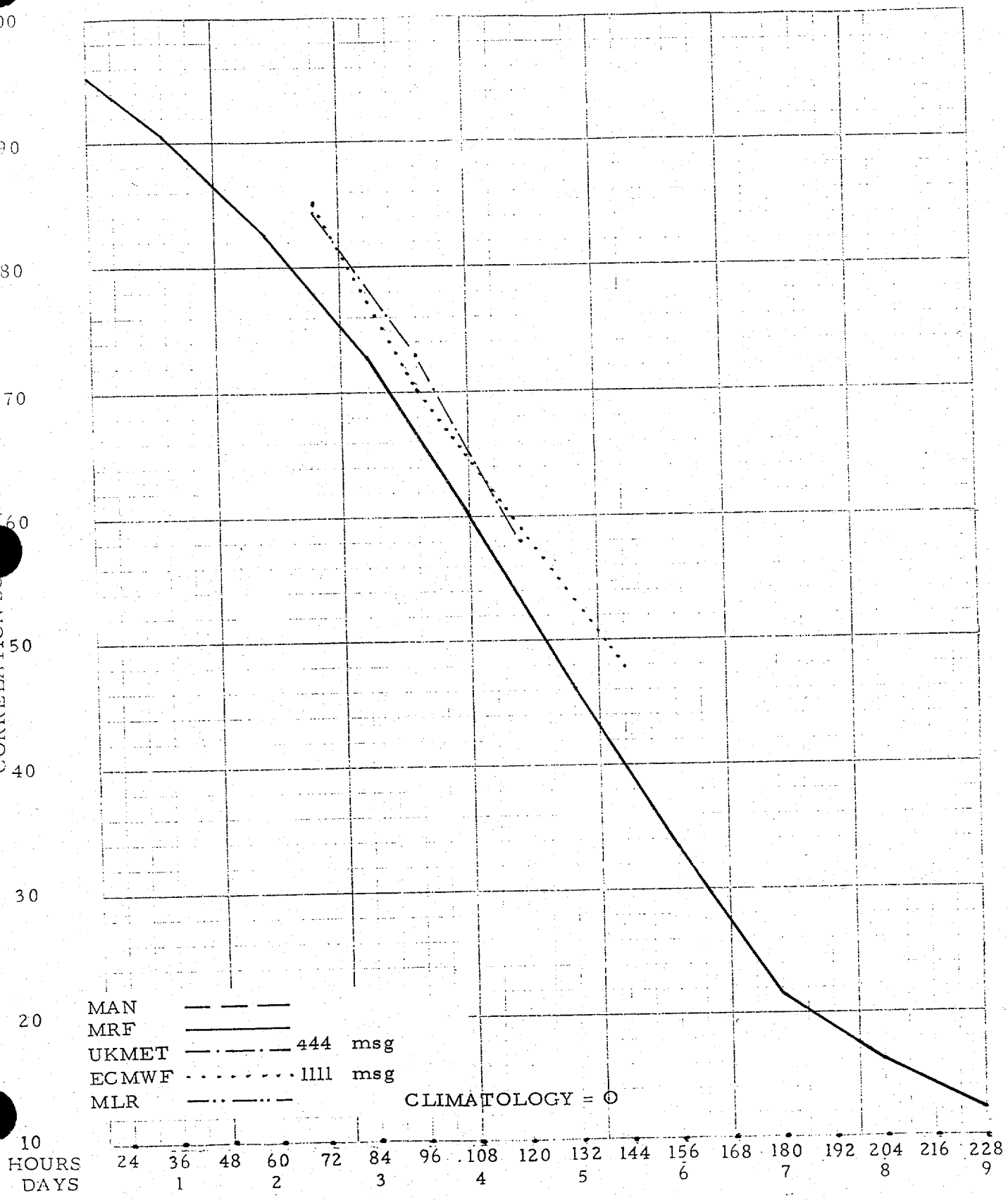


Fig. 35

DAYS 1 THROUGH 9 NORTH AMERICAN AREA 500MB
STANDARDIZED CORRELATION SCORES FOR OCT 1989

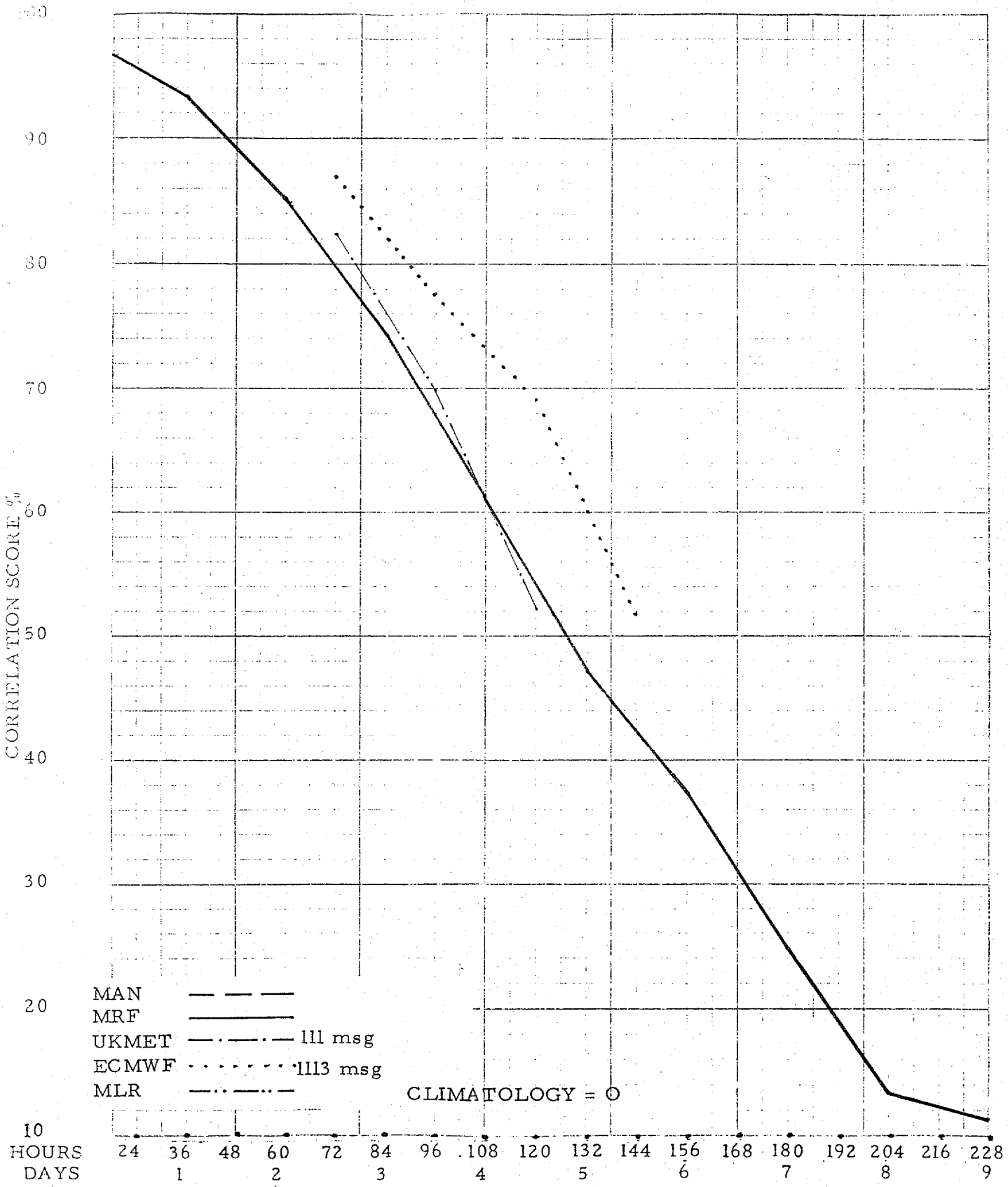
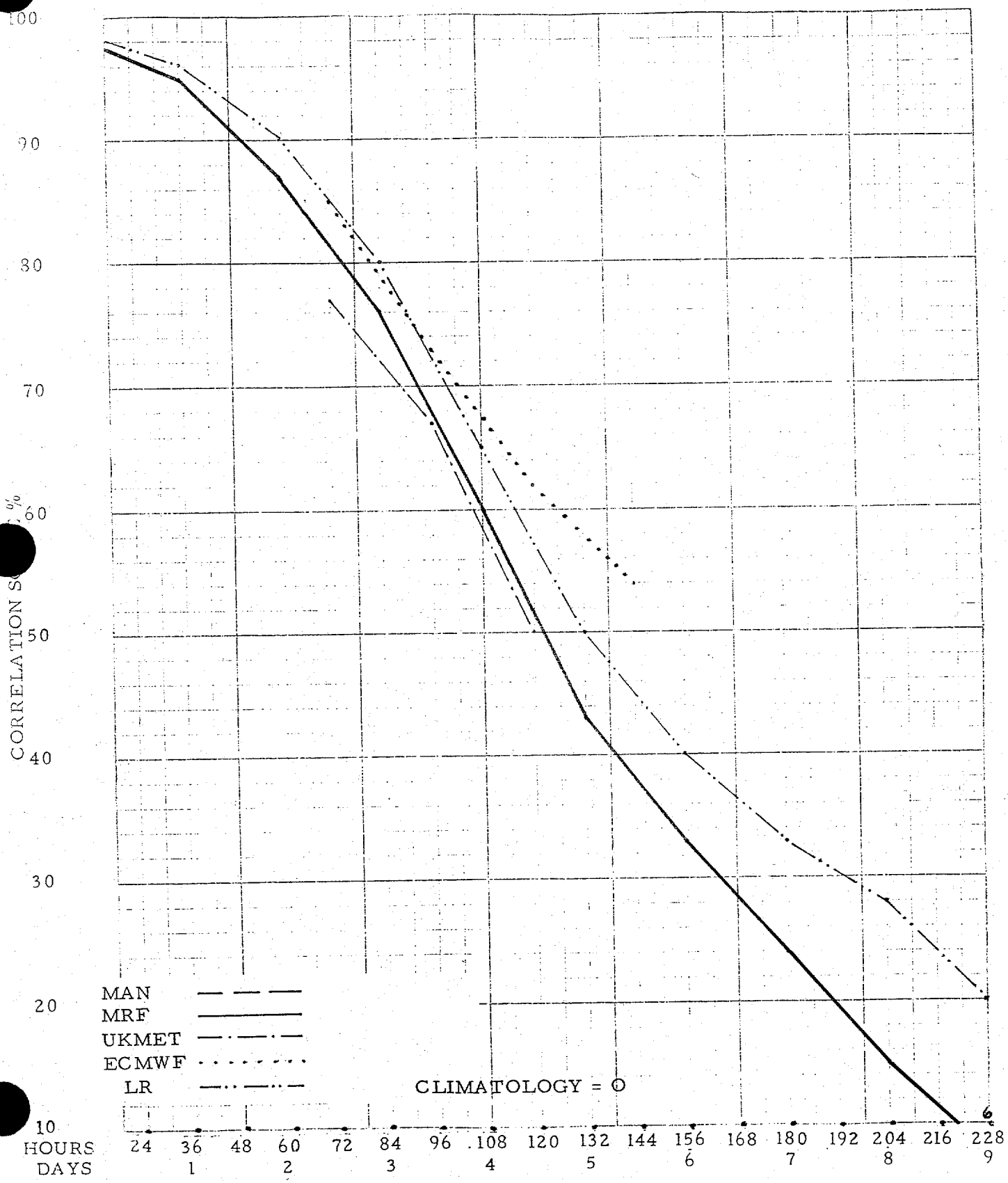


Fig. 36

DAYS 1 THROUGH 9 NORTH AMERICAN AREA 5 00 MB
STANDARDIZED CORRELATION SCORES FOR NOV 89



DAYS 1 THROUGH 9 NORTH AMERICAN AREA 5 00 MB
STANDARDIZED CORRELATION SCORES FOR DEC 89

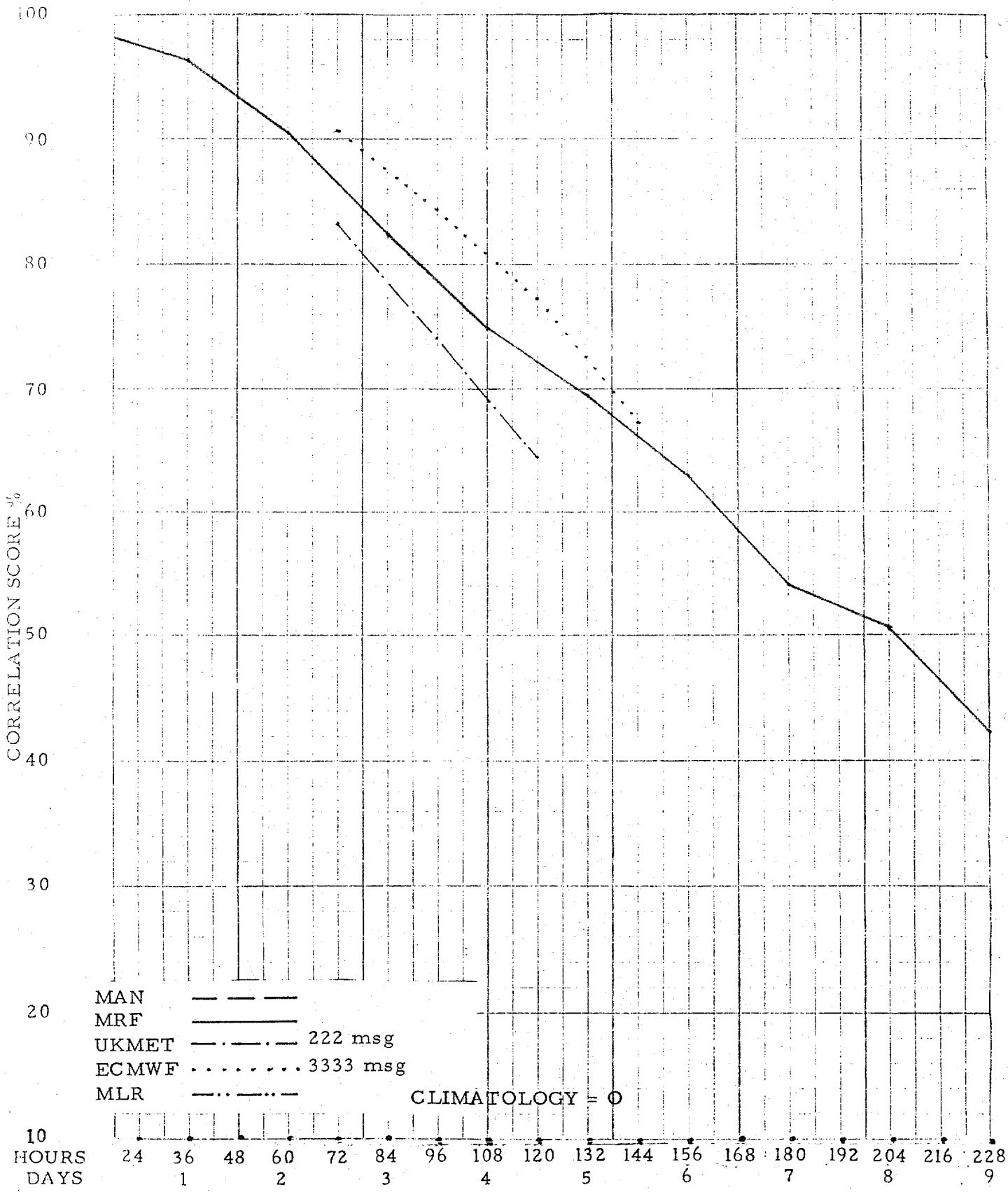


Fig. 38

DAYS 1 THRU 3 NORTH AMERICAN AREA MSLP
STANDARDIZED CORRELATION SCORES FOR JAN 89

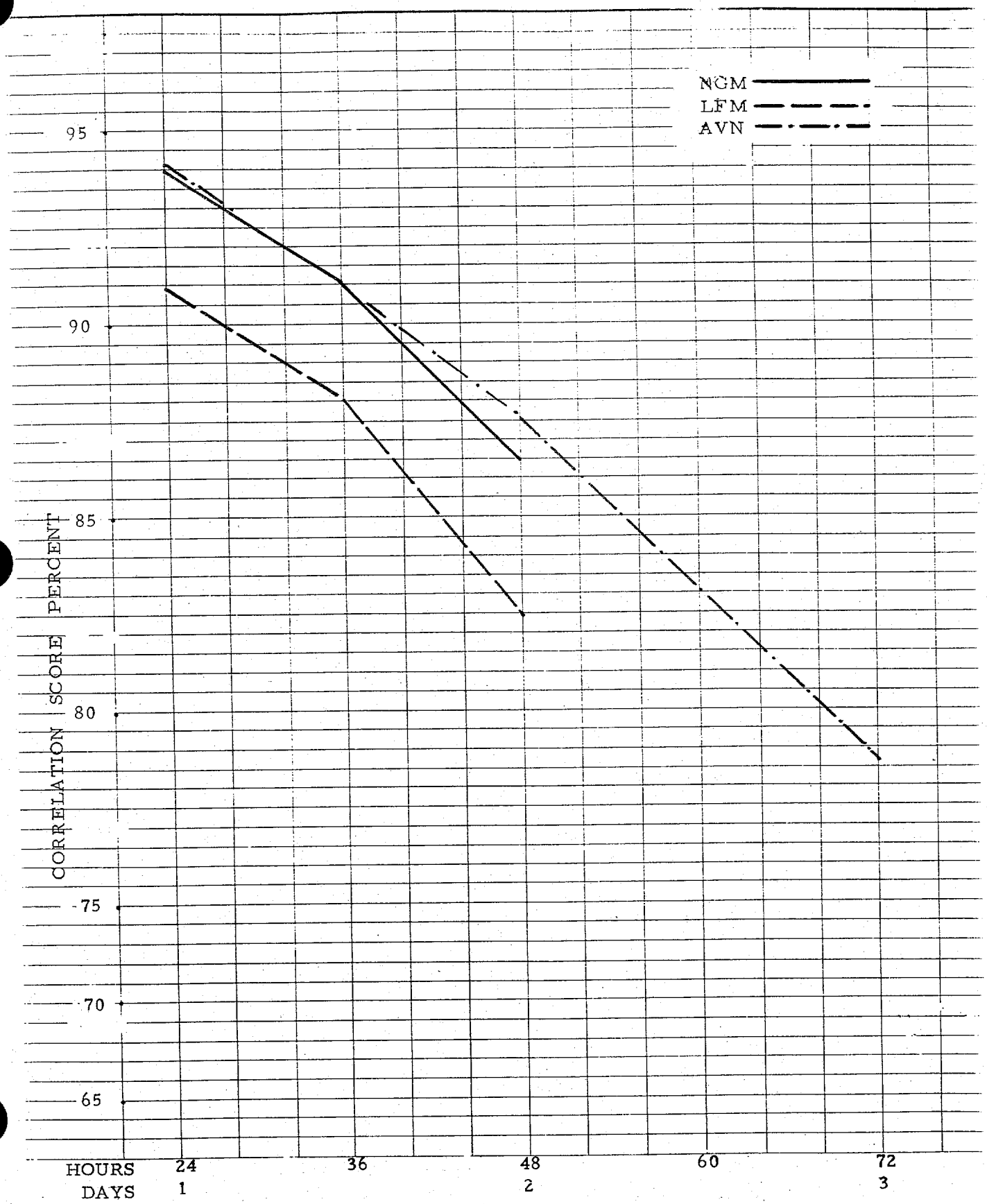


Fig. 39

DAYS 1 THRU 3 NORTH AMERICAN AREA MSLP
STANDARDIZED CORRELATION SCORES FOR FEB 1989

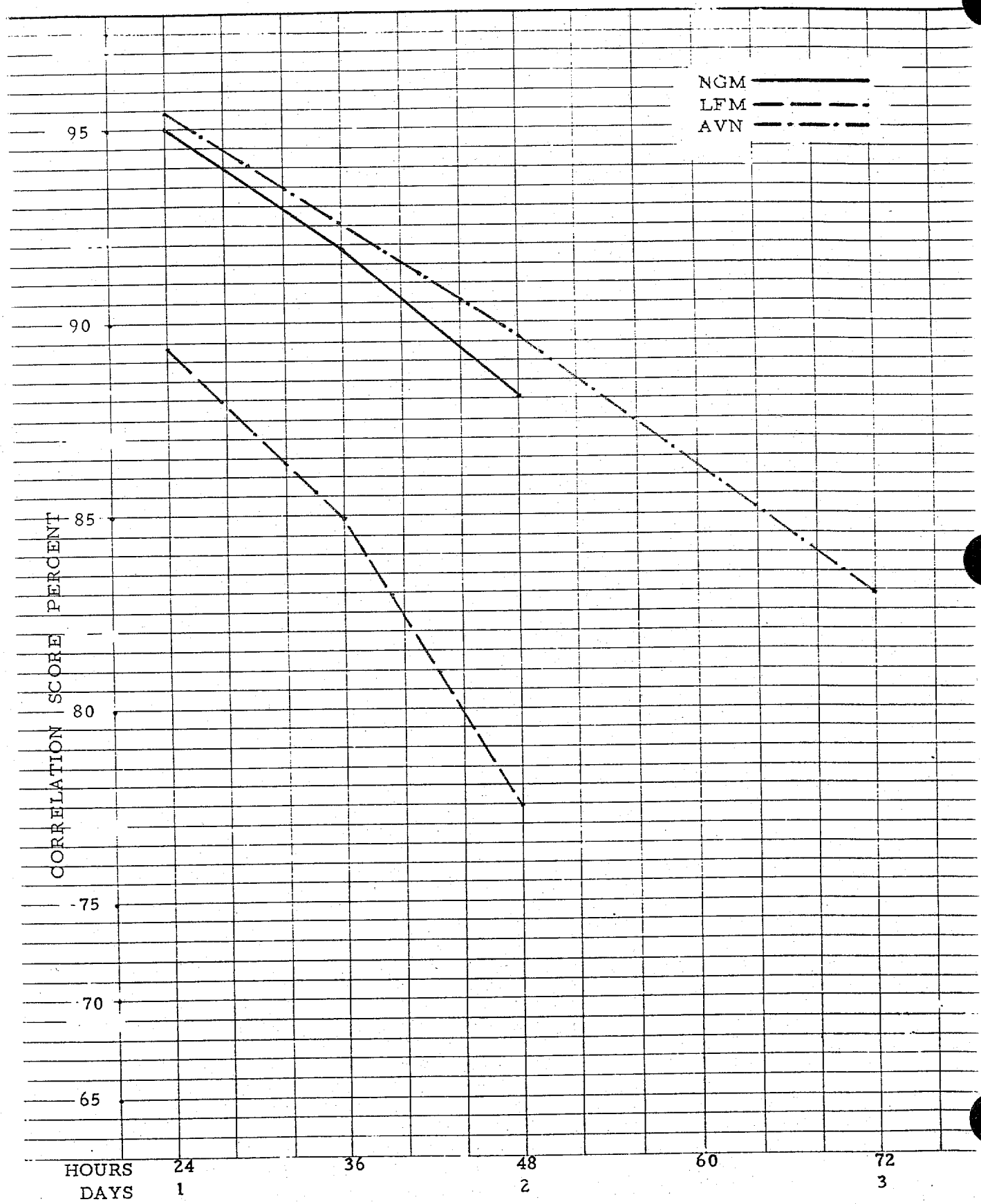


Fig. 40

DAYS 1 THRU 3 NORTH AMERICAN AREA MSLP
STANDARDIZED CORRELATION SCORES FOR MAR 89

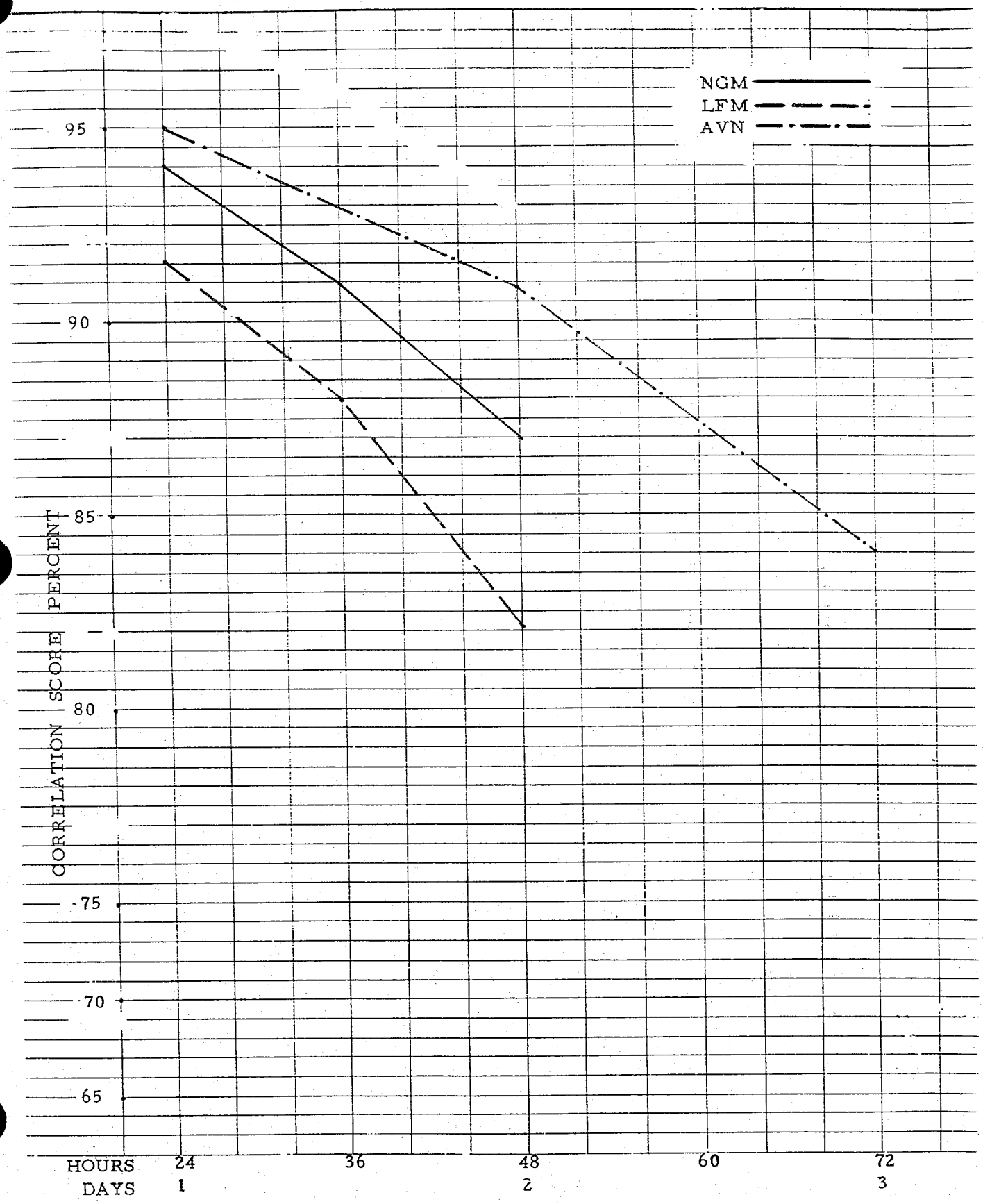


Fig. 41

DAYS 1 THRU 3 NORTH AMERICAN AREA MSLP
STANDARDIZED CORRELATION SCORES FOR APRIL 89

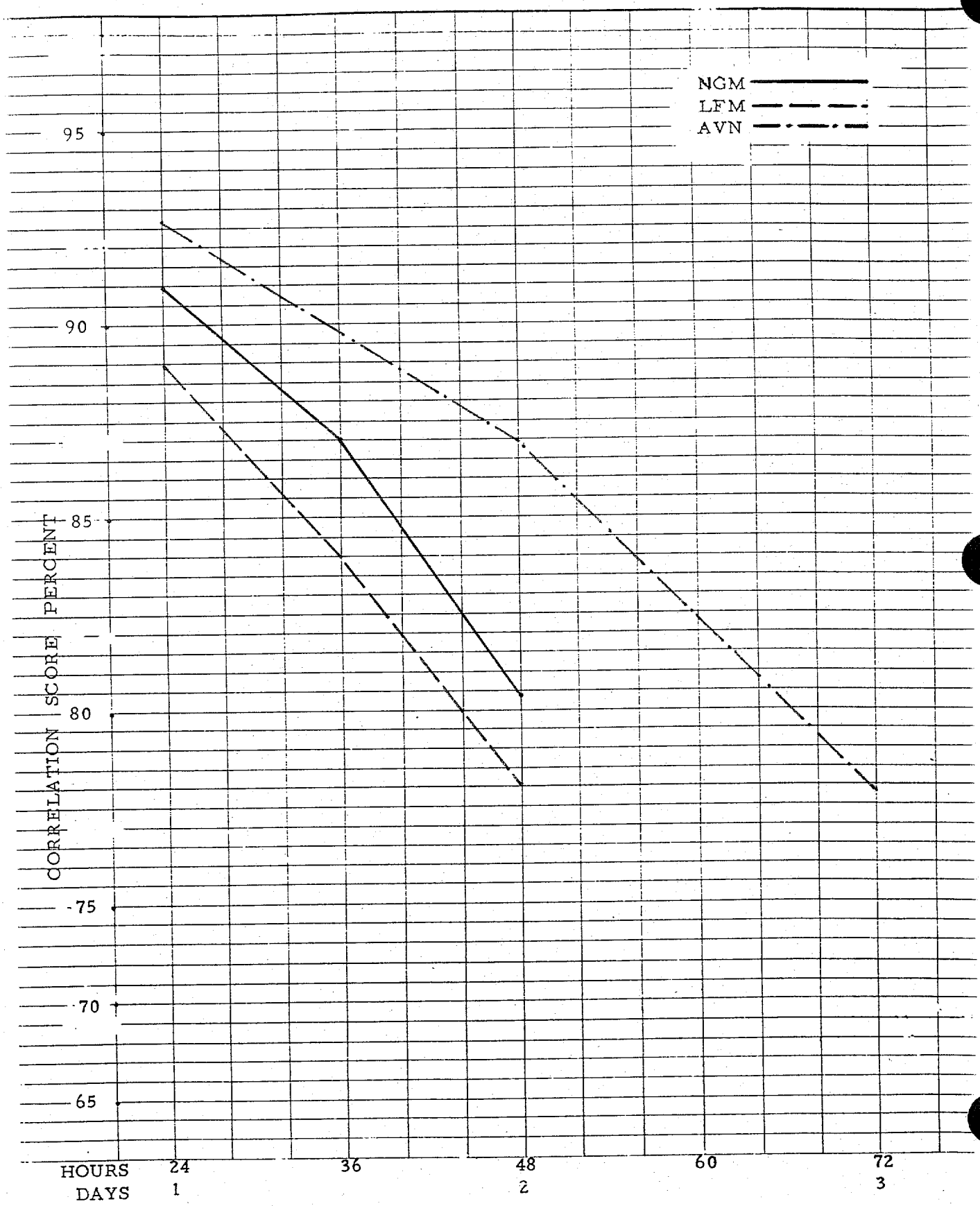
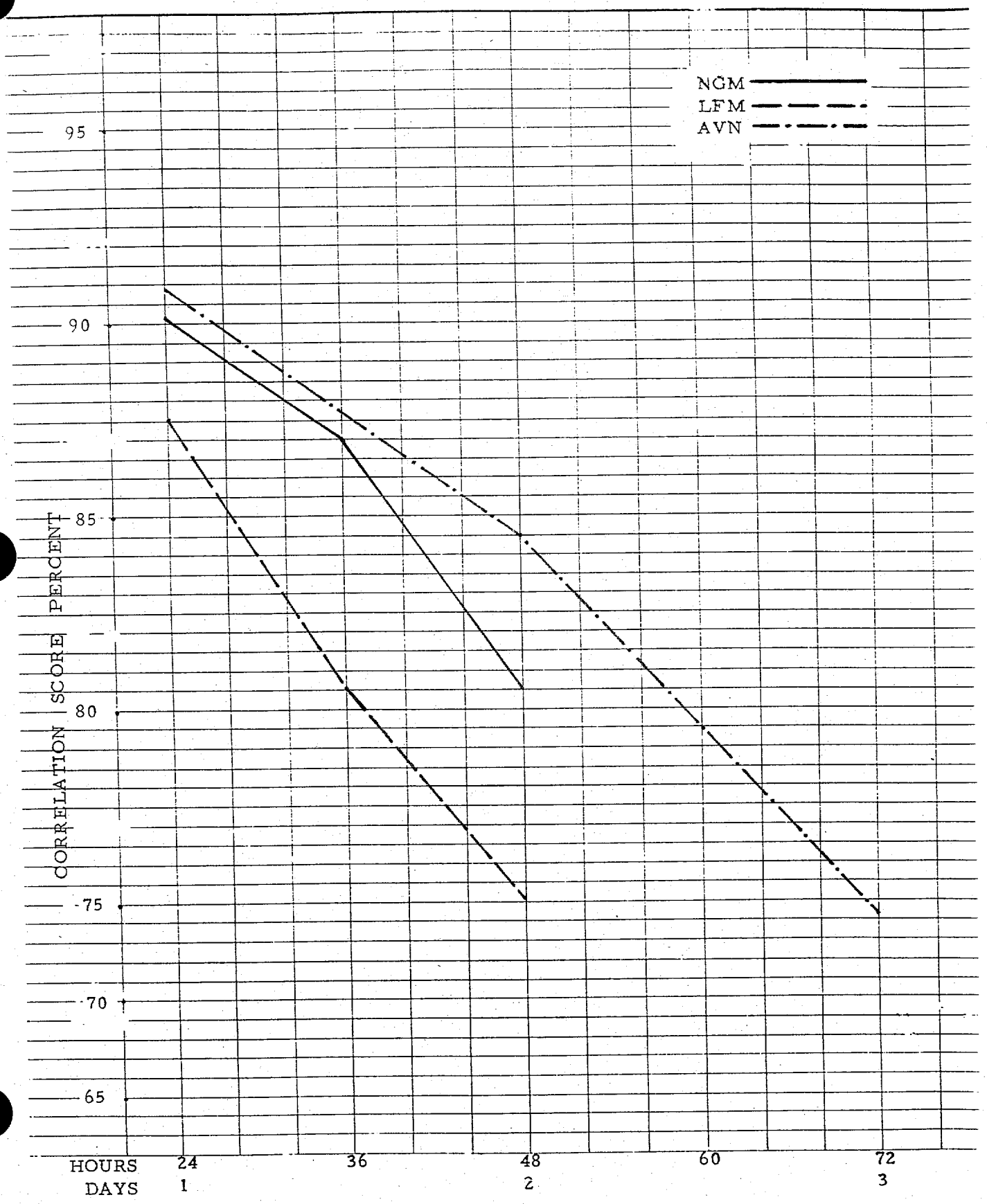


Fig. 42

DAYS 1 THRU 3 NORTH AMERICAN AREA MSLP
STANDARDIZED CORRELATION SCORES FOR MAY 89



DAYS 1 THRU 3 NORTH AMERICAN AREA MSLP
STANDARDIZED CORRELATION SCORES FOR JUN 89

Fig. 43

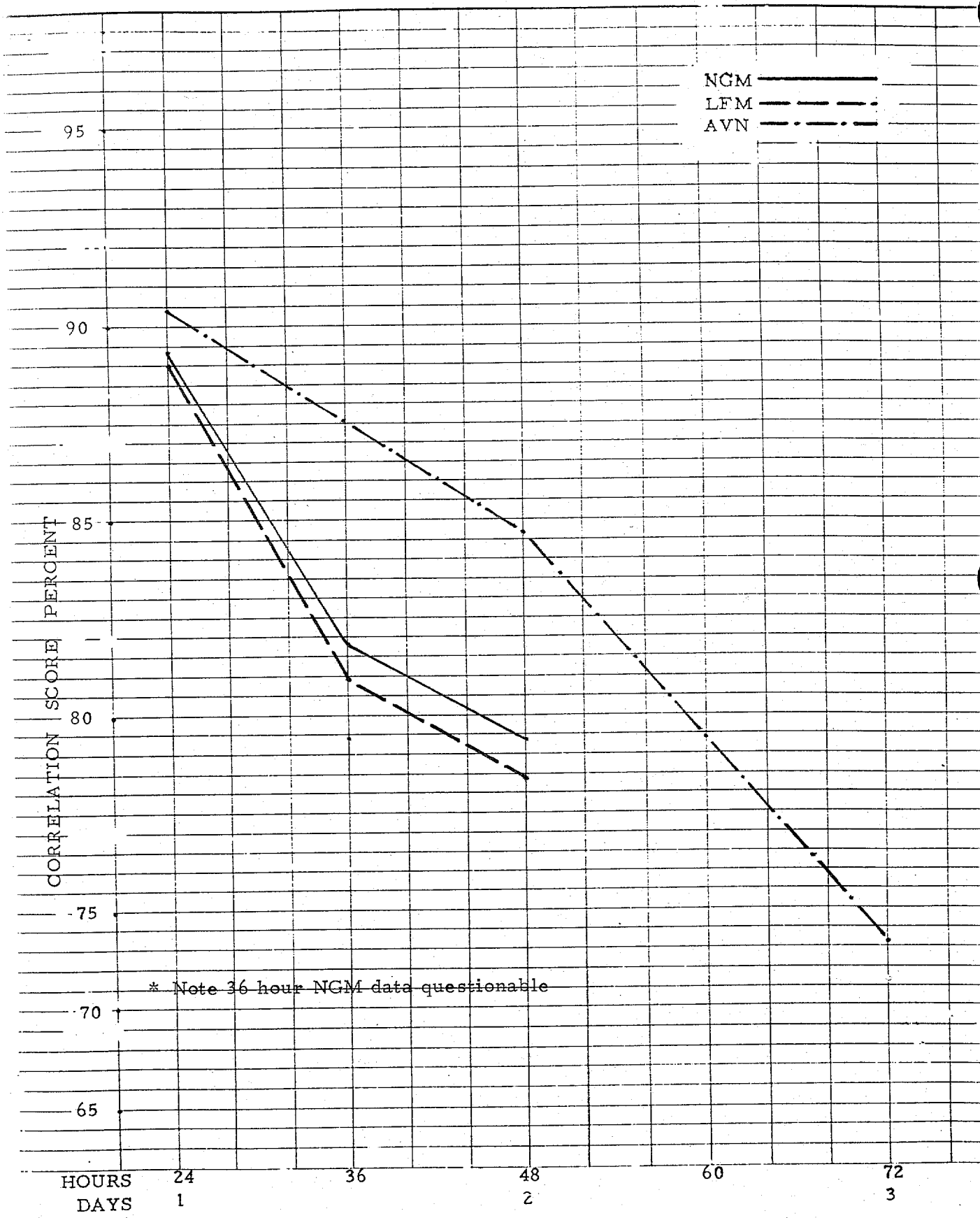


Fig. 44

DAYS 1 THRU 3 NORTH AMERICAN AREA MSLP
STANDARDIZED CORRELATION SCORES FOR JUL 89

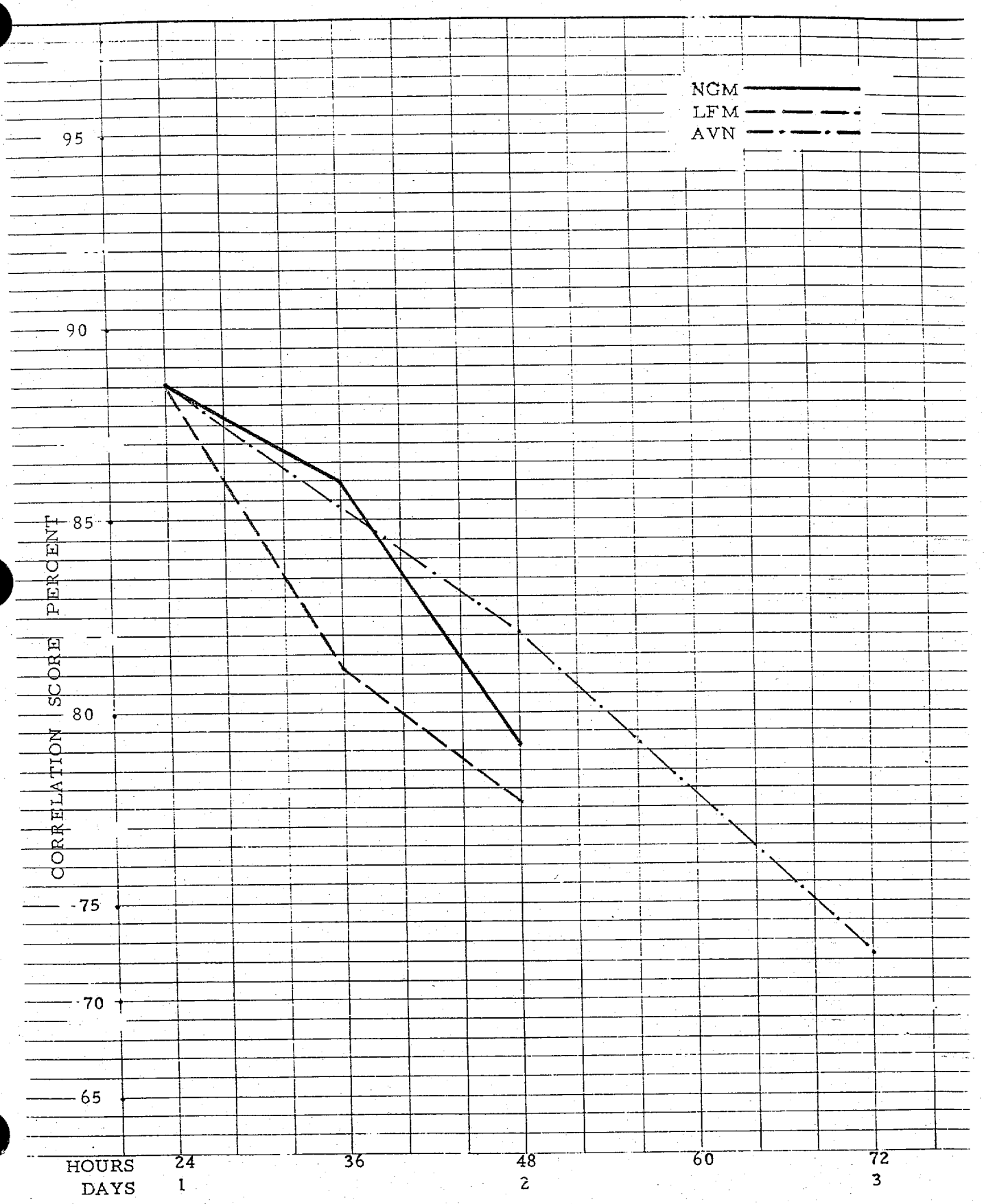


Fig. 45

DAYS 1 THRU 3 NORTH AMERICAN AREA MSLP
STANDARDIZED CORRELATION SCORES FOR AUG 89

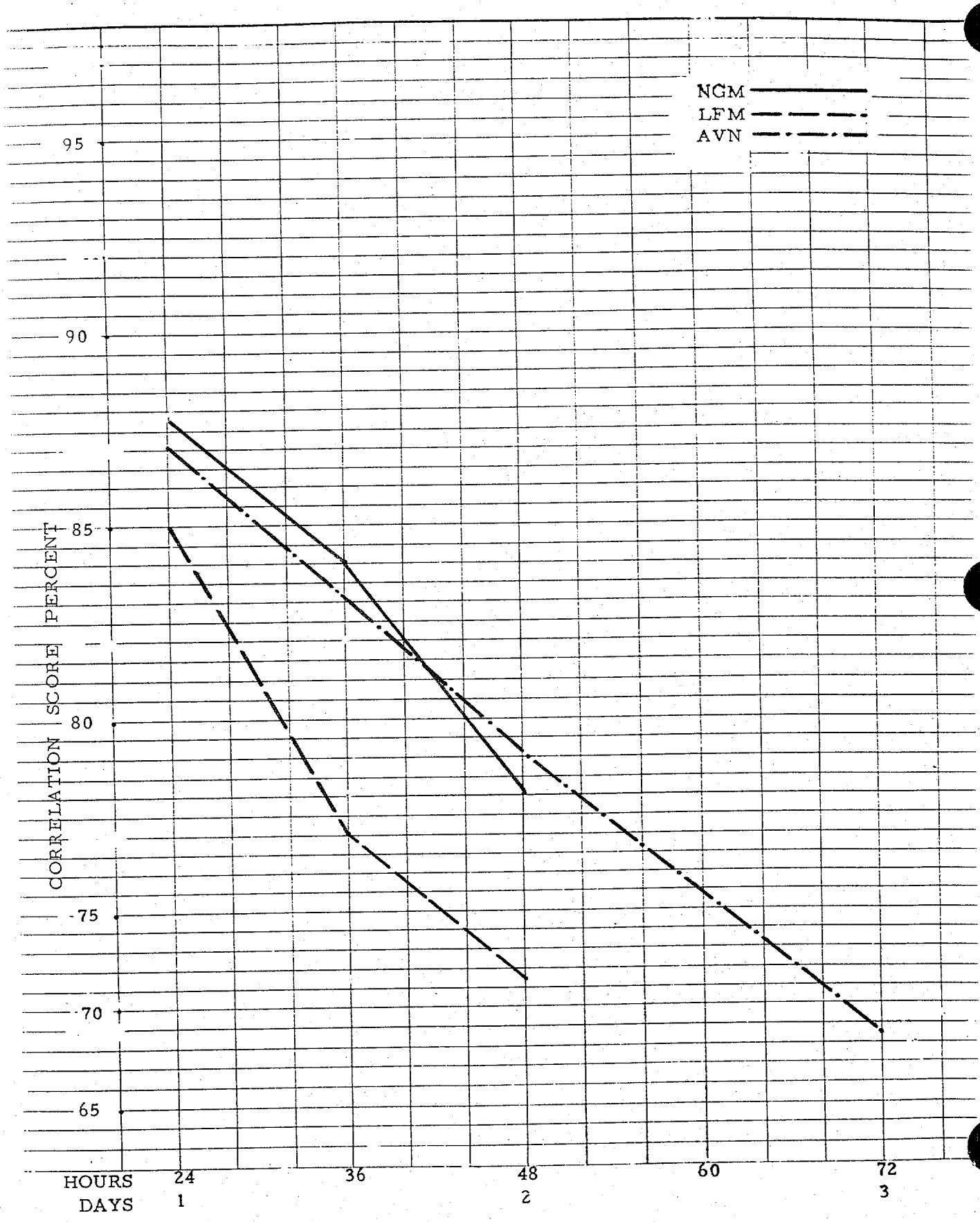


Fig. 46

DAYS 1 THRU 3 NORTH AMERICAN AREA MSLP
STANDARDIZED CORRELATION SCORES FOR SEP 89

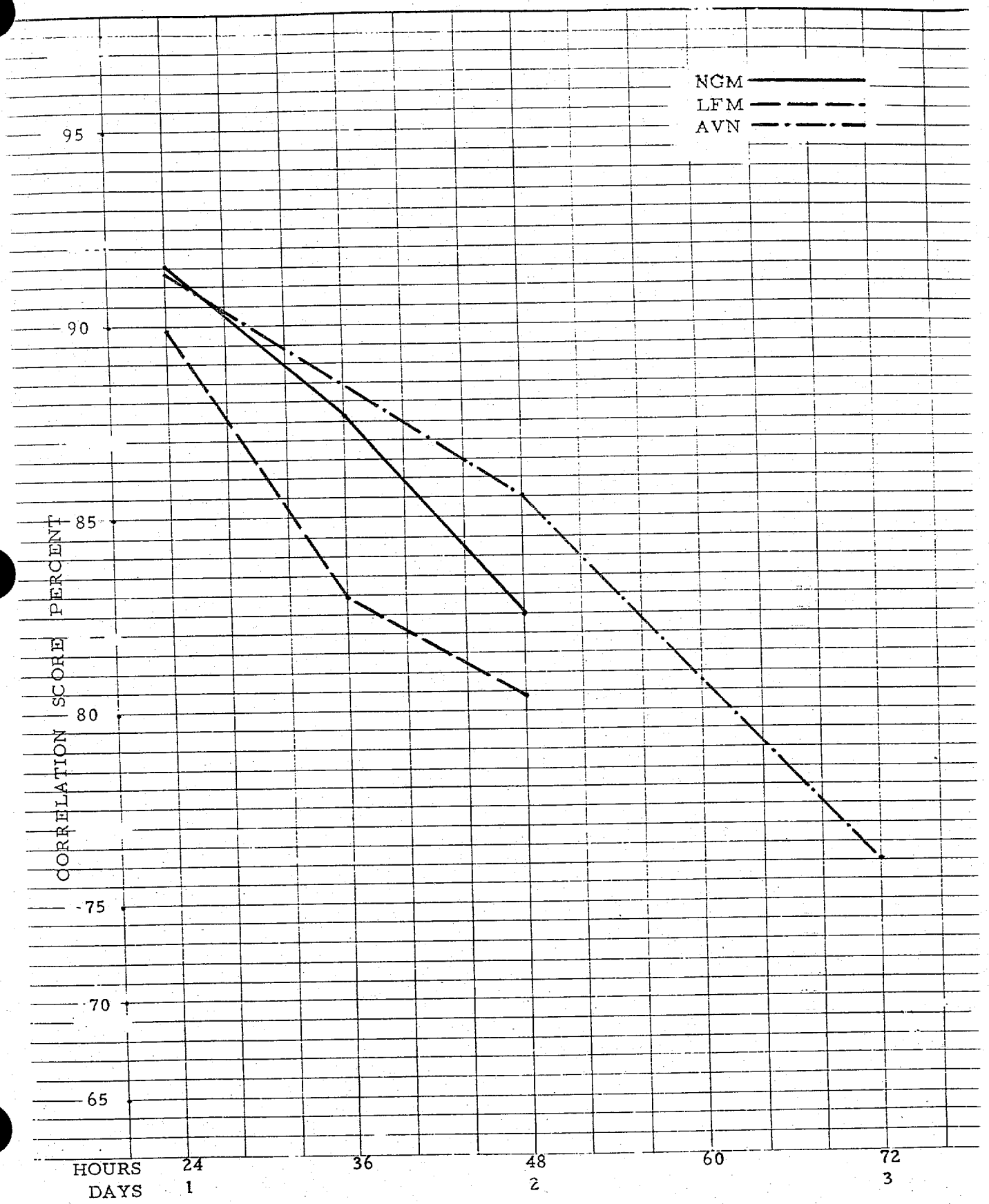
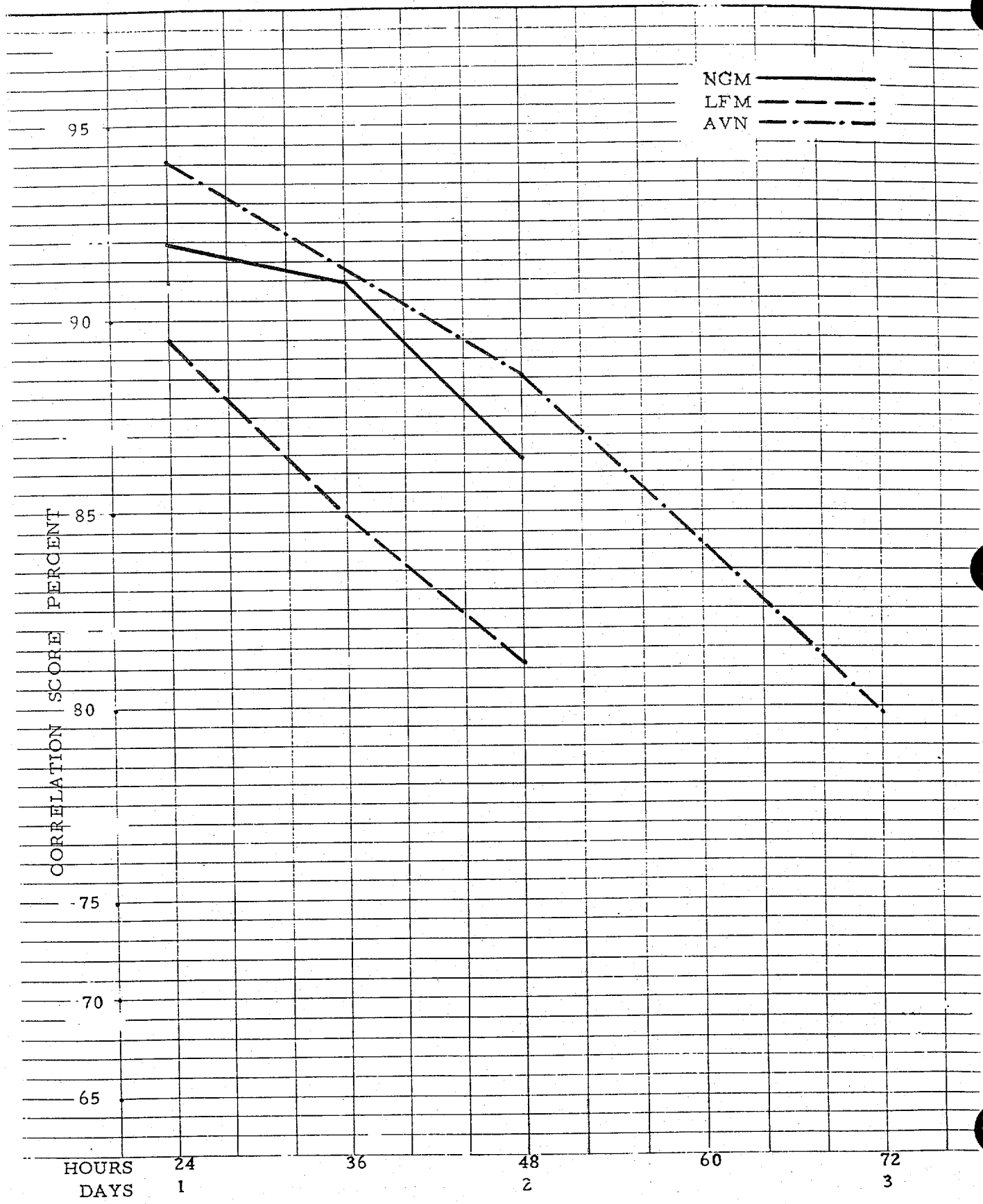


Fig. 47

DAYS 1 THRU 3 NORTH AMERICAN AREA MSLP
STANDARDIZED CORRELATION SCORES FOR OCT 1989



DAYS 1 THRU 3 NORTH AMERICAN AREA MSLP
STANDARDIZED CORRELATION SCORES FOR NOV 89

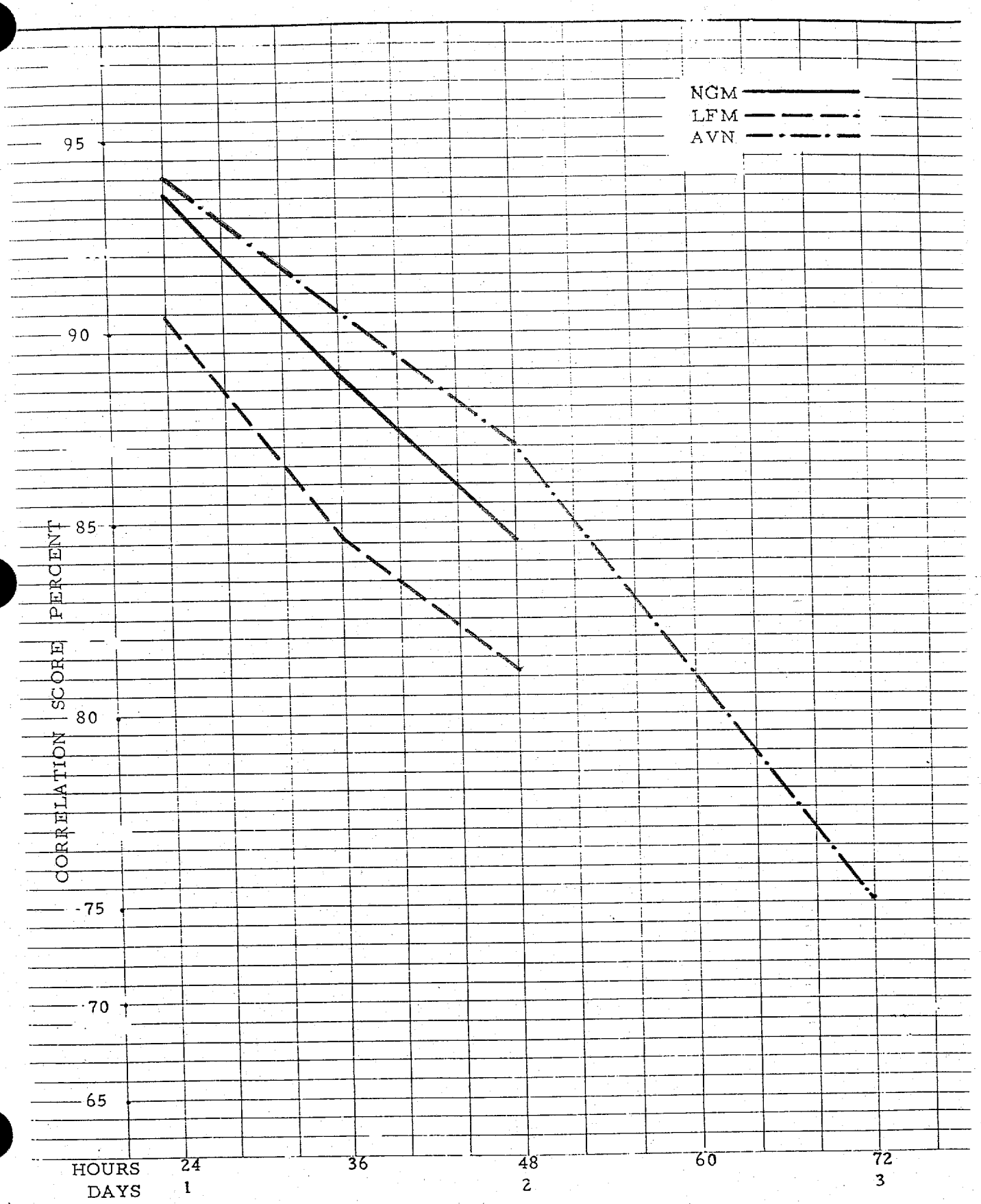


Fig. 49

DAYS 1 THRU 3 NORTH AMERICAN AREA MSLP
STANDARDIZED CORRELATION SCORES FOR DEC 89

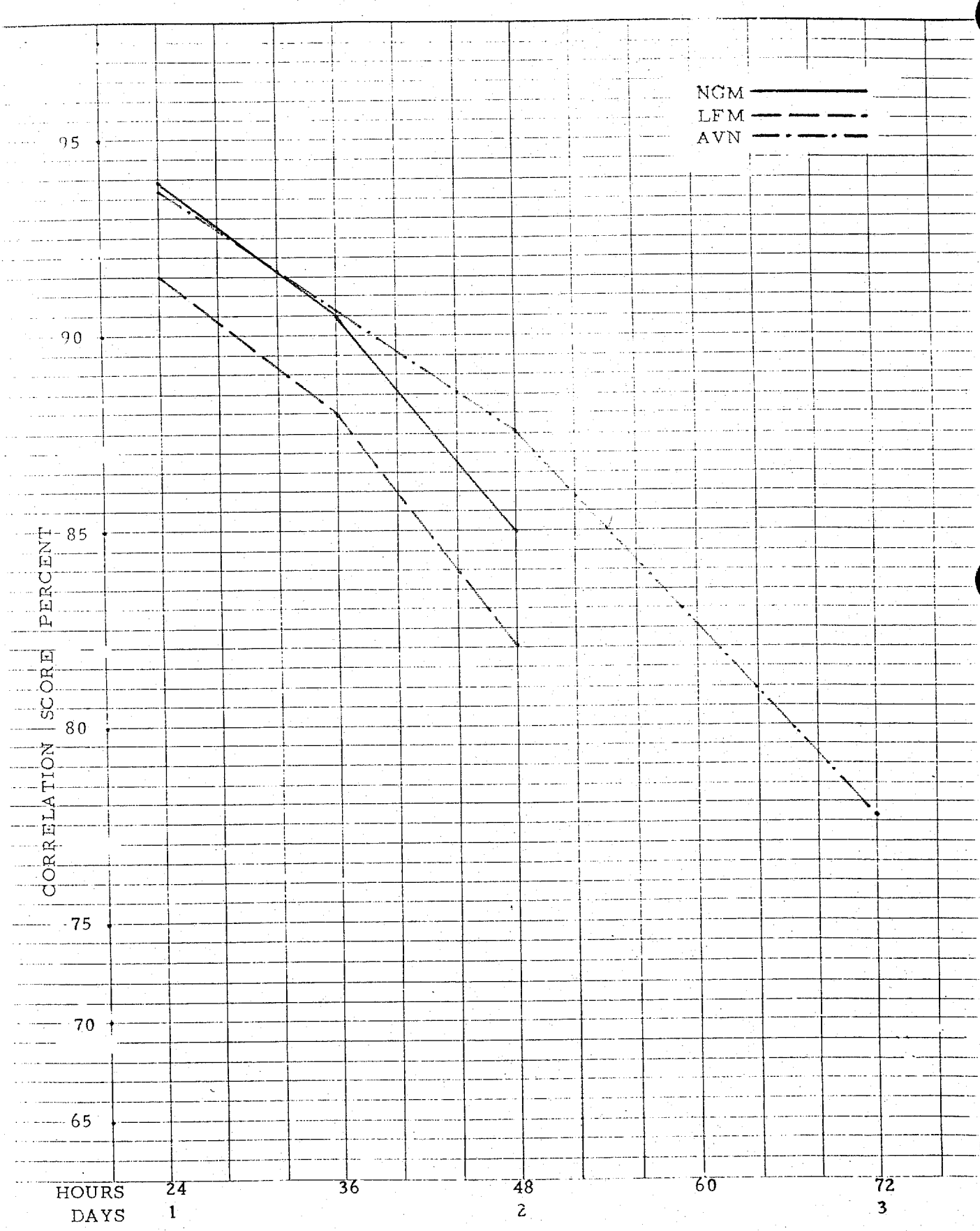


Fig. 50

DAYS 1 THRU 3 NORTH AMERICAN AREA 500MB
STANDARDIZED CORRELATION SCORES FOR JAN 89

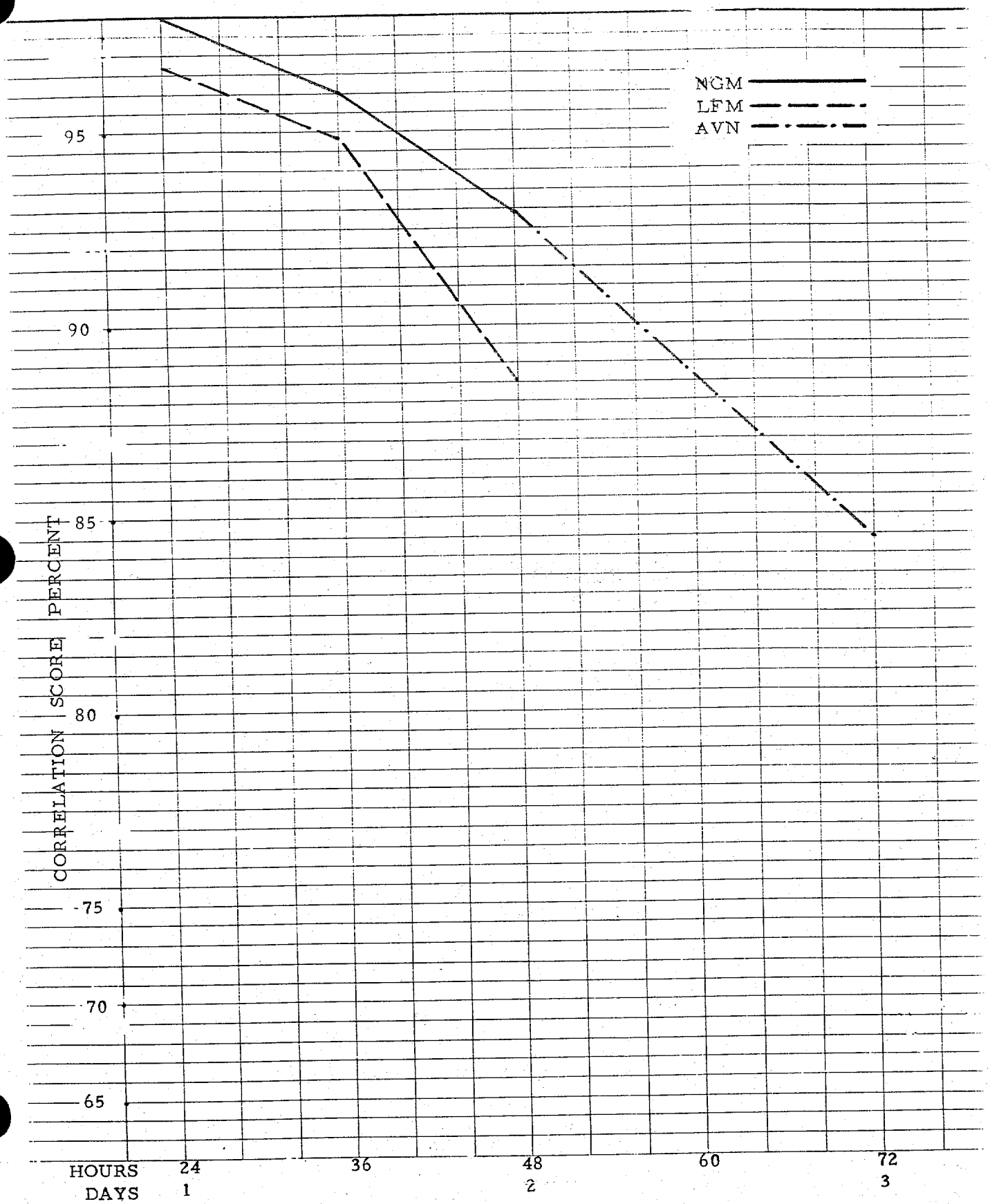


Fig. 51

DAYS 1 THRU 3 NORTH AMERICAN AREA 500MB
STANDARDIZED CORRELATION SCORES FOR FEB 1989

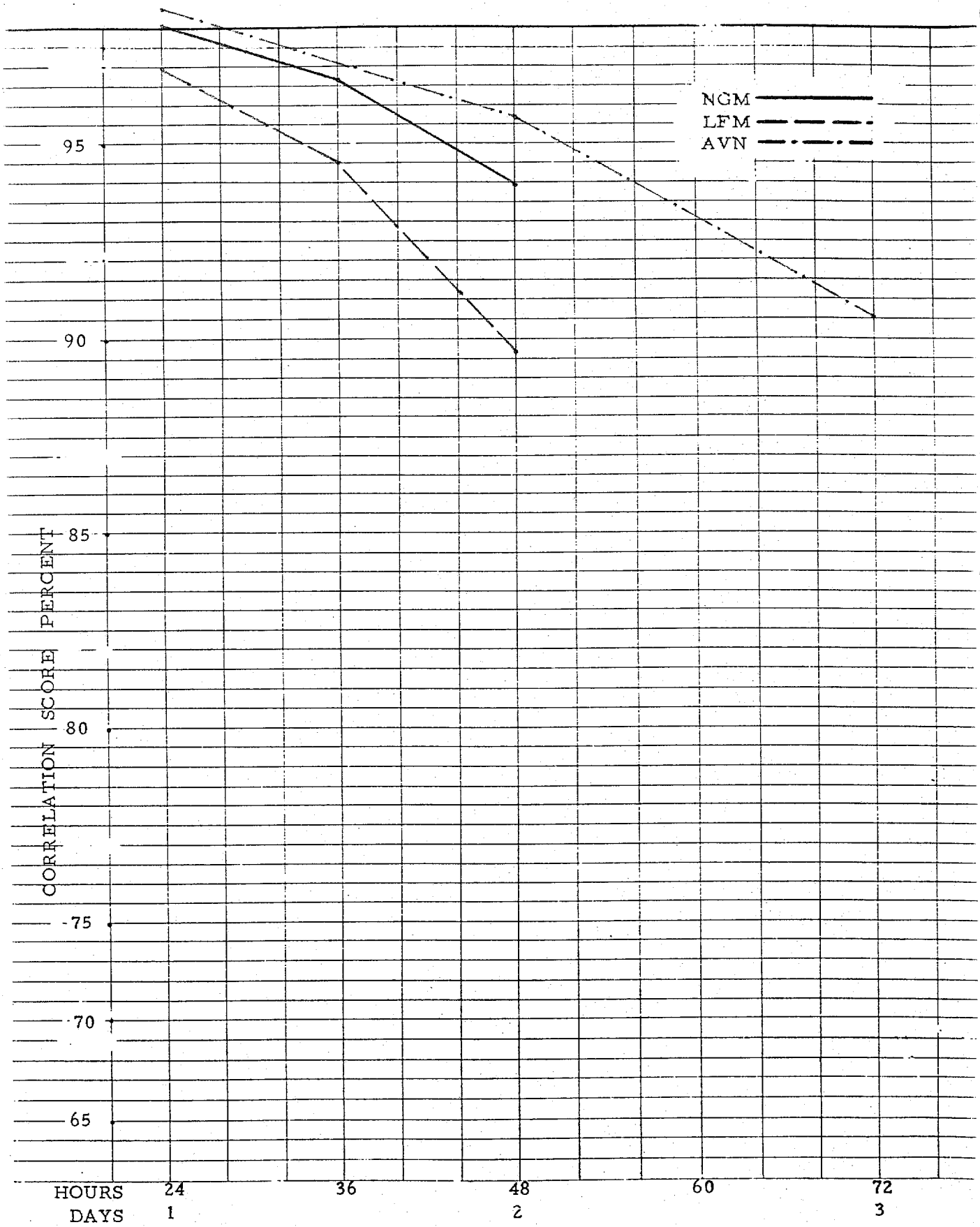


Fig. 52

DAYS 1 THRU 3 NORTH AMERICAN AREA 500MB
STANDARDIZED CORRELATION SCORES FOR MAR 89

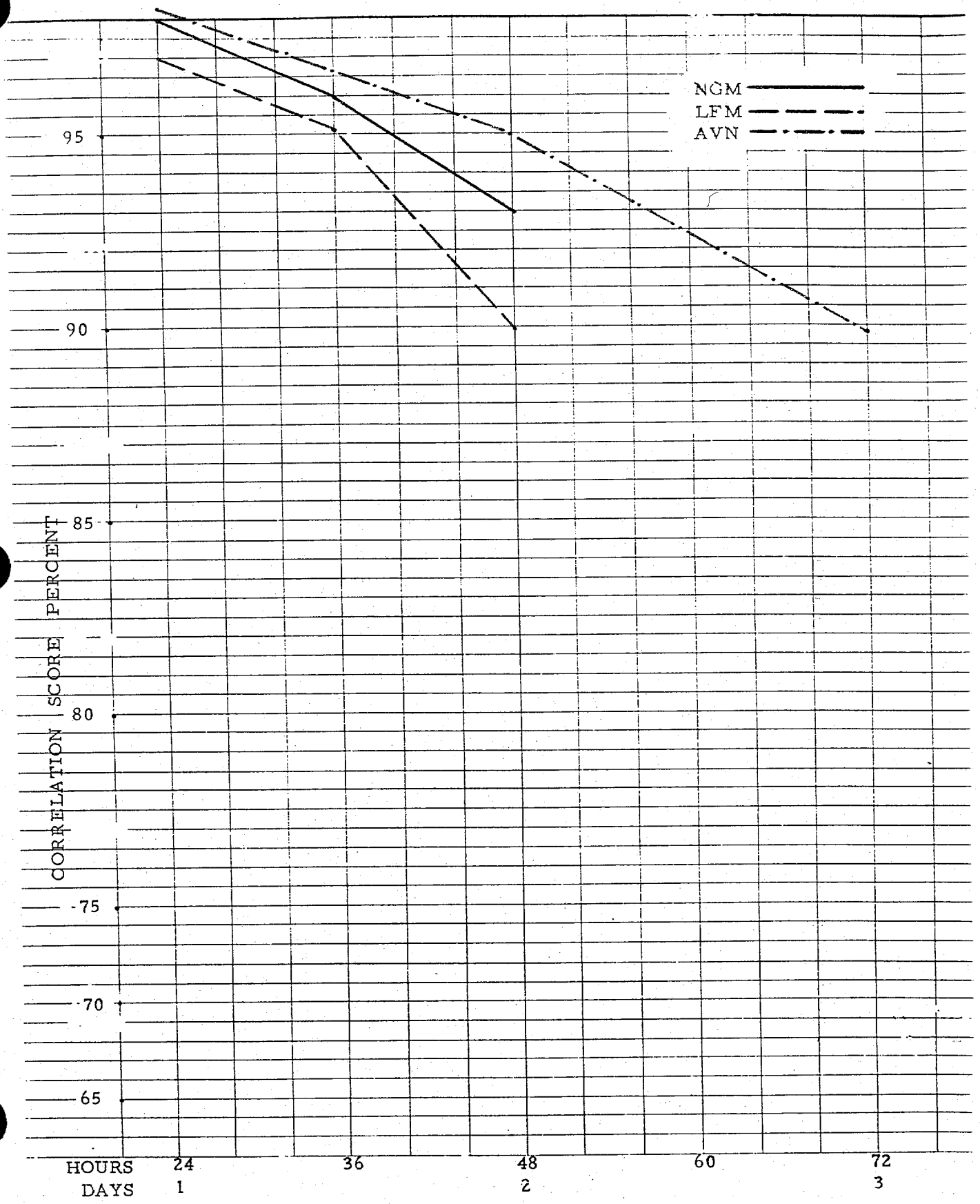


Fig. 53

DAYS 1 THRU 3 NORTH AMERICAN AREA 500MB
STANDARDIZED CORRELATION SCORES FOR APRIL 89

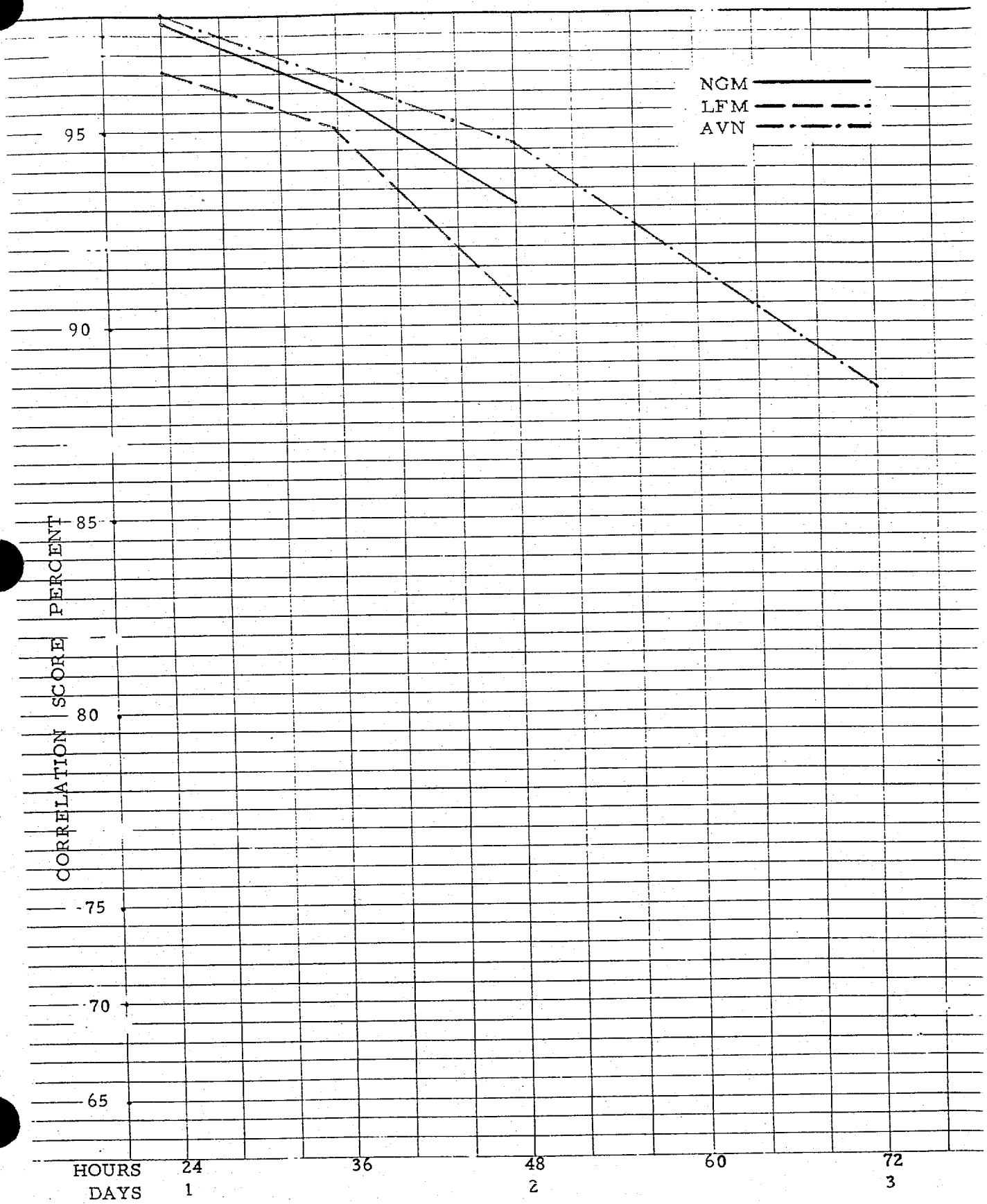
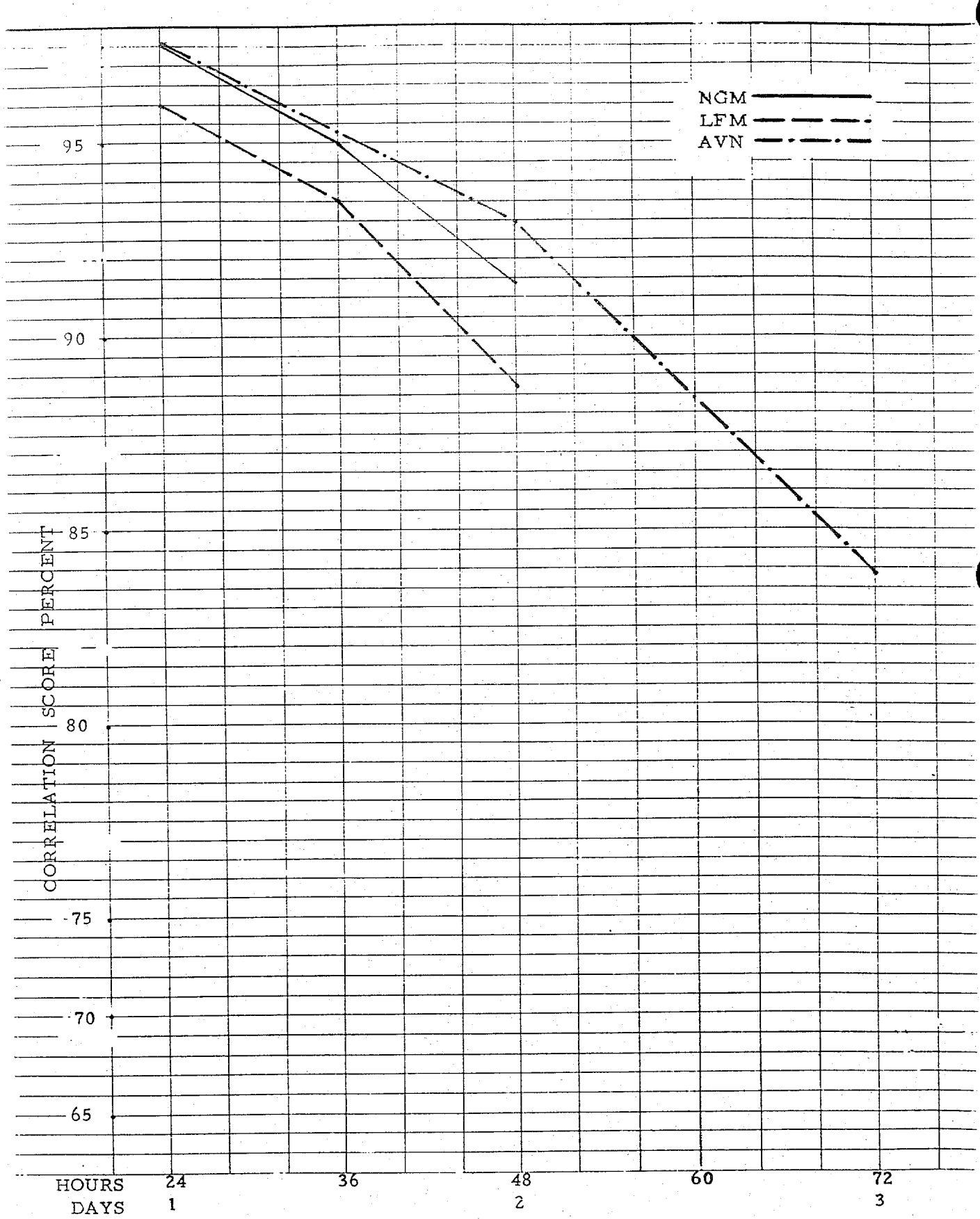
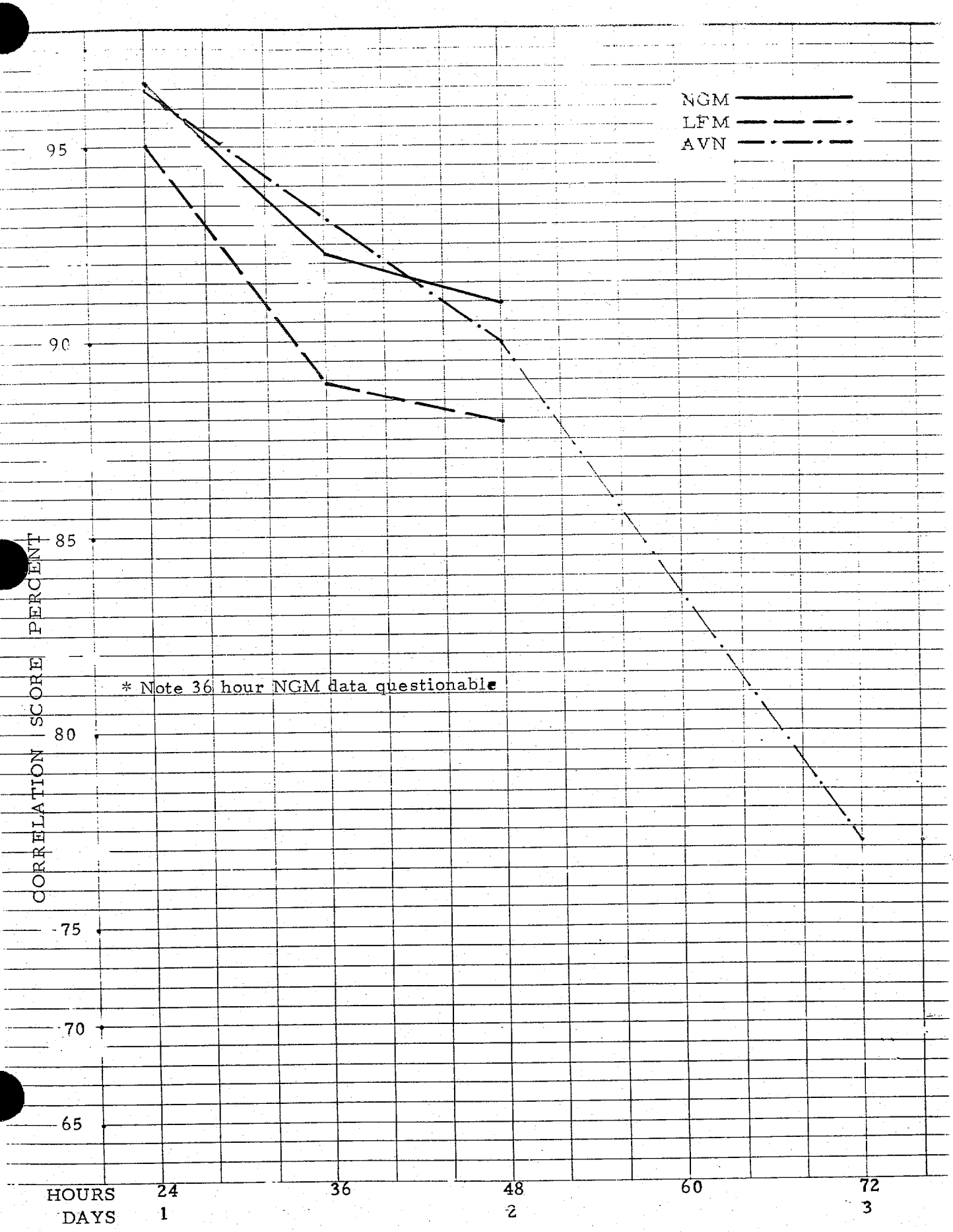


Fig. 54

DAYS 1 THRU 3 NORTH AMERICAN AREA 500MB
STANDARDIZED CORRELATION SCORES FOR MAY 89

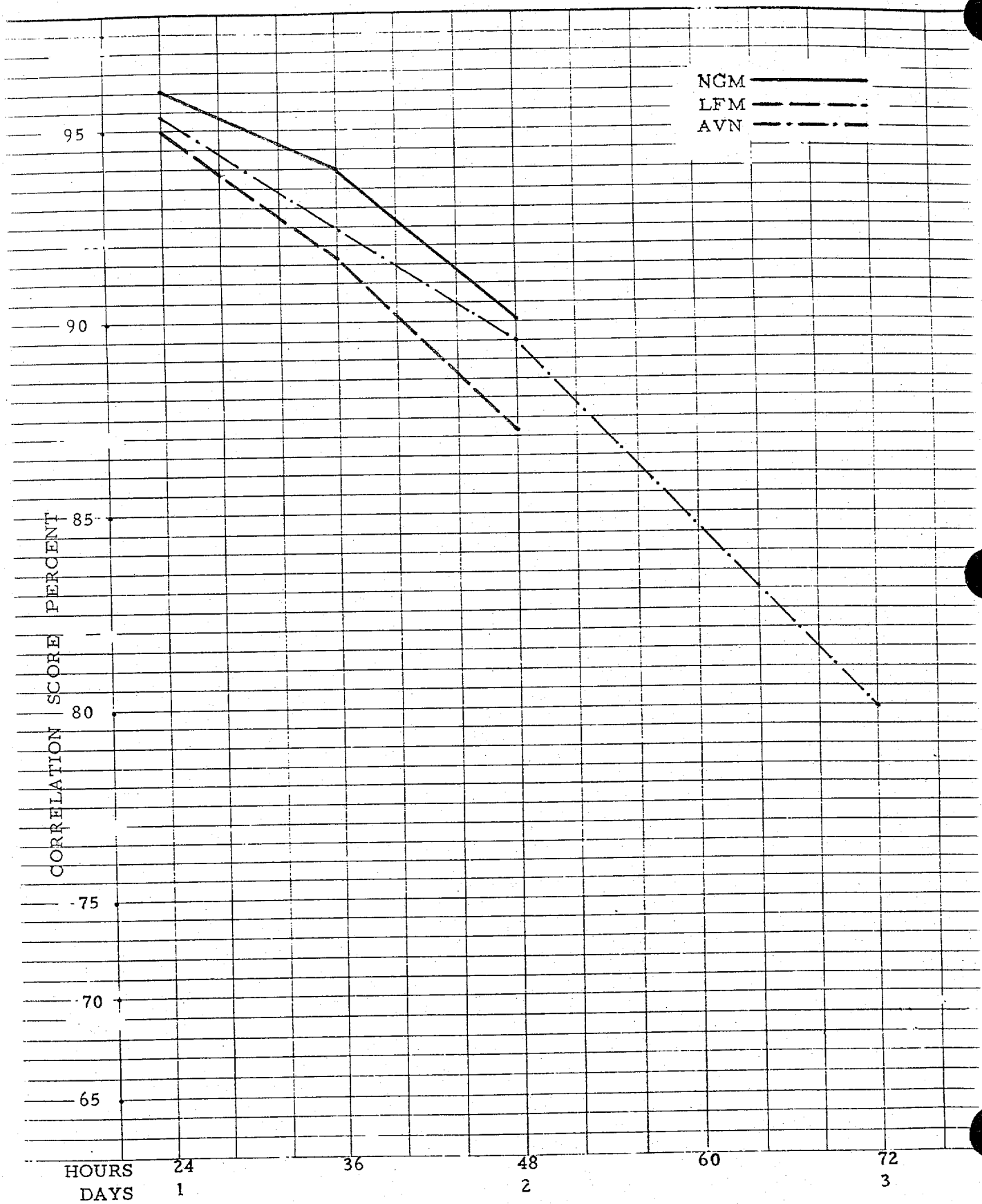


DAYS 1 THRU 3 NORTH AMERICAN AREA 500MB Fig. 55
STANDARDIZED CORRELATION SCORES FOR JUN 89



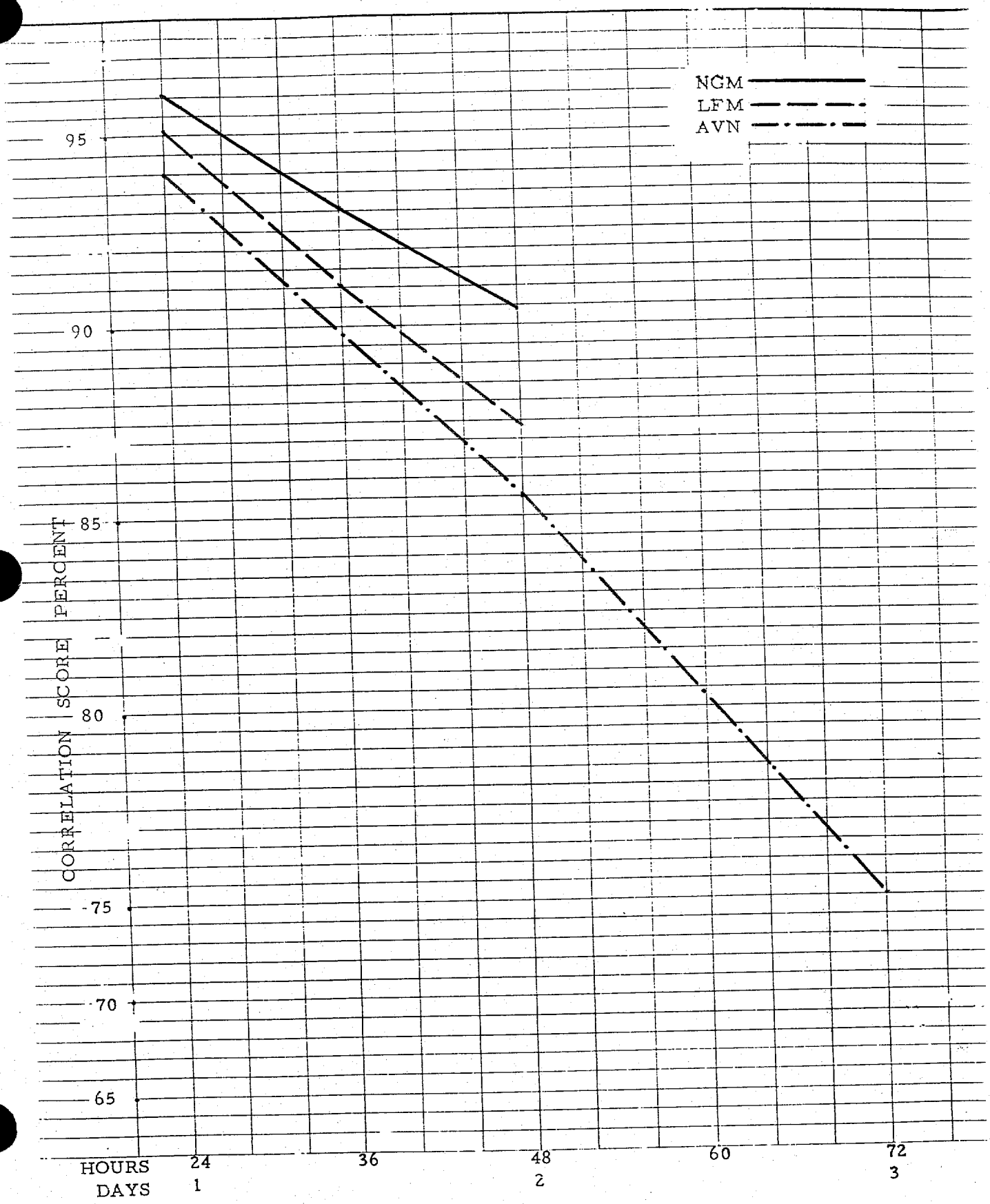
DAYS 1 THRU 3 NORTH AMERICAN AREA 500MB
STANDARDIZED CORRELATION SCORES FOR JUL 89

Fig. 56



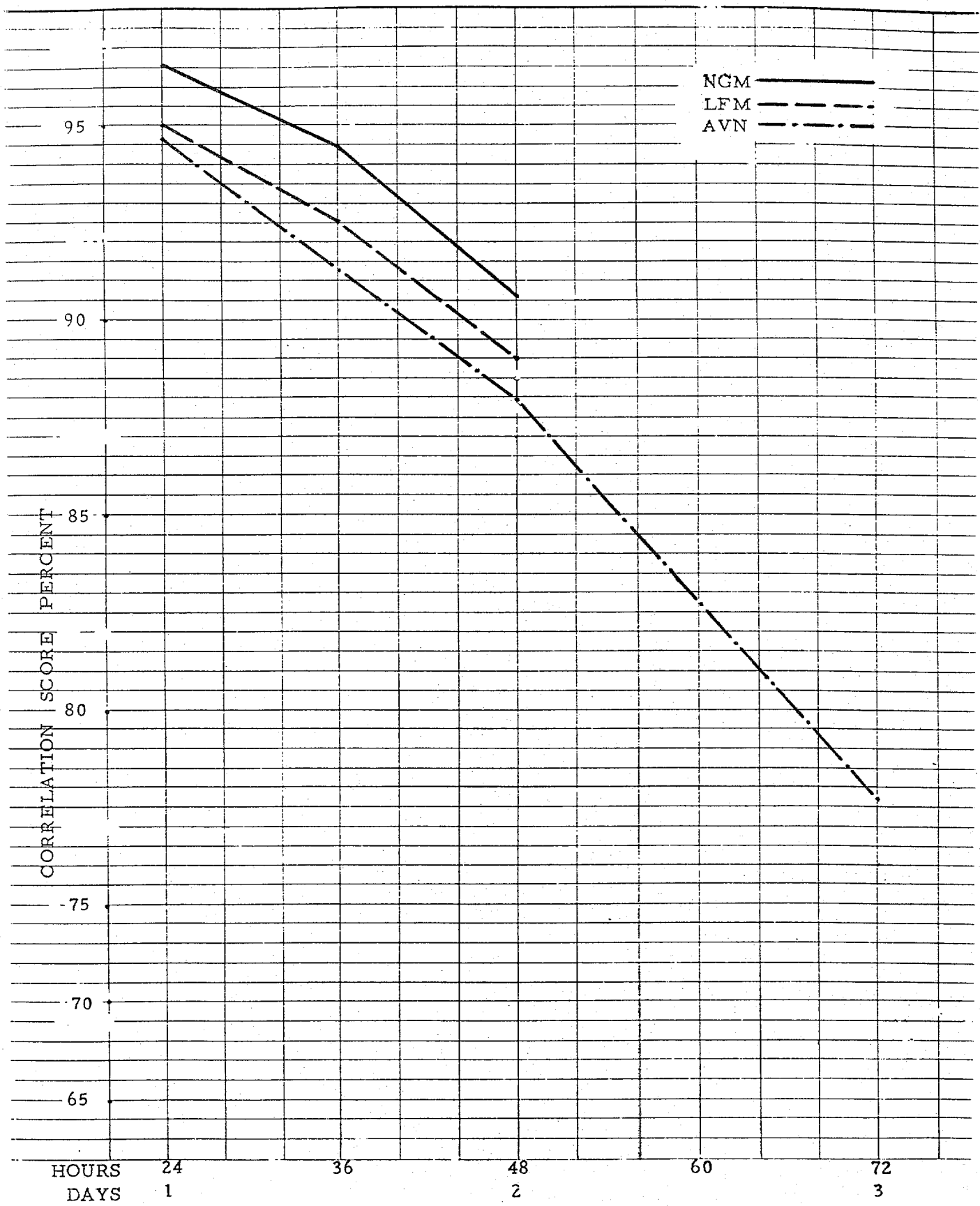
DAYS 1 THRU 3 NORTH AMERICAN AREA 500MB
STANDARDIZED CORRELATION SCORES FOR AUG 89

Fig. 57



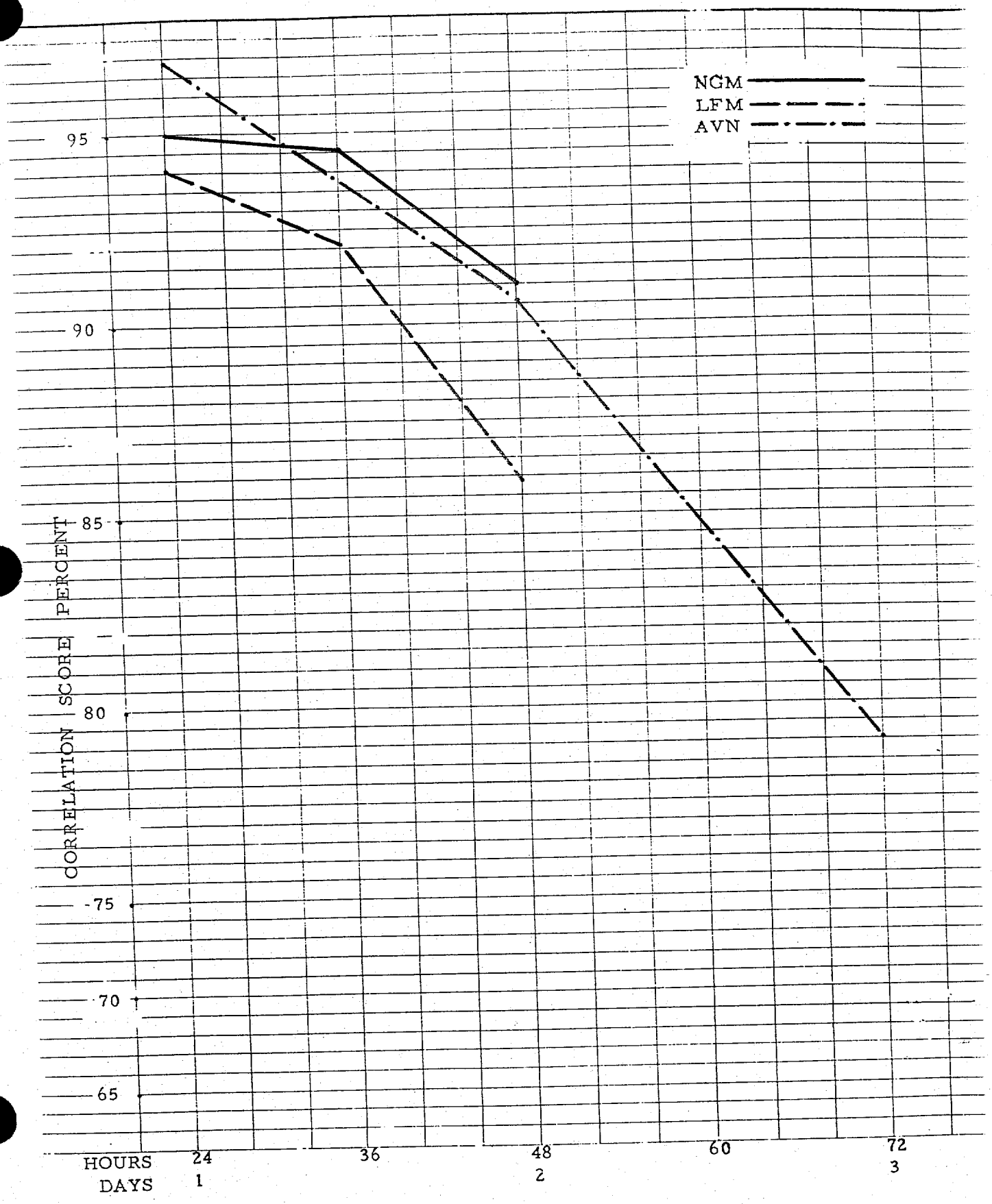
DAYS 1 THRU 3 NORTH AMERICAN AREA 500MB
STANDARDIZED CORRELATION SCORES FOR SEP 89

Fig. 58



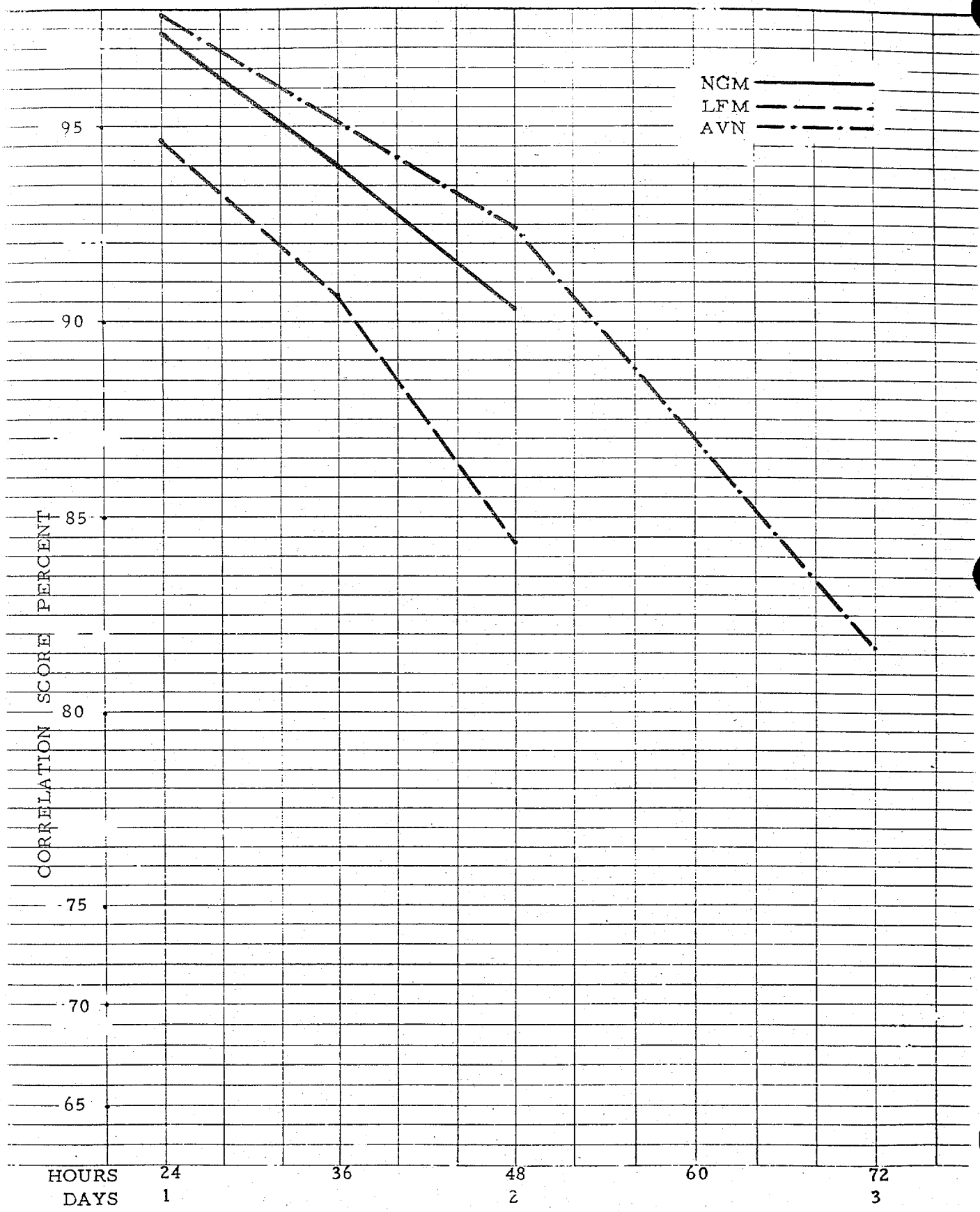
DAYS 1 THRU 3 NORTH AMERICAN AREA 500MB
STANDARDIZED CORRELATION SCORES FOR OCT 1989

Fig. 59



DAYS 1 THRU 3 NORTH AMERICAN AREA 500MB
STANDARDIZED CORRELATION SCORES FOR NOV 89

Fig. 60



DAYS 1 THRU 3 NORTH AMERICAN AREA 500MB
CORRELATION SCORES FOR DEC 89

Fig. 61

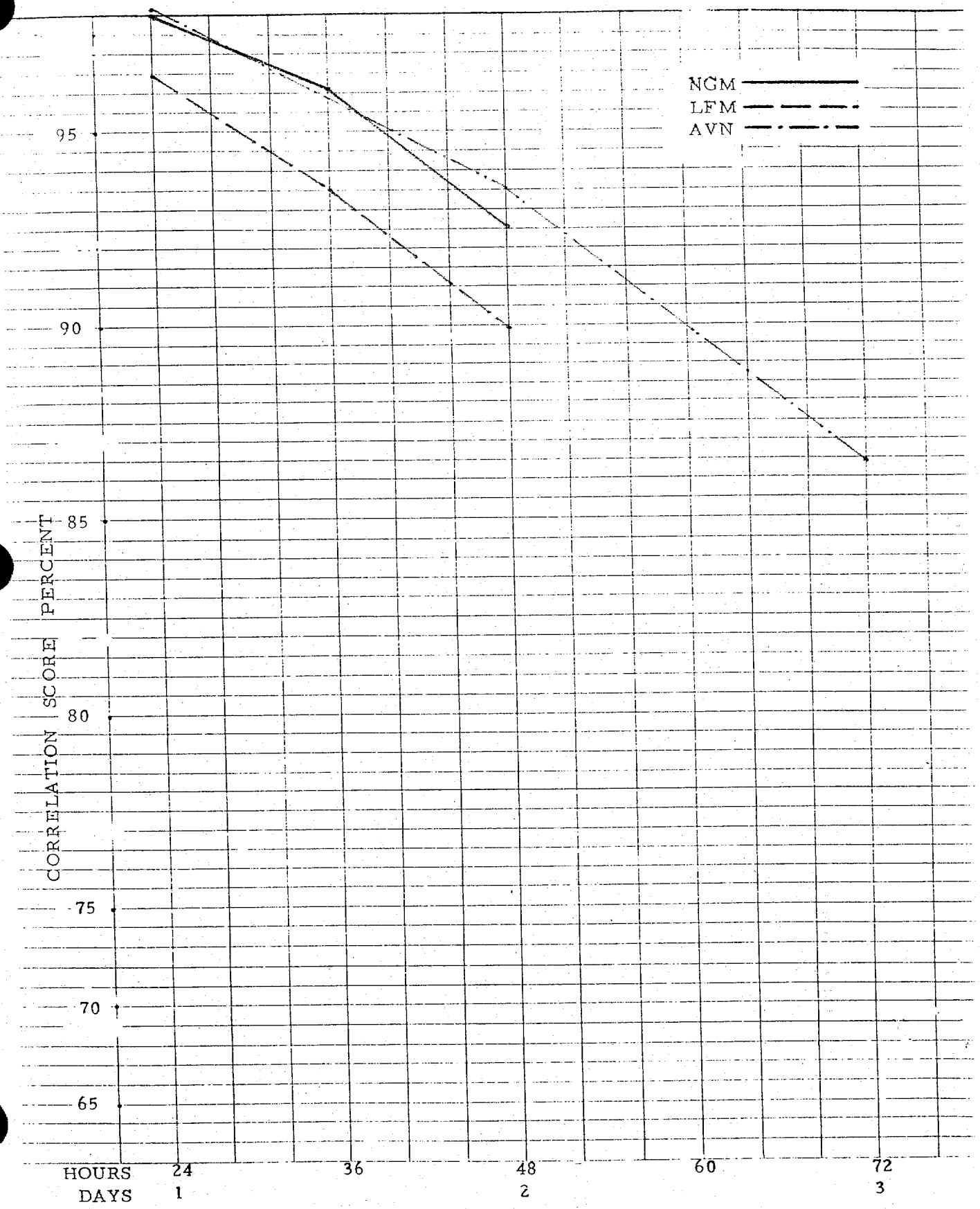


Fig. 62

NMC/NWP MODEL CALENDAR YEAR AVERAGE
NORTH AMERICAN AREA MSLP STANDARDIZED
CORRELATION SCORES FOR DAYS 3, 4, AND 5 PROGS

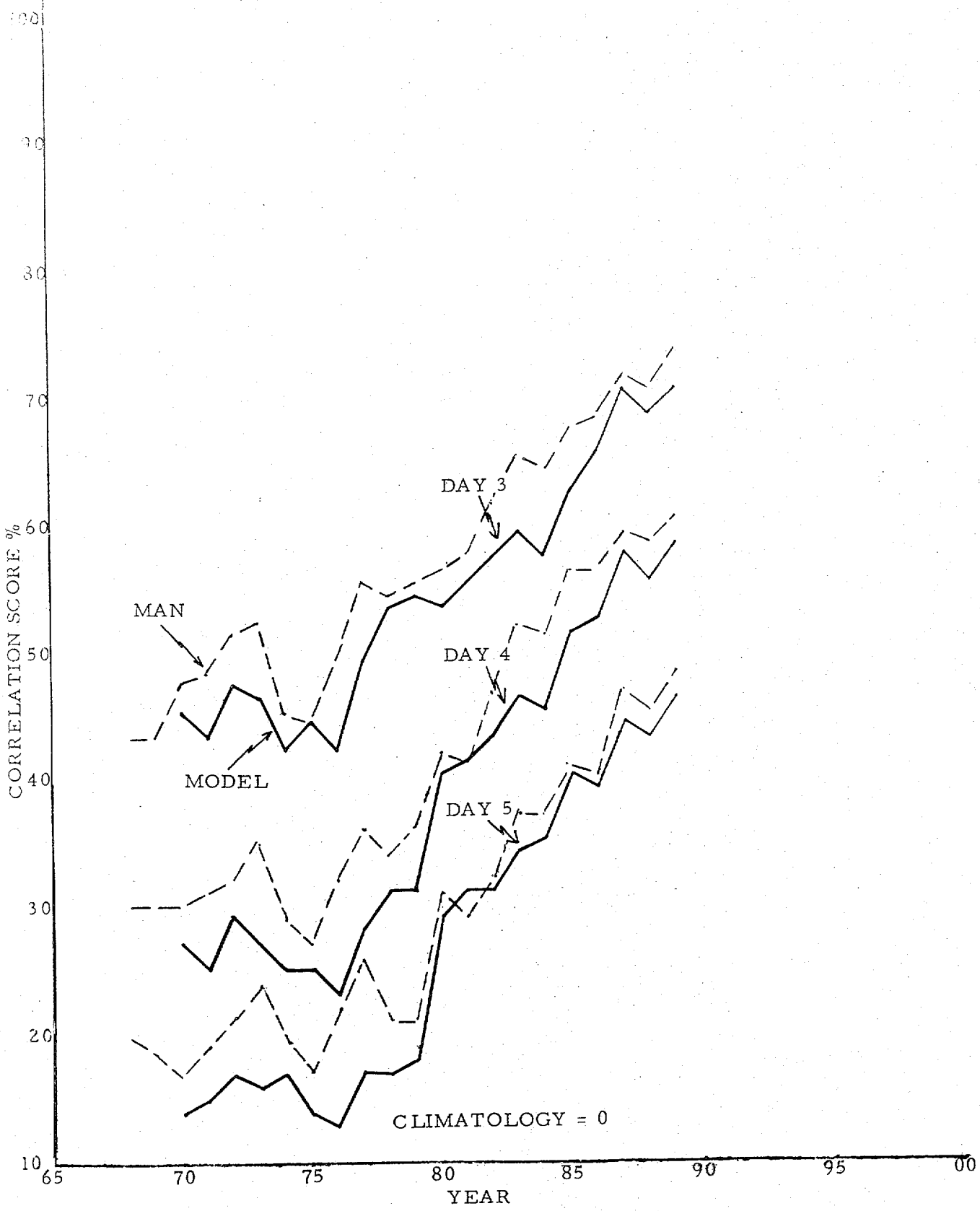


Fig. 63

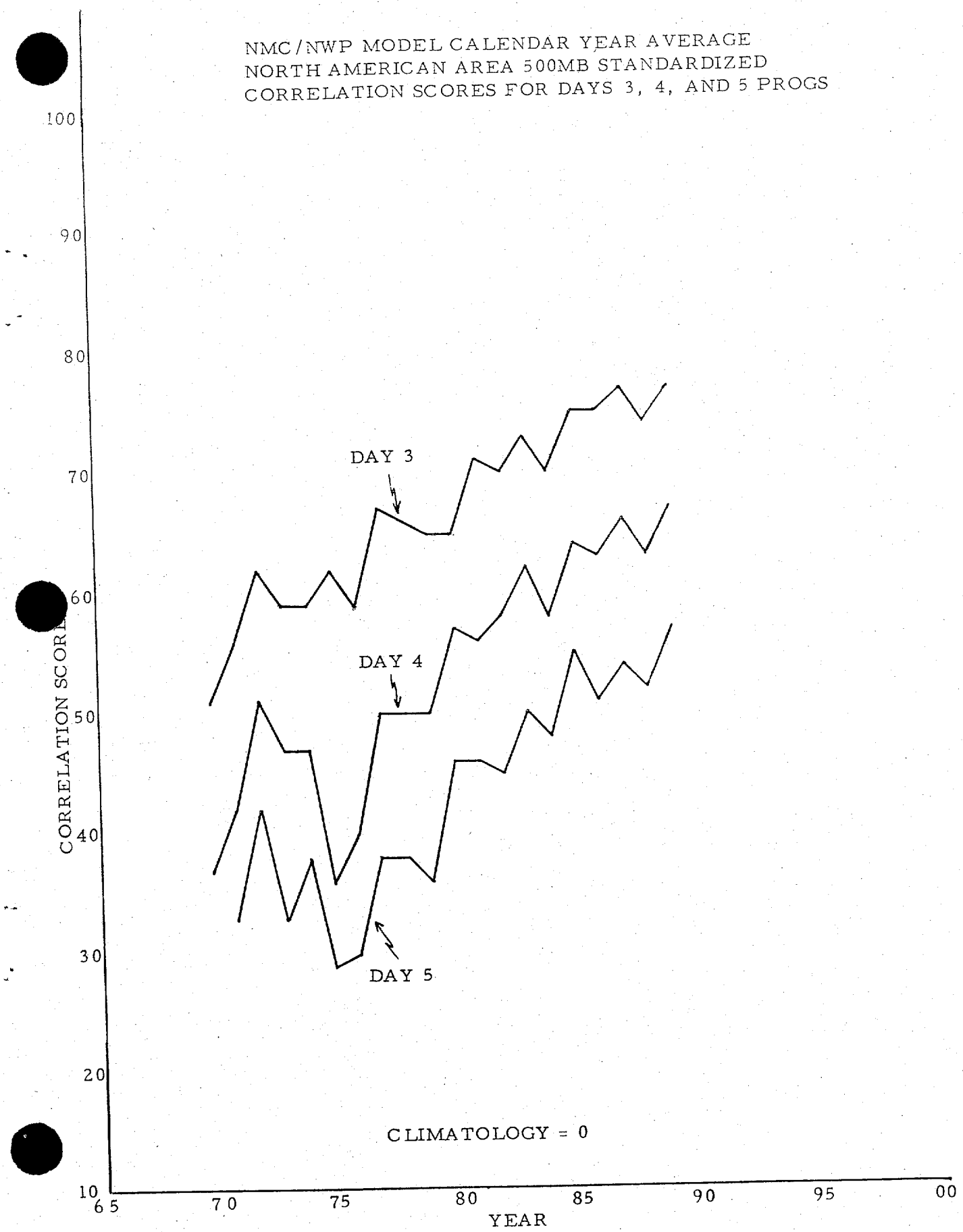
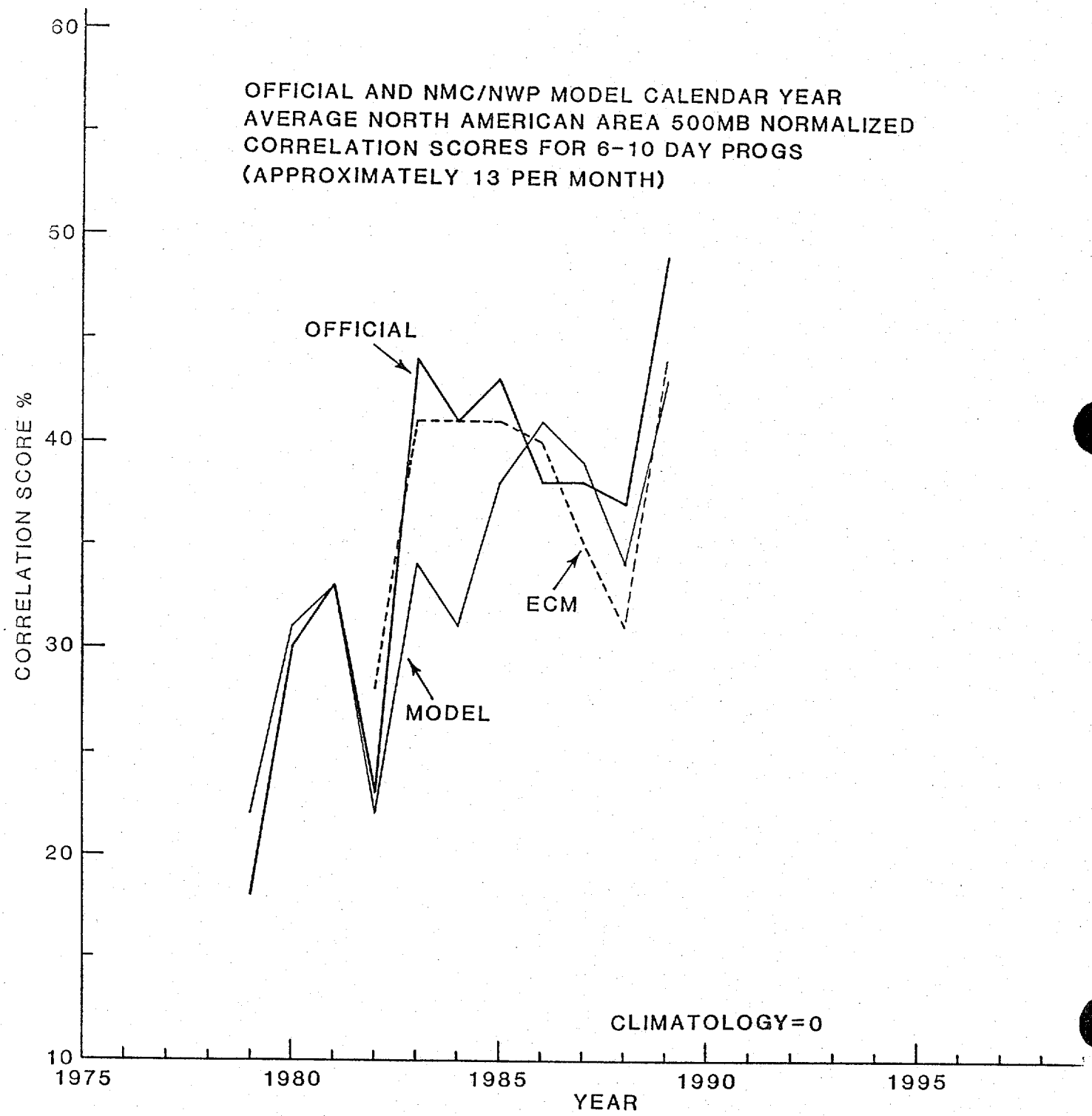

NMC/NWP MODEL CALENDAR YEAR AVERAGE
NORTH AMERICAN AREA 500MB STANDARDIZED
CORRELATION SCORES FOR DAYS 3, 4, AND 5 PROGS
100
90
80
70
60
50
40
30
20
10
CORRELATION SCORE
DAY 3
DAY 4
DAY 5
CLIMATOLOGY = 0
65
70
75
80
85
90
95
00
YEAR

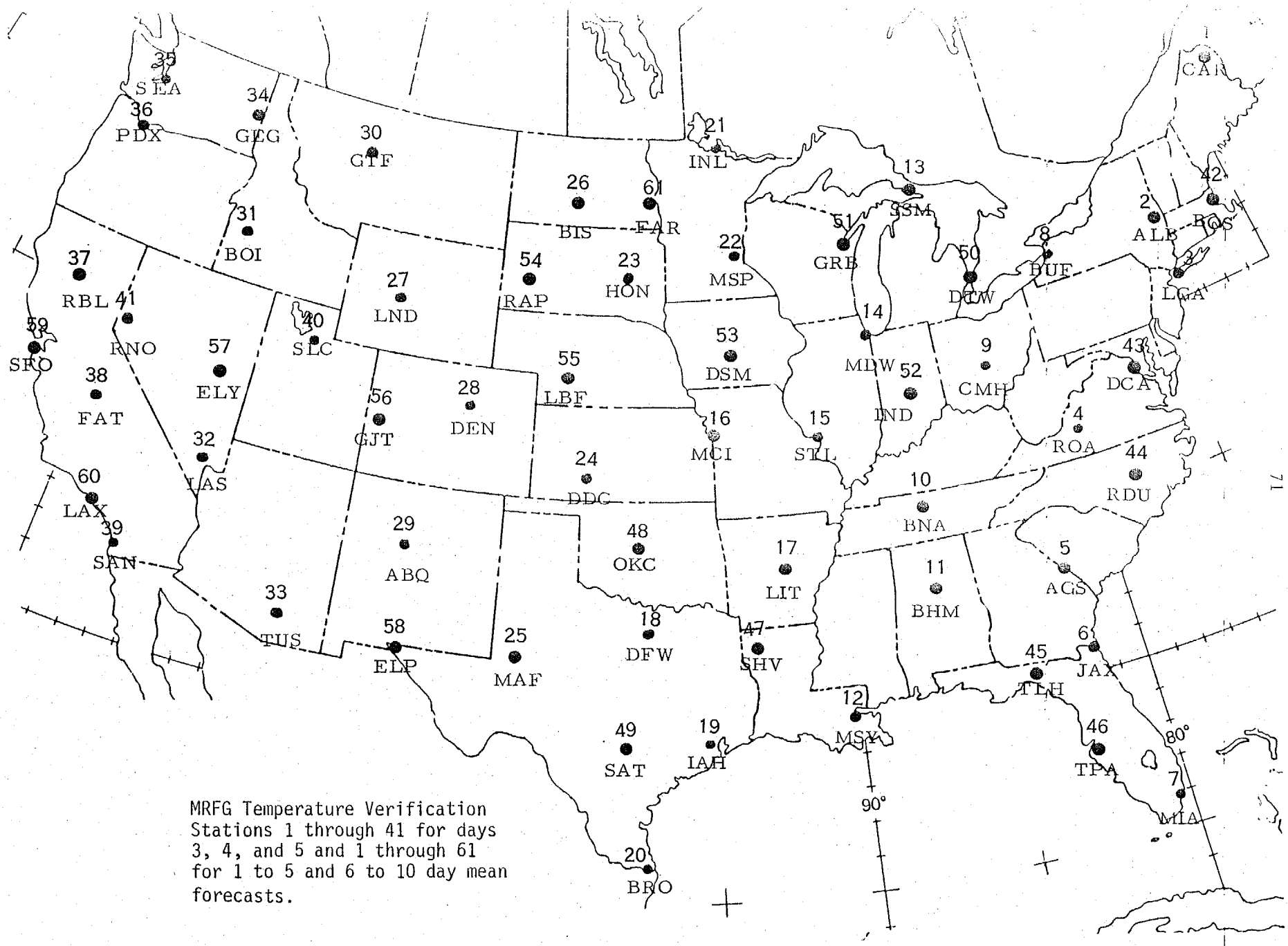
Fig. 64


OFFICIAL AND NMC/NWP MODEL CALENDAR YEAR
AVERAGE NORTH AMERICAN AREA 500MB NORMALIZED
CORRELATION SCORES FOR 6-10 DAY PROGS
(APPROXIMATELY 13 PER MONTH)
OFFICIAL
ECM
MODEL
CLIMATOLOGY=0
CORRELATION SCORE %
60
50
40
30
20
10
1975
1980
1985
1990
1995
YEAR

SECTION 2

Man and Machine (Klein-Lewis Perfect Prog Guidance) Average

Absolute Error Temperature Scores



MRFG Temperature Verification Stations 1 through 41 for days 3, 4, and 5 and 1 through 61 for 1 to 5 and 6 to 10 day mean forecasts.

Fig. 6

Fig. 66

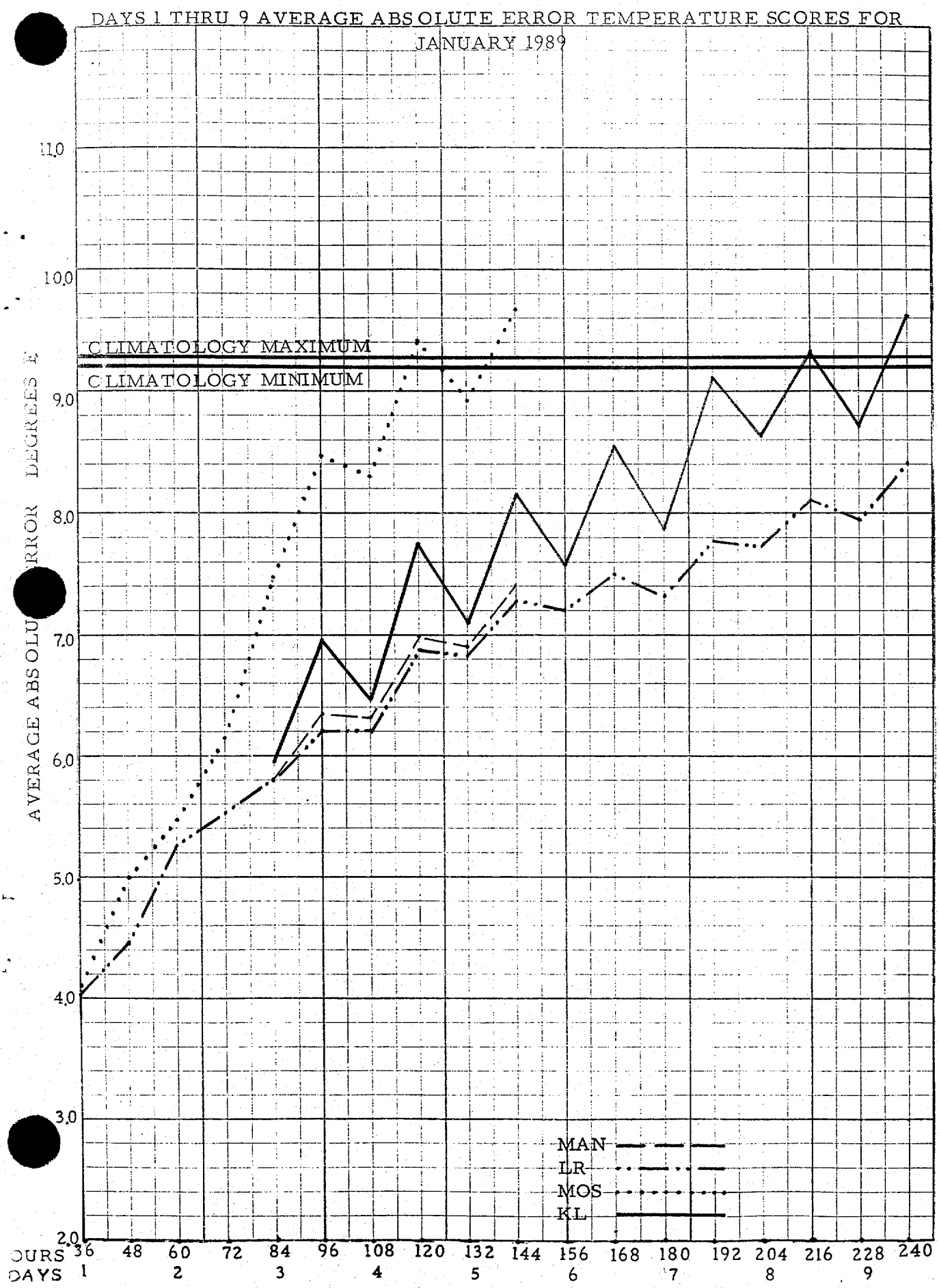

DAYS 1 THRU 9 AVERAGE ABSOLUTE ERROR TEMPERATURE SCORES FOR JANUARY 1989
AVERAGE ABSOLUTE ERROR DEGREES F
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
CLIMATOLOGY MAXIMUM
CLIMATOLOGY MINIMUM
MAN
LR
MOS
KL
HOURS 36 48 60 72 84 96 108 120 132 144 156 168 180 192 204 216 228 240
DAYS 1 2 3 4 5 6 7 8 9

Fig. 67

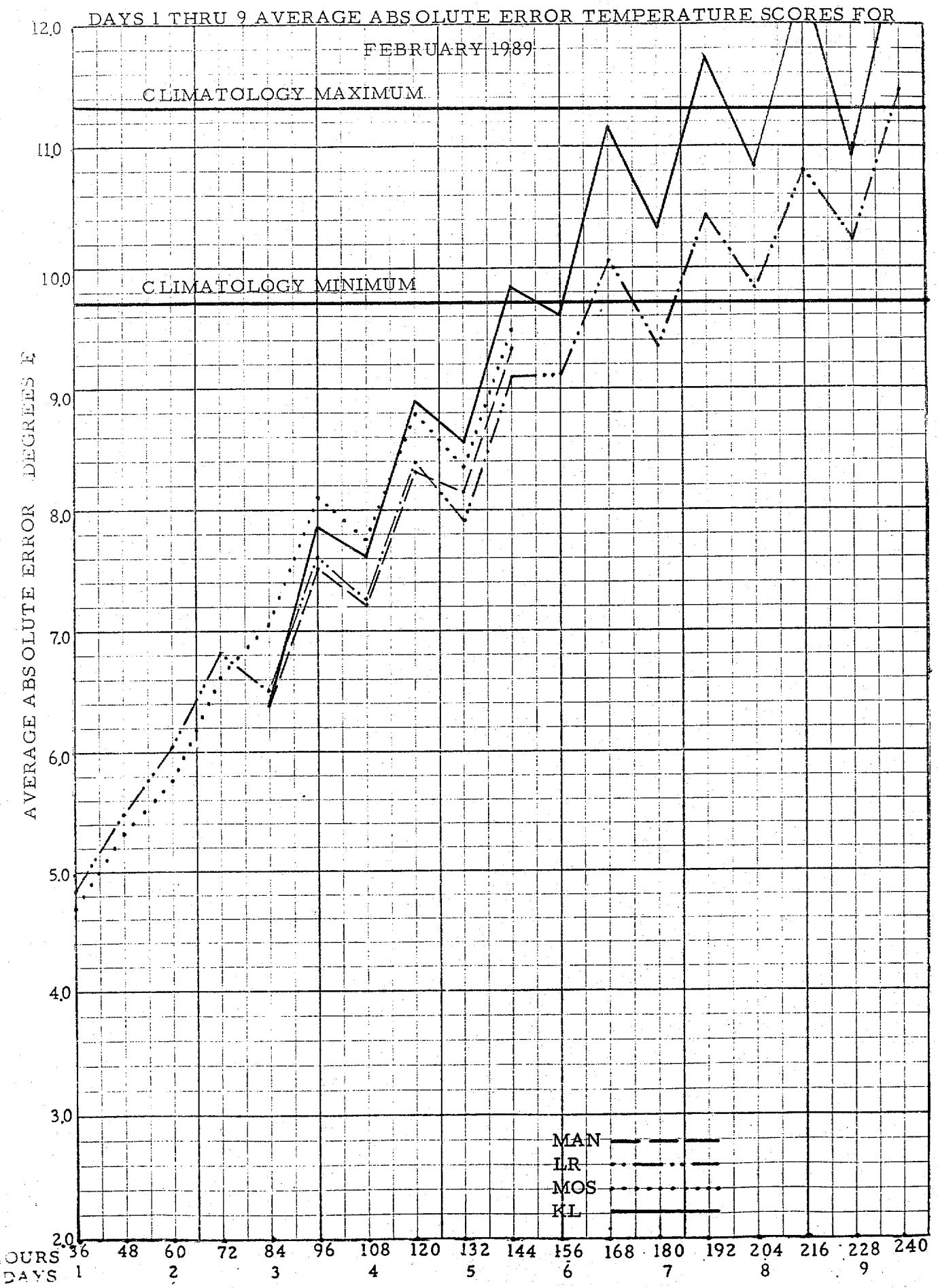

DAYS 1 THRU 9 AVERAGE ABSOLUTE ERROR TEMPERATURE SCORES FOR
FEBRUARY 1989
CLIMATOLOGY MAXIMUM
CLIMATOLOGY MINIMUM
AVERAGE ABSOLUTE ERROR DEGREES F
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
MAN
LR
MOS
KL
HOURS 36 48 60 72 84 96 108 120 132 144 156 168 180 192 204 216 228 240
DAYS 1 2 3 4 5 6 7 8 9

Fig. 68

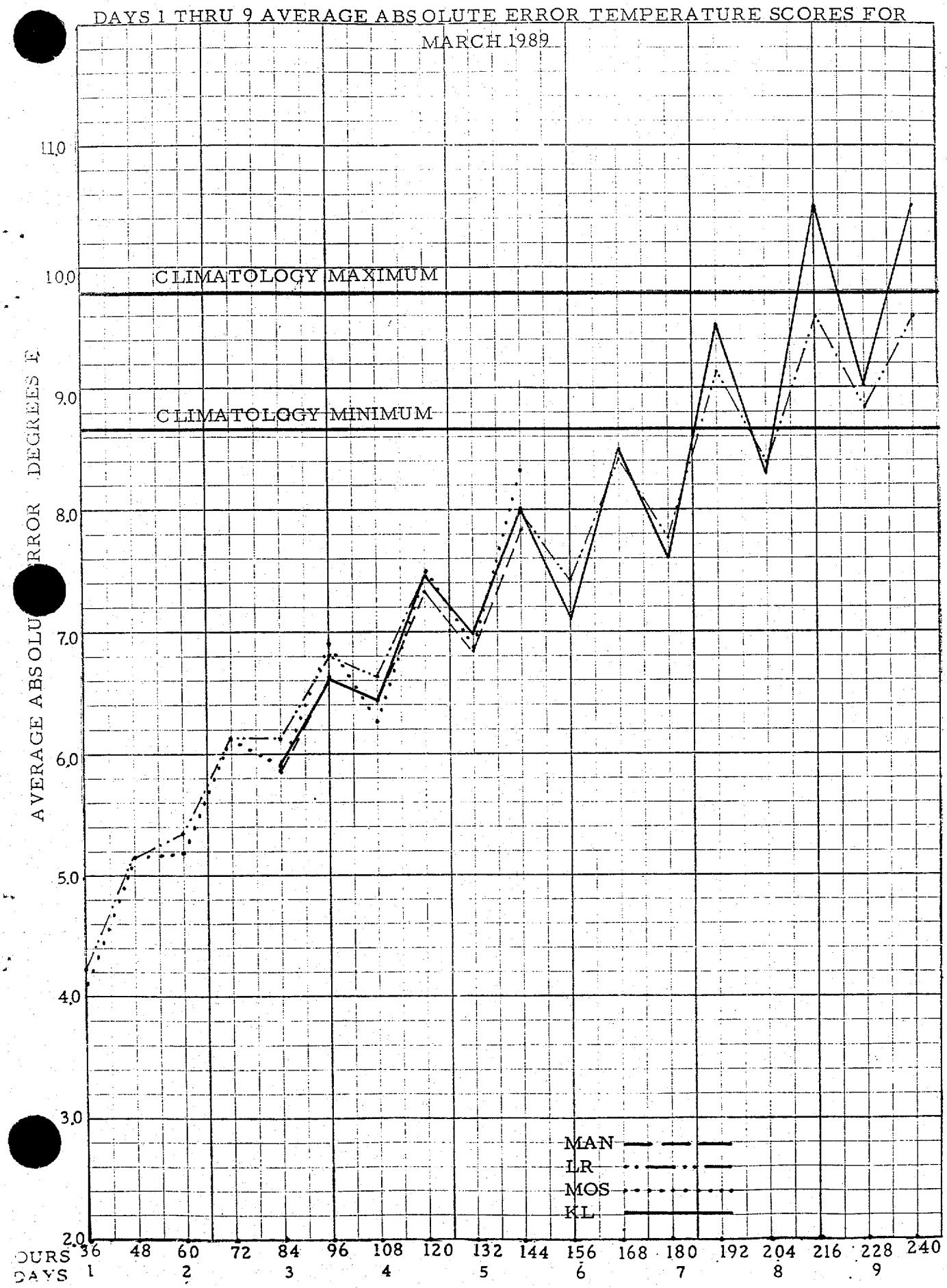

DAYS 1 THRU 9 AVERAGE ABSOLUTE ERROR TEMPERATURE SCORES FOR MARCH 1989
CLIMATOLOGY MAXIMUM
CLIMATOLOGY MINIMUM
AVERAGE ABSOLUTE ERROR DEGREES F
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
MAN
LR
MOS
KL
HOURS 36 48 60 72 84 96 108 120 132 144 156 168 180 192 204 216 228 240
DAYS 1 2 3 4 5 6 7 8 9

Fig. 69

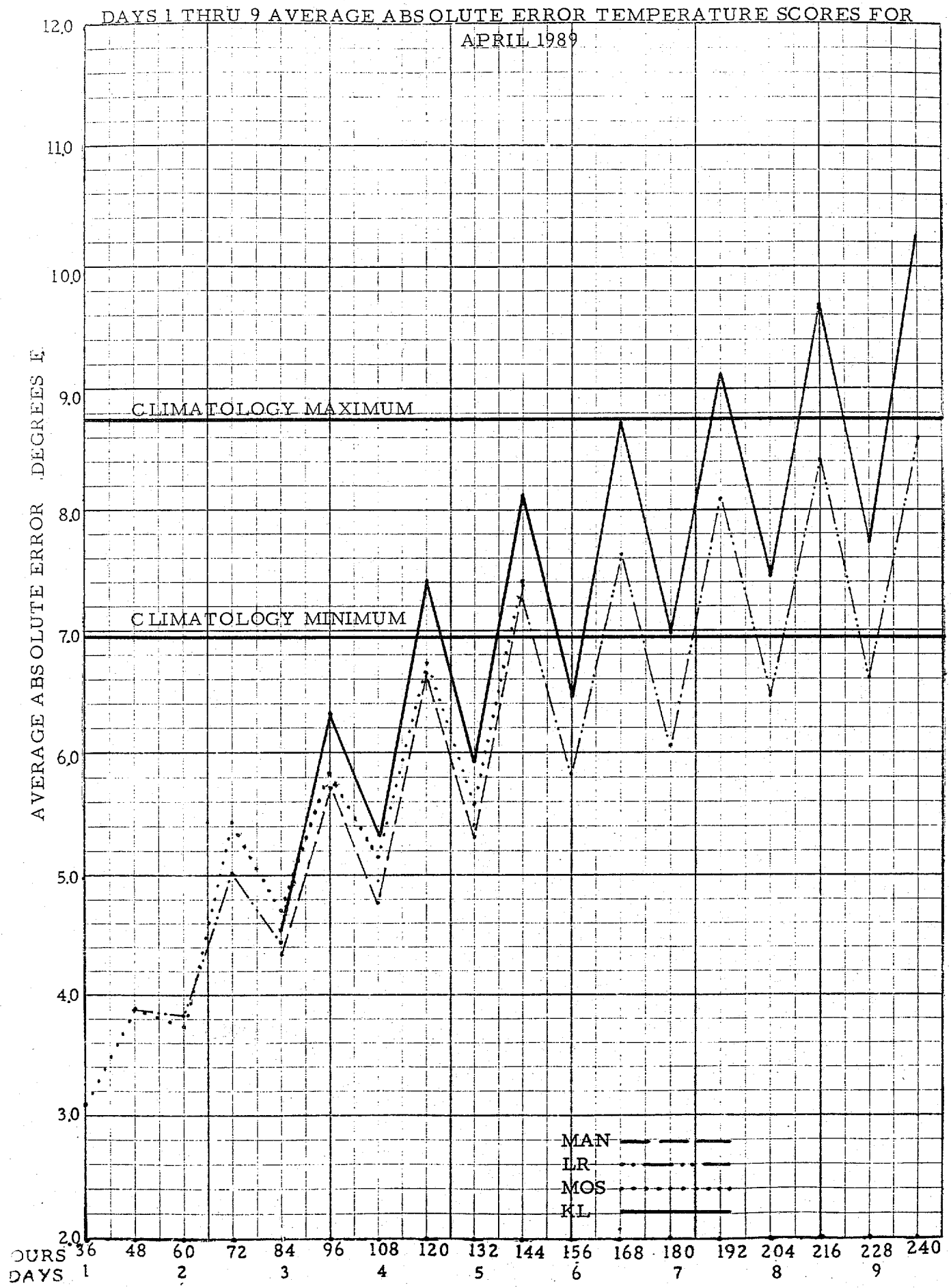

DAYS 1 THRU 9 AVERAGE ABSOLUTE ERROR TEMPERATURE SCORES FOR APRIL 1989
AVERAGE ABSOLUTE ERROR DEGREES F
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
CLIMATOLOGY MAXIMUM
CLIMATOLOGY MINIMUM
MAN
LR
MOS
KL
HOURS 36 48 60 72 84 96 108 120 132 144 156 168 180 192 204 216 228 240
DAYS 1 2 3 4 5 6 7 8 9

Fig. 70

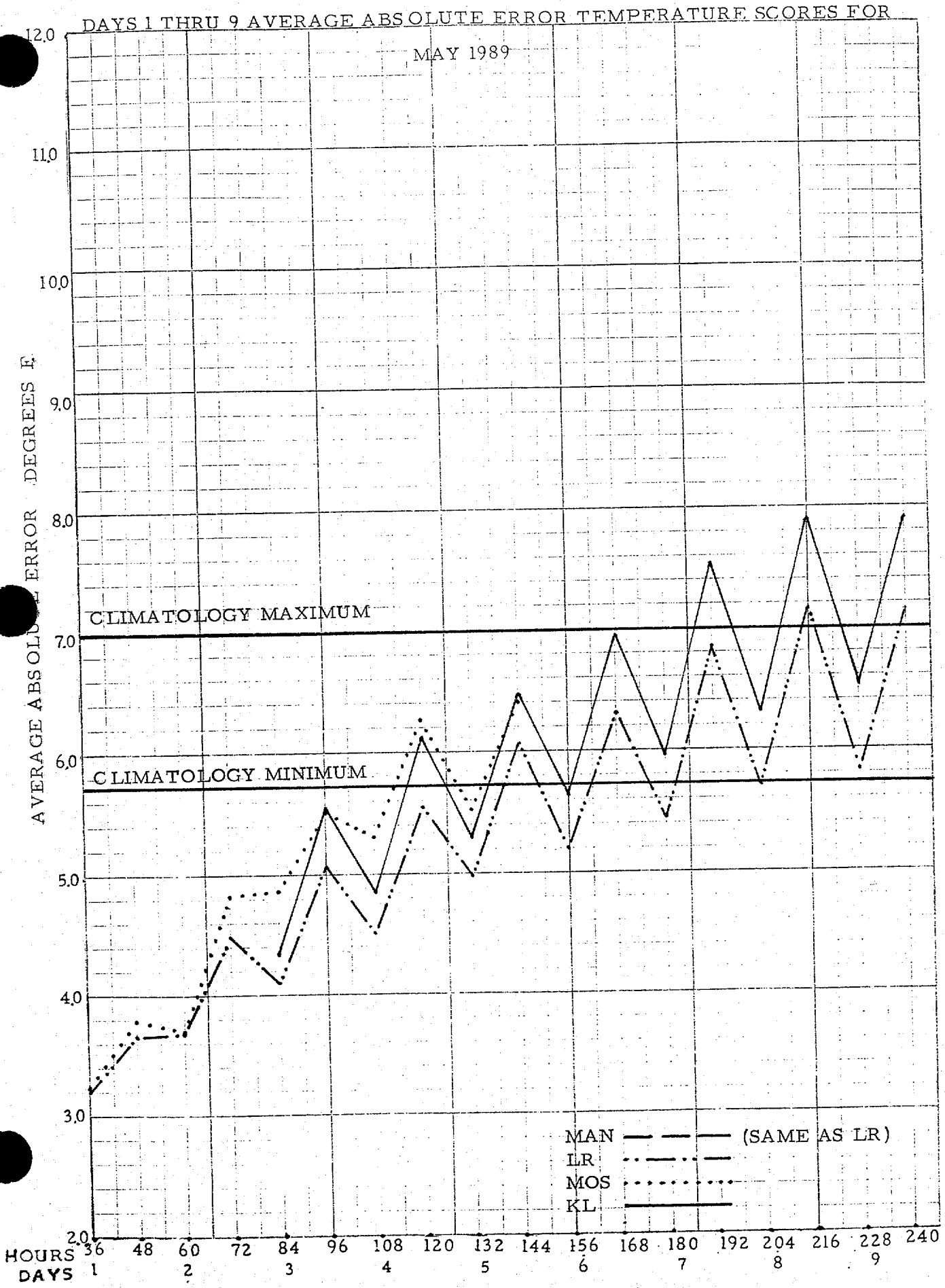

DAYS 1 THRU 9 AVERAGE ABSOLUTE ERROR TEMPERATURE SCORES FOR
MAY 1989
AVERAGE ABSOLUTE ERROR DEGREES F.
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
CLIMATOLOGY MAXIMUM
CLIMATOLOGY MINIMUM
MAN (SAME AS LR)
LR
MOS
KL
HOURS 36 48 60 72 84 96 108 120 132 144 156 168 180 192 204 216 228 240
DAYS 1 2 3 4 5 6 7 8 9

Fig. 71

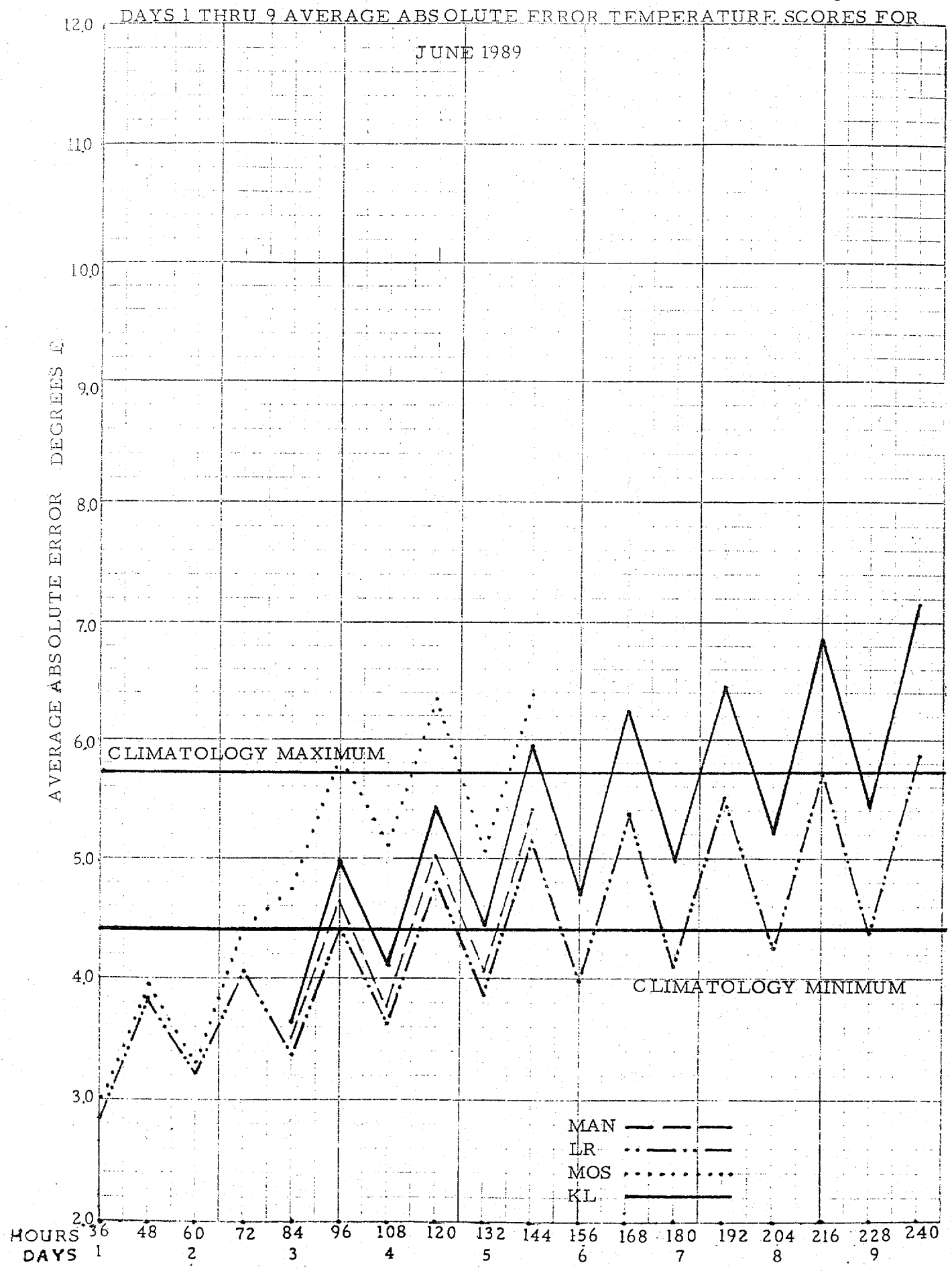

DAYS 1 THRU 9 AVERAGE ABSOLUTE ERROR TEMPERATURE SCORES FOR
JUNE 1989
AVERAGE ABSOLUTE ERROR DEGREES F
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
CLIMATOLOGY MAXIMUM
CLIMATOLOGY MINIMUM
MAN
LR
MOS
KL
HOURS 36 48 60 72 84 96 108 120 132 144 156 168 180 192 204 216 228 240
DAYS 1 2 3 4 5 6 7 8 9

Fig. 72

DAYS 1 THRU 9 AVERAGE ABSOLUTE ERROR TEMPERATURE SCORES FOR JULY 1989

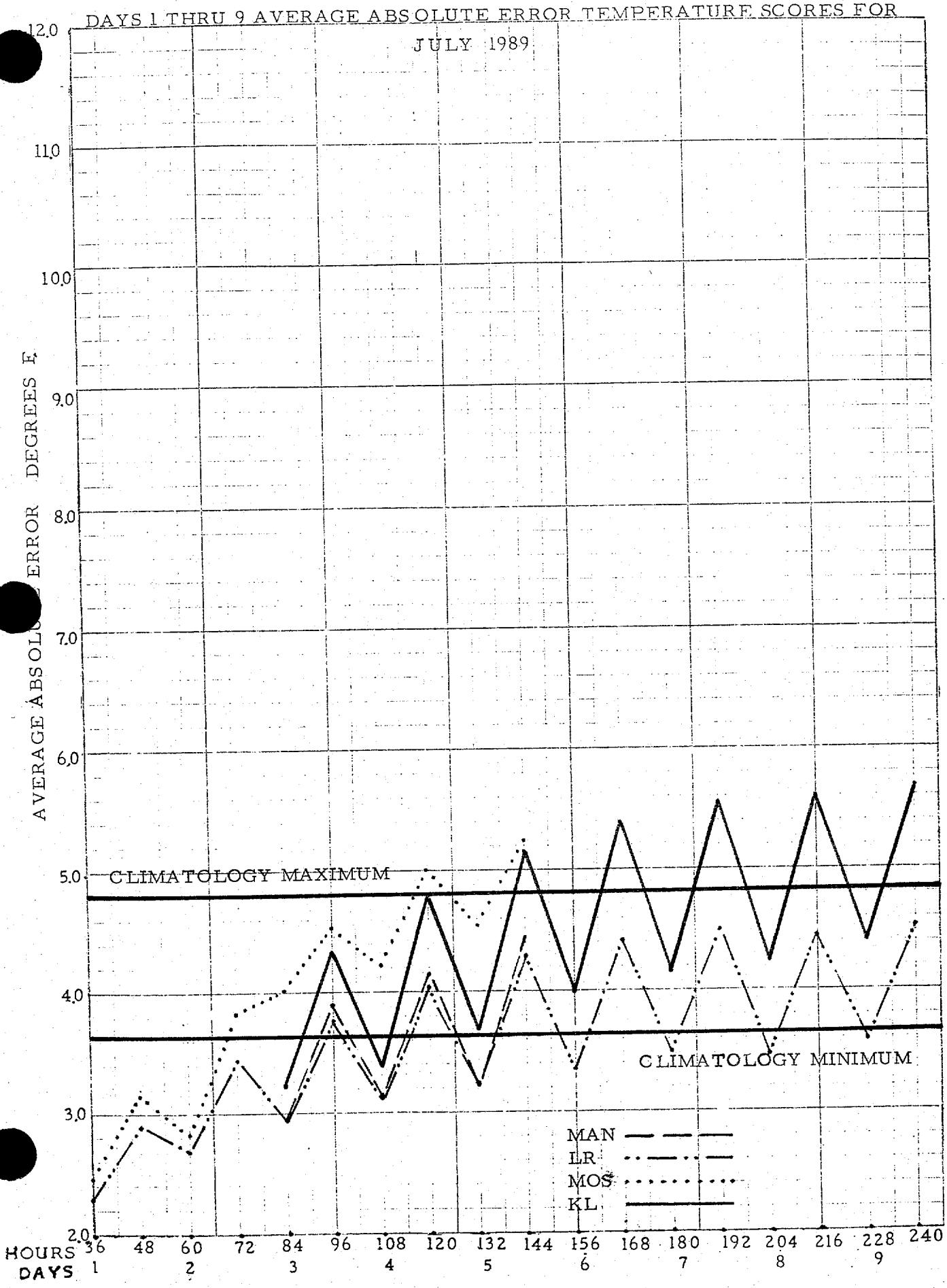


Fig. 73

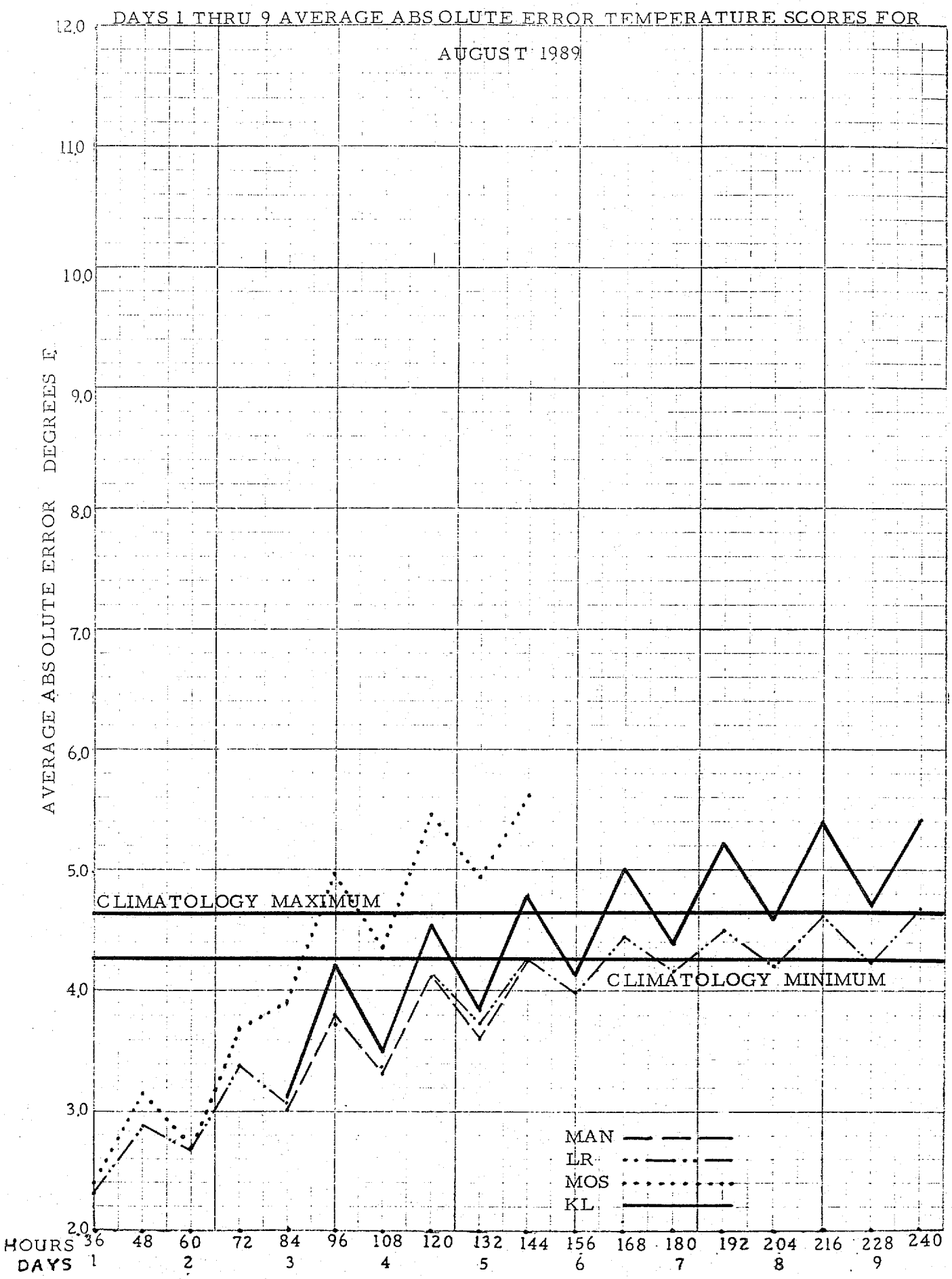

DAYS 1 THRU 9 AVERAGE ABSOLUTE ERROR TEMPERATURE SCORES FOR
AUGUST 1989
AVERAGE ABSOLUTE ERROR DEGREES F
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
CLIMATOLOGY MAXIMUM
CLIMATOLOGY MINIMUM
MAN
LR
MOS
KL
HOURS 36 48 60 72 84 96 108 120 132 144 156 168 180 192 204 216 228 240
DAYS 1 2 3 4 5 6 7 8 9

Fig. 74

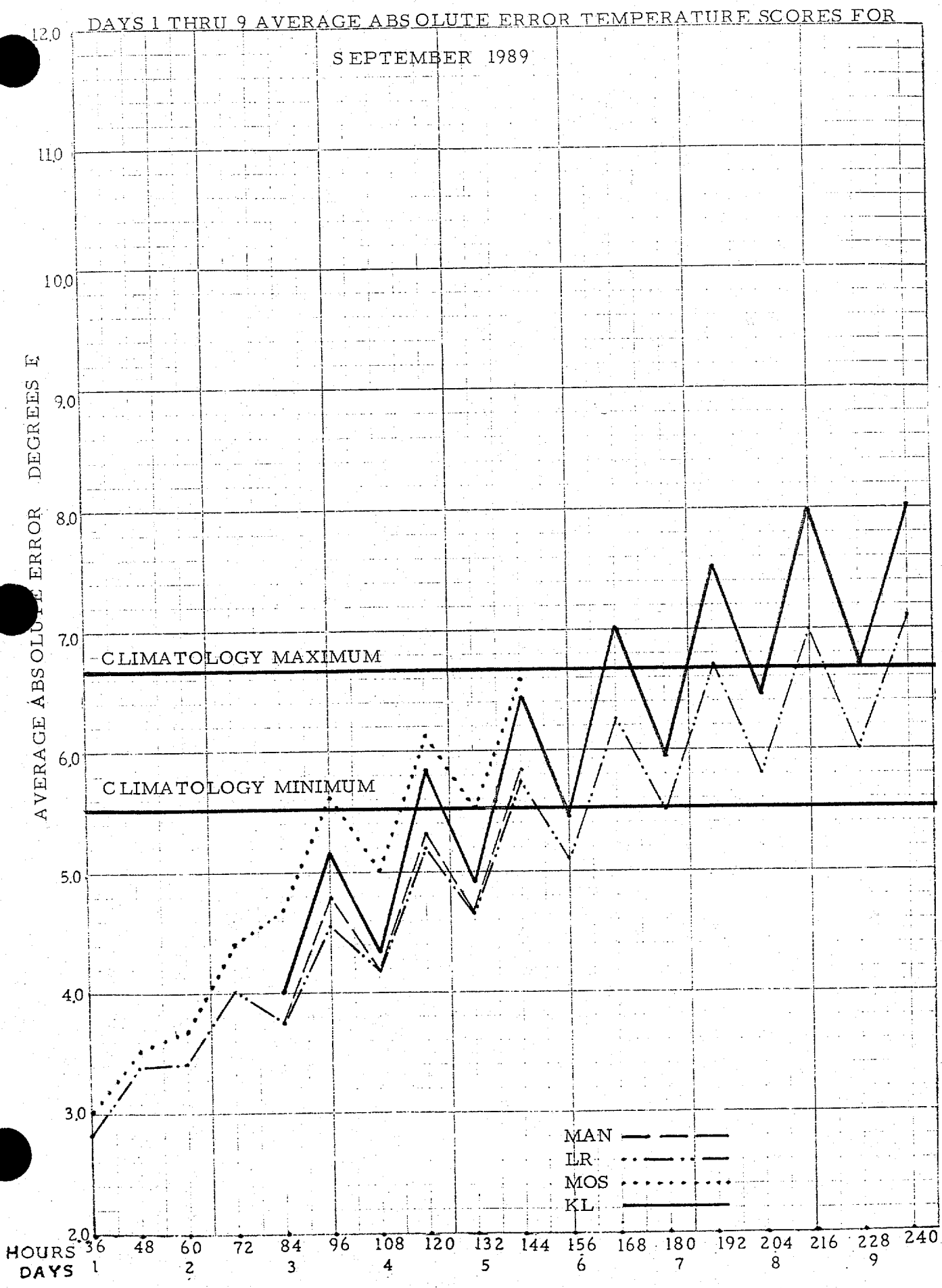

DAYS 1 THRU 9 AVERAGE ABSOLUTE ERROR TEMPERATURE SCORES FOR
SEPTEMBER 1989
AVERAGE ABSOLUTE ERROR DEGREES F
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
CLIMATOLOGY MAXIMUM
CLIMATOLOGY MINIMUM
MAN
LR
MOS
KL
HOURS 36 48 60 72 84 96 108 120 132 144 156 168 180 192 204 216 228 240
DAYS 1 2 3 4 5 6 7 8 9

Fig. 75

DAYS 1 THRU 9 AVERAGE ABSOLUTE ERROR TEMPERATURE SCORES FOR OCTOBER 1989

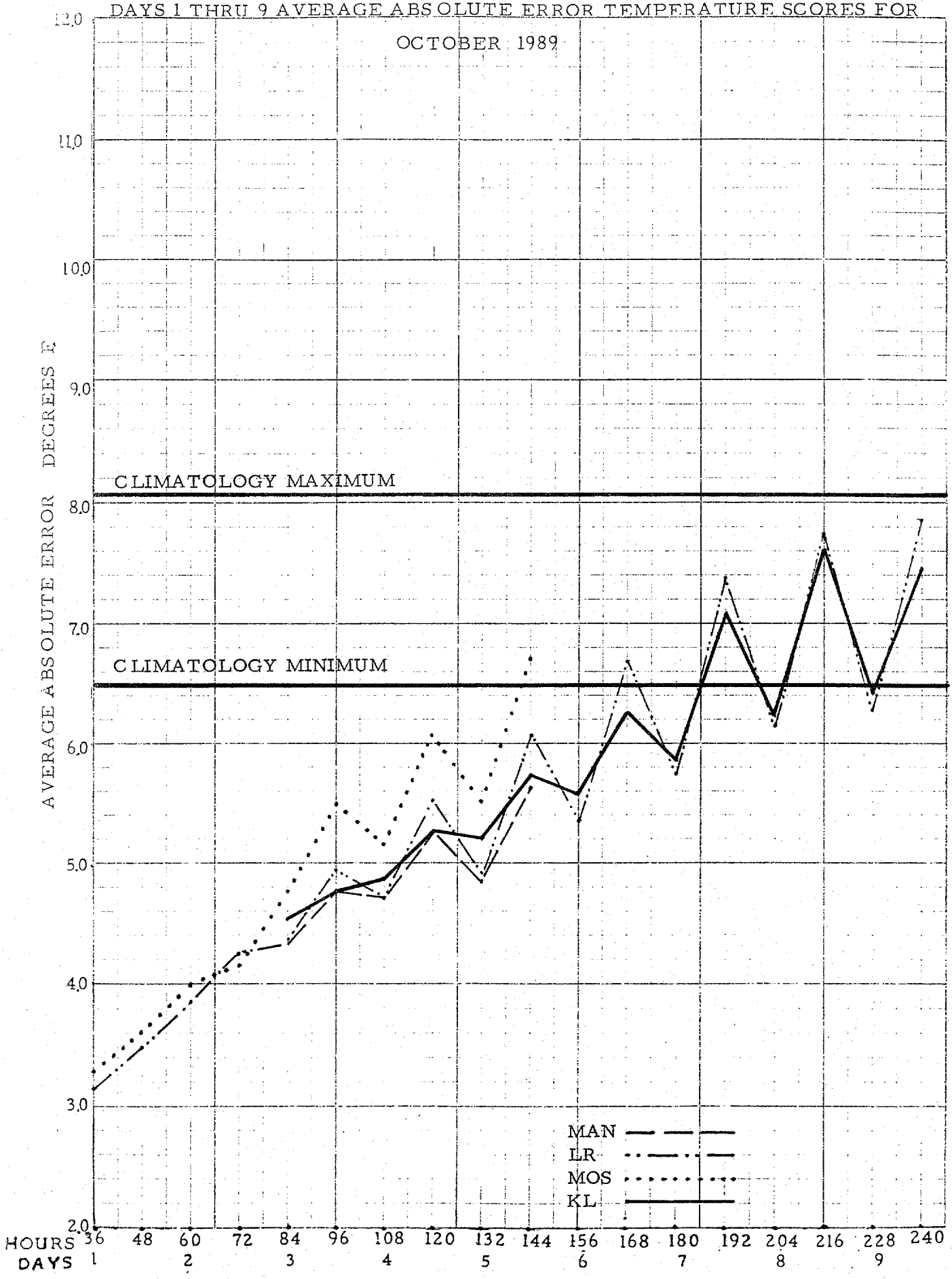


Fig. 76

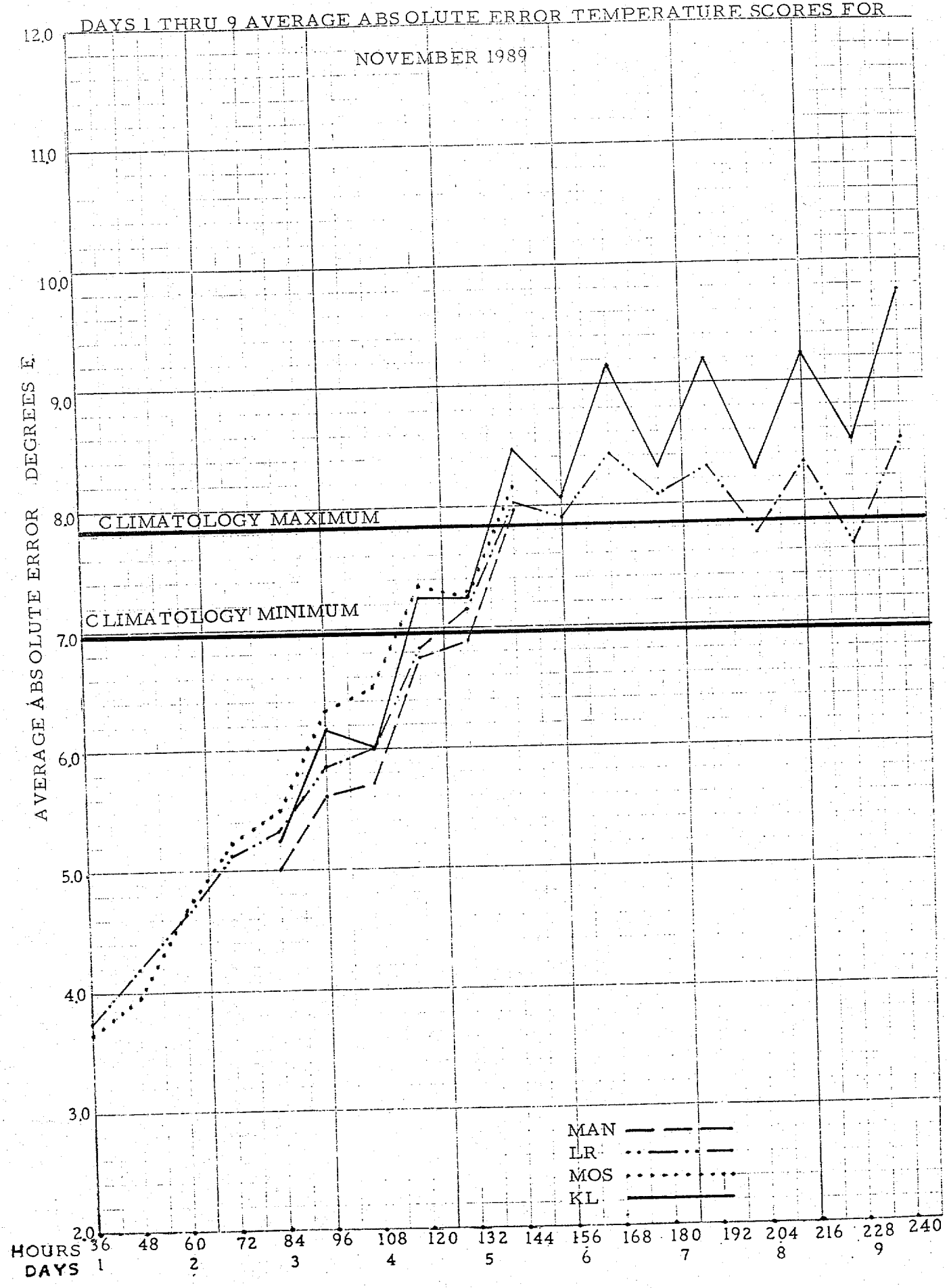

DAYS 1 THRU 9 AVERAGE ABSOLUTE ERROR TEMPERATURE SCORES FOR
NOVEMBER 1989
AVERAGE ABSOLUTE ERROR DEGREES F
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
CLIMATOLOGY MAXIMUM
CLIMATOLOGY MINIMUM
MAN
LR
MOS
KL
HOURS 36 48 60 72 84 96 108 120 132 144 156 168 180 192 204 216 228 240
DAYS 1 2 3 4 5 6 7 8 9

Fig. 78

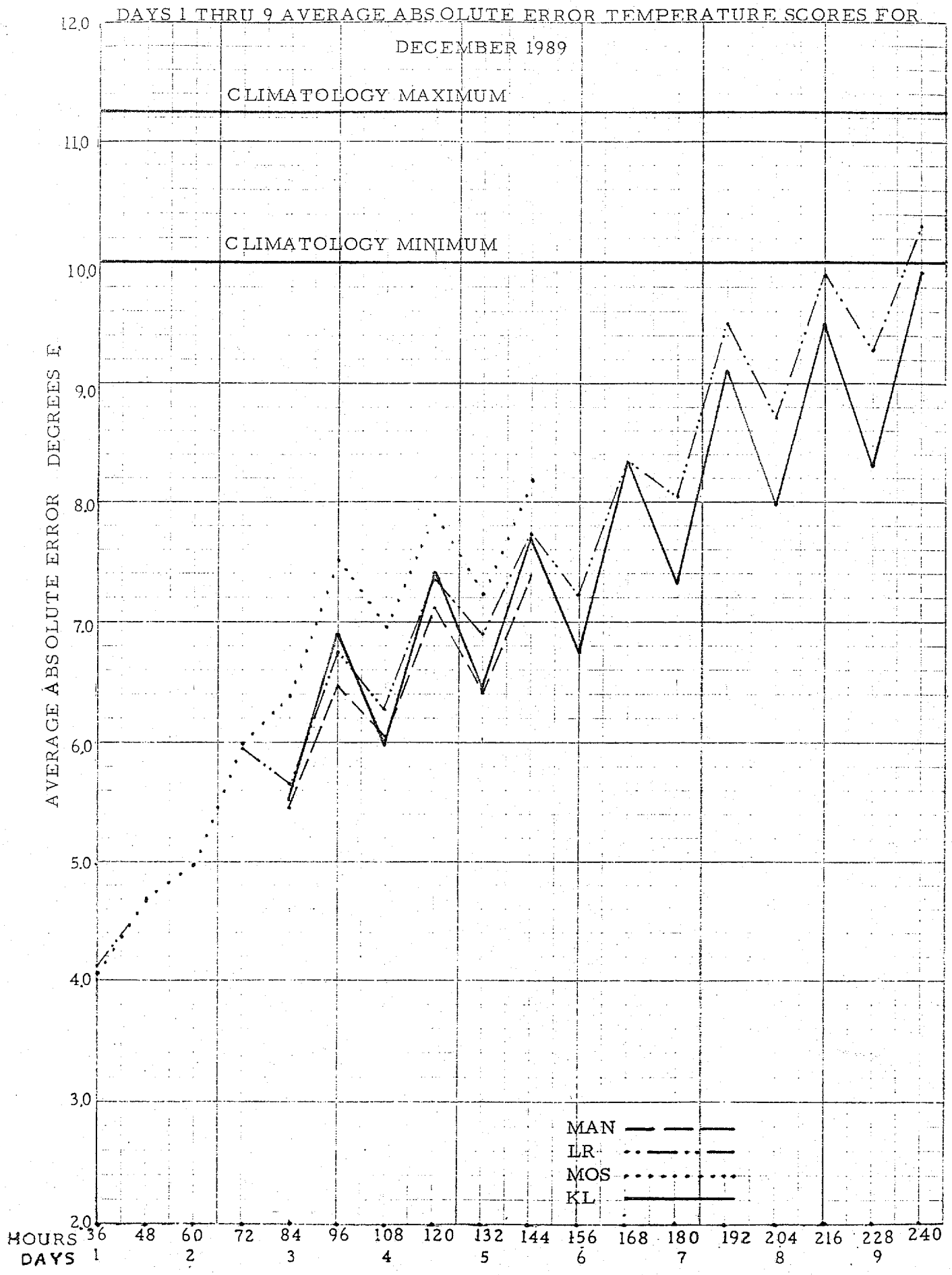

DAYS 1 THRU 9 AVERAGE ABSOLUTE ERROR TEMPERATURE SCORES FOR
DECEMBER 1989
CLIMATOLOGY MAXIMUM
CLIMATOLOGY MINIMUM
AVERAGE ABSOLUTE ERROR DEGREES F
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
MAN
LR
MOS
KL
HOURS 36 48 60 72 84 96 108 120 132 144 156 168 180 192 204 216 228 240
DAYS 1 2 3 4 5 6 7 8 9

Fig. 78

OFFICIAL DAYS 3 AND 5 CALENDAR YEAR AVERAGE
MINIMUM TEMPERATURE ABSOLUTE ERROR SCORES

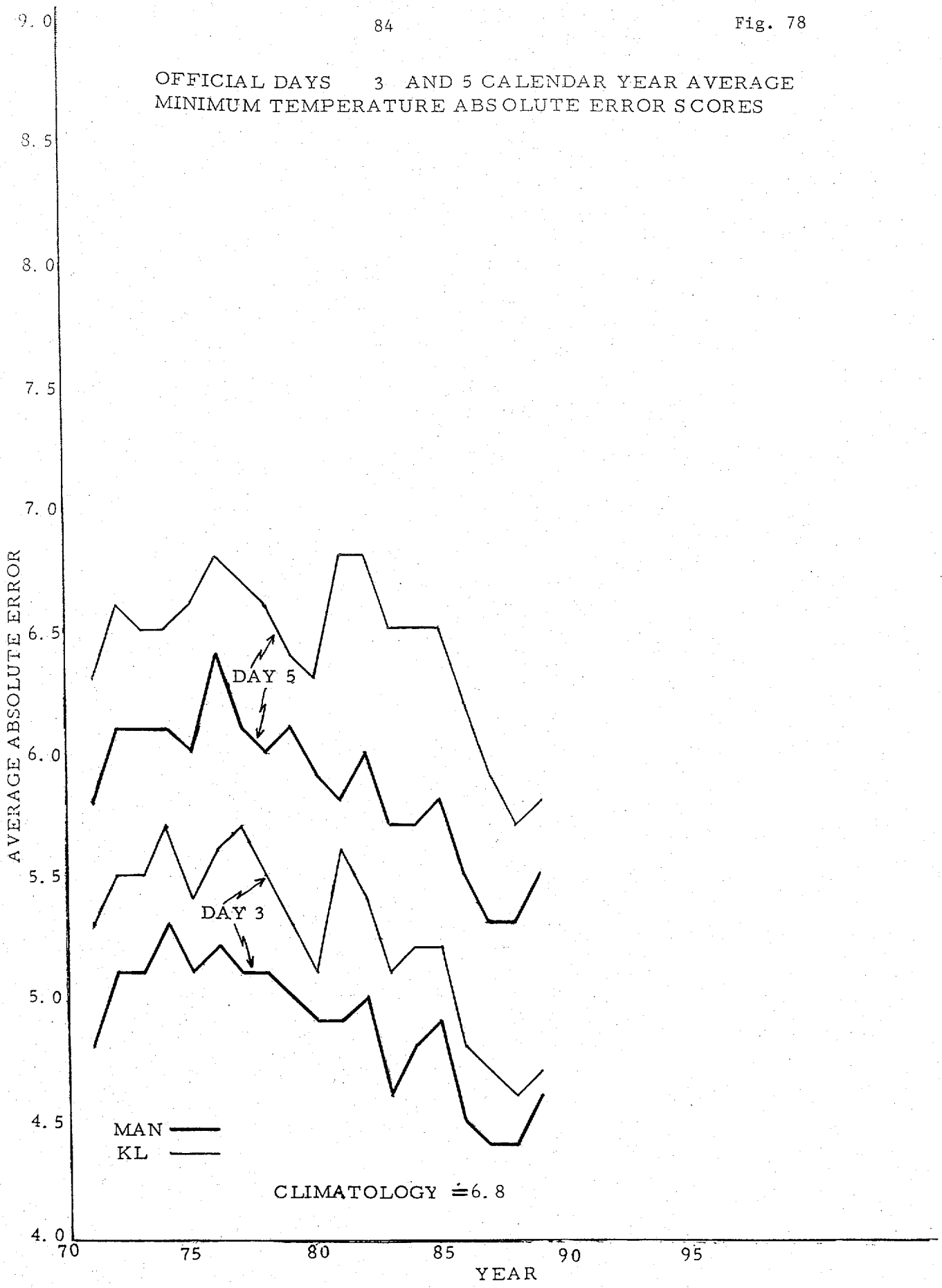


Fig. 79

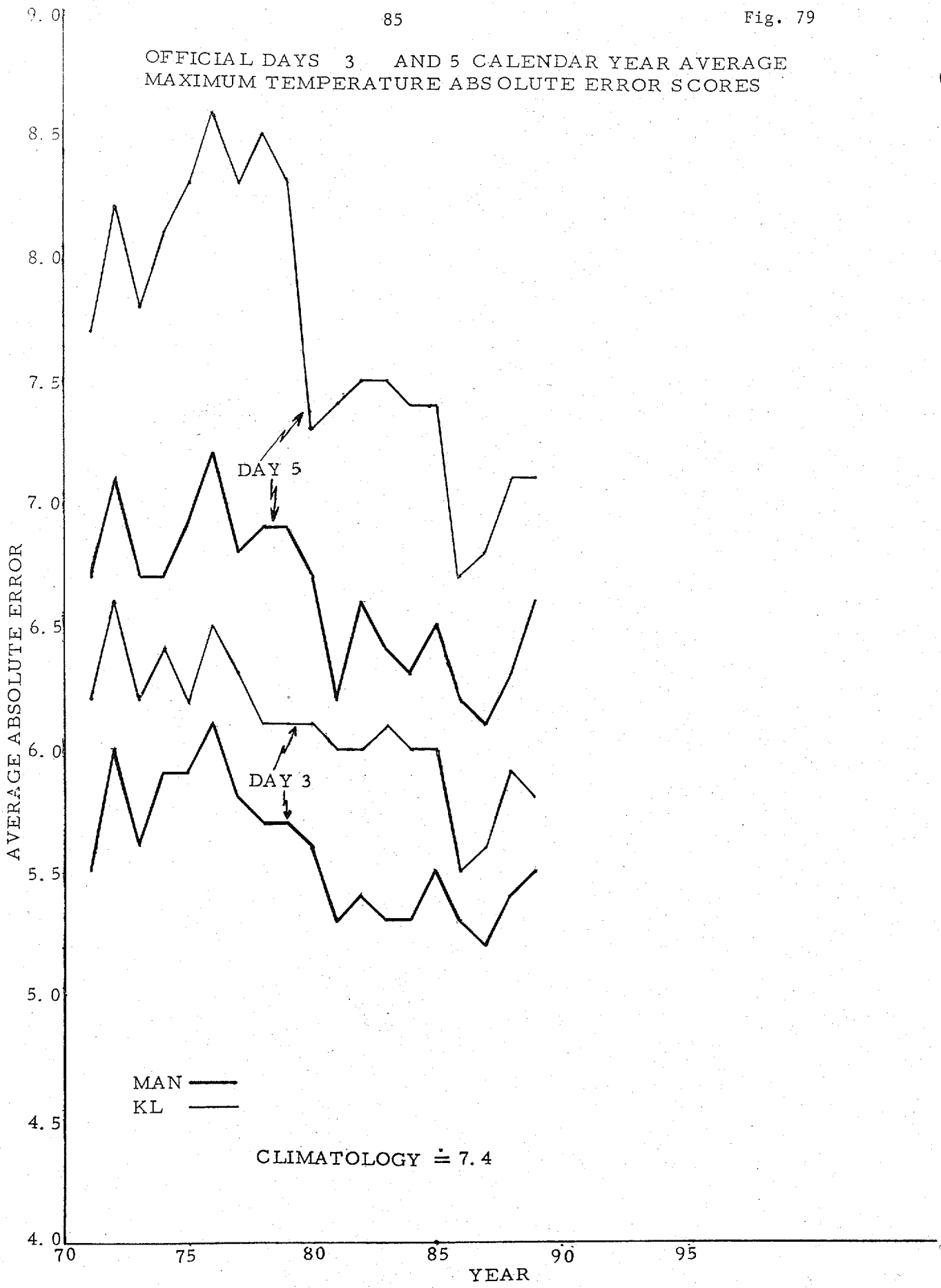

OFFICIAL DAYS 3 AND 5 CALENDAR YEAR AVERAGE
MAXIMUM TEMPERATURE ABSOLUTE ERROR SCORES
AVERAGE ABSOLUTE ERROR
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
DAY 5
DAY 3
MAN
KL
CLIMATOLOGY ≐ 7.4
70
75
80
85
90
95
YEAR

Fig. 80

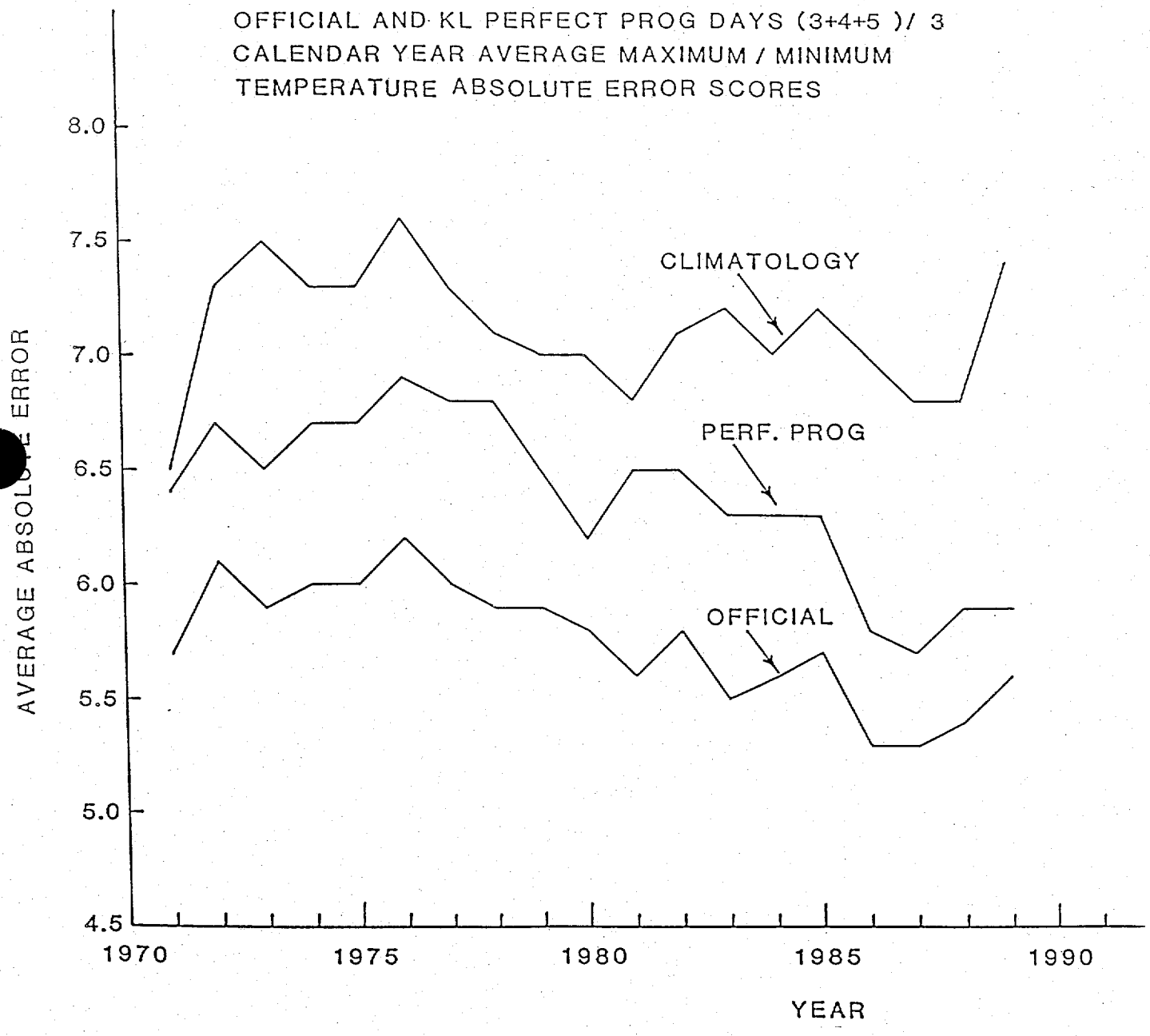
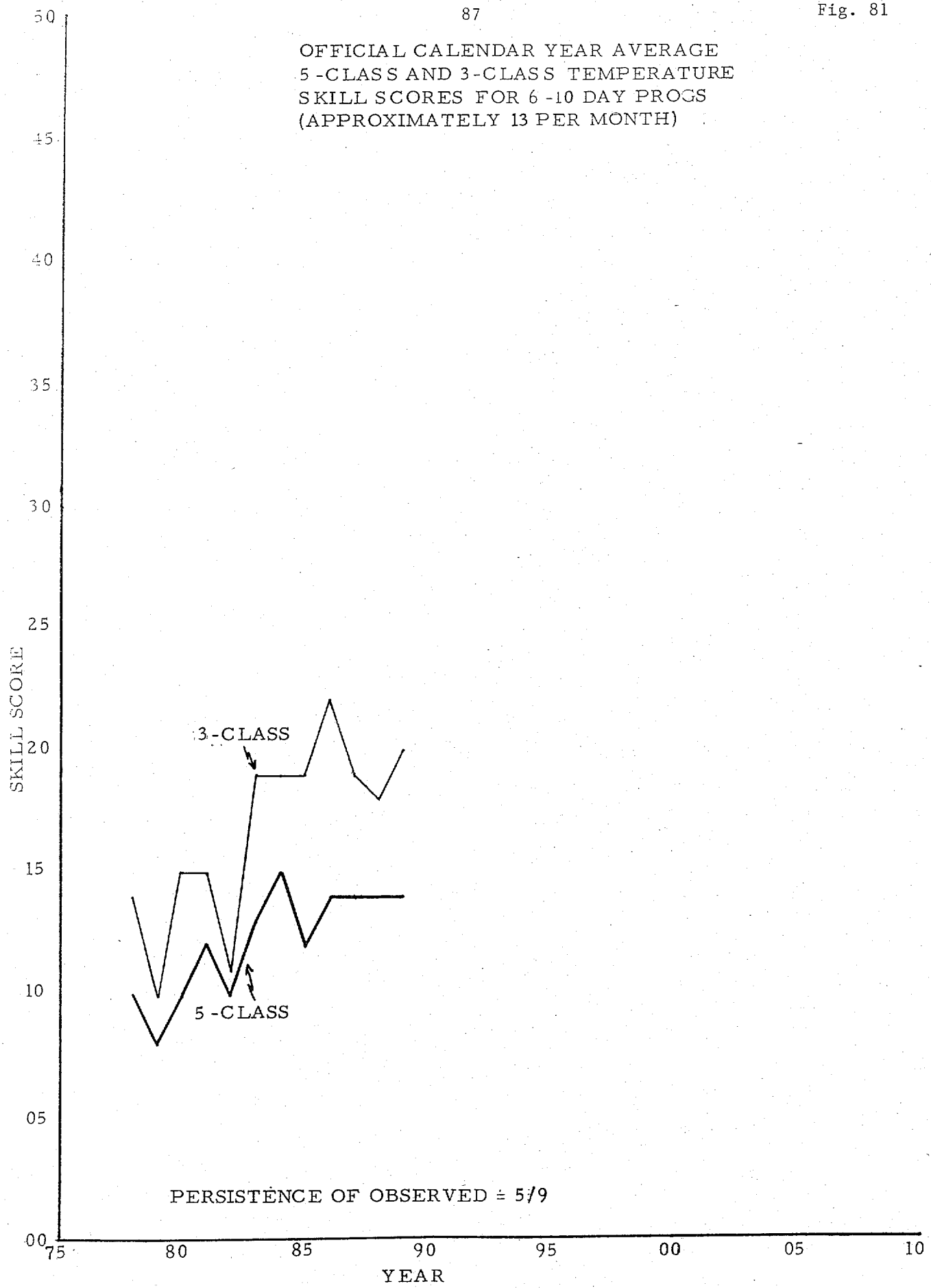

OFFICIAL AND KL PERFECT PROG DAYS (3+4+5)/ 3
CALENDAR YEAR AVERAGE MAXIMUM / MINIMUM
TEMPERATURE ABSOLUTE ERROR SCORES
AVERAGE ABSOLUTE ERROR
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
CLIMATOLOGY
PERF. PROG
OFFICIAL
1970
1975
1980
1985
1990
YEAR

Fig. 81

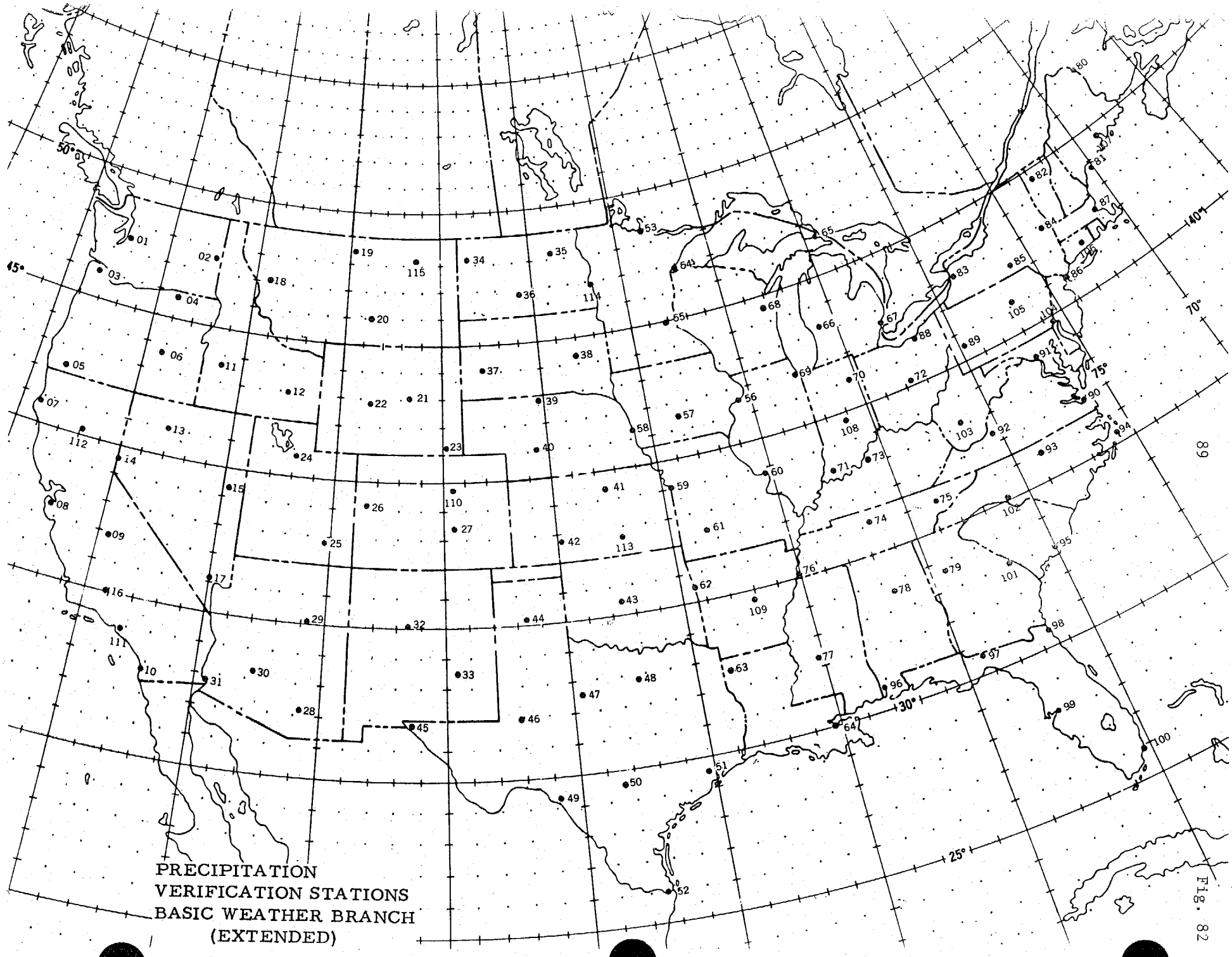
OFFICIAL CALENDAR YEAR AVERAGE
5-CLASS AND 3-CLASS TEMPERATURE
SKILL SCORES FOR 6-10 DAY PROGS
(APPROXIMATELY 13 PER MONTH)



SECTION 3

Man and Machine (NMC/NWP Model Guidance)

Precipitation Skill Scores



PRECIPITATION
VERIFICATION STATIONS
BASIC WEATHER BRANCH
(EXTENDED)

Fig. 82

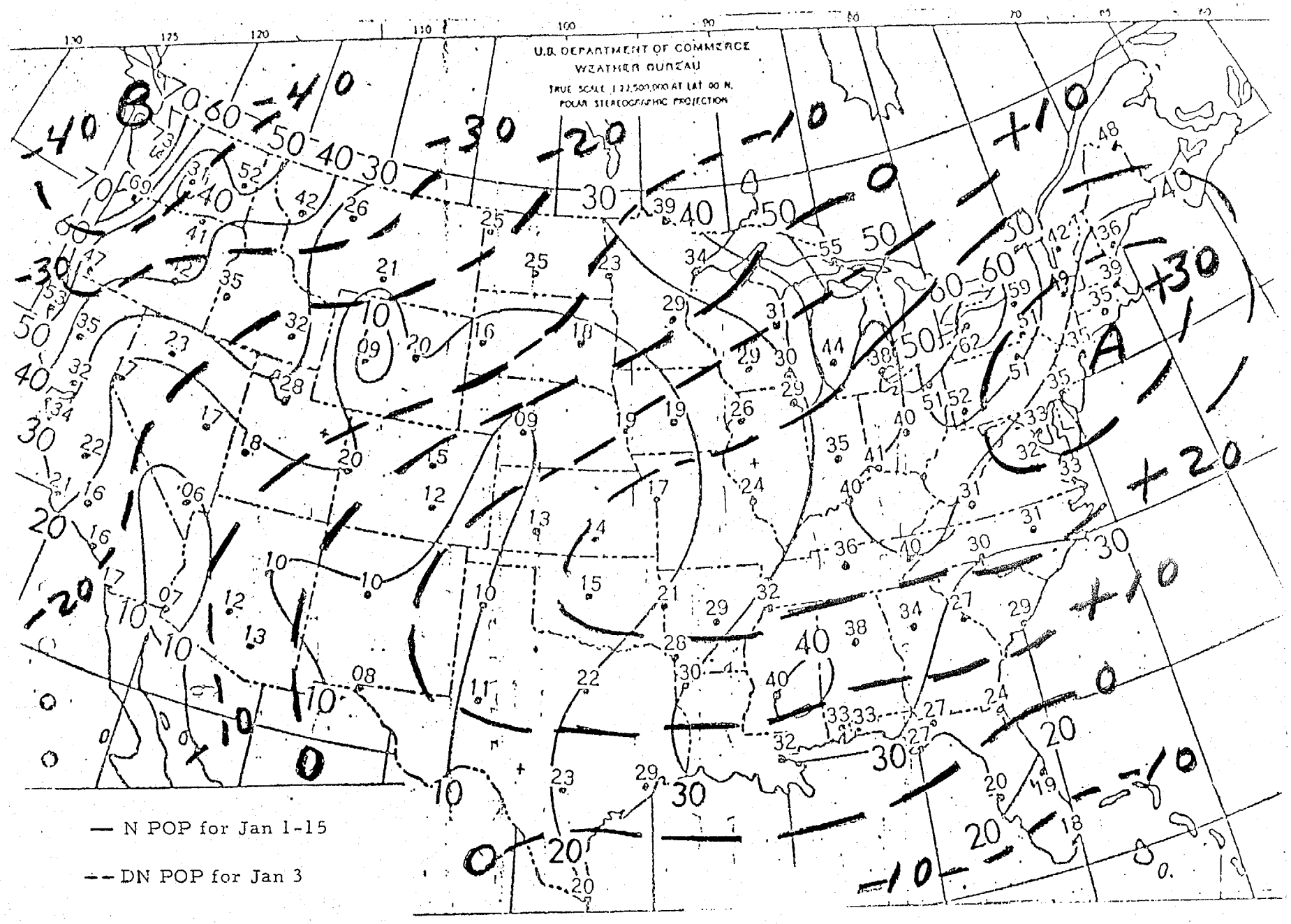
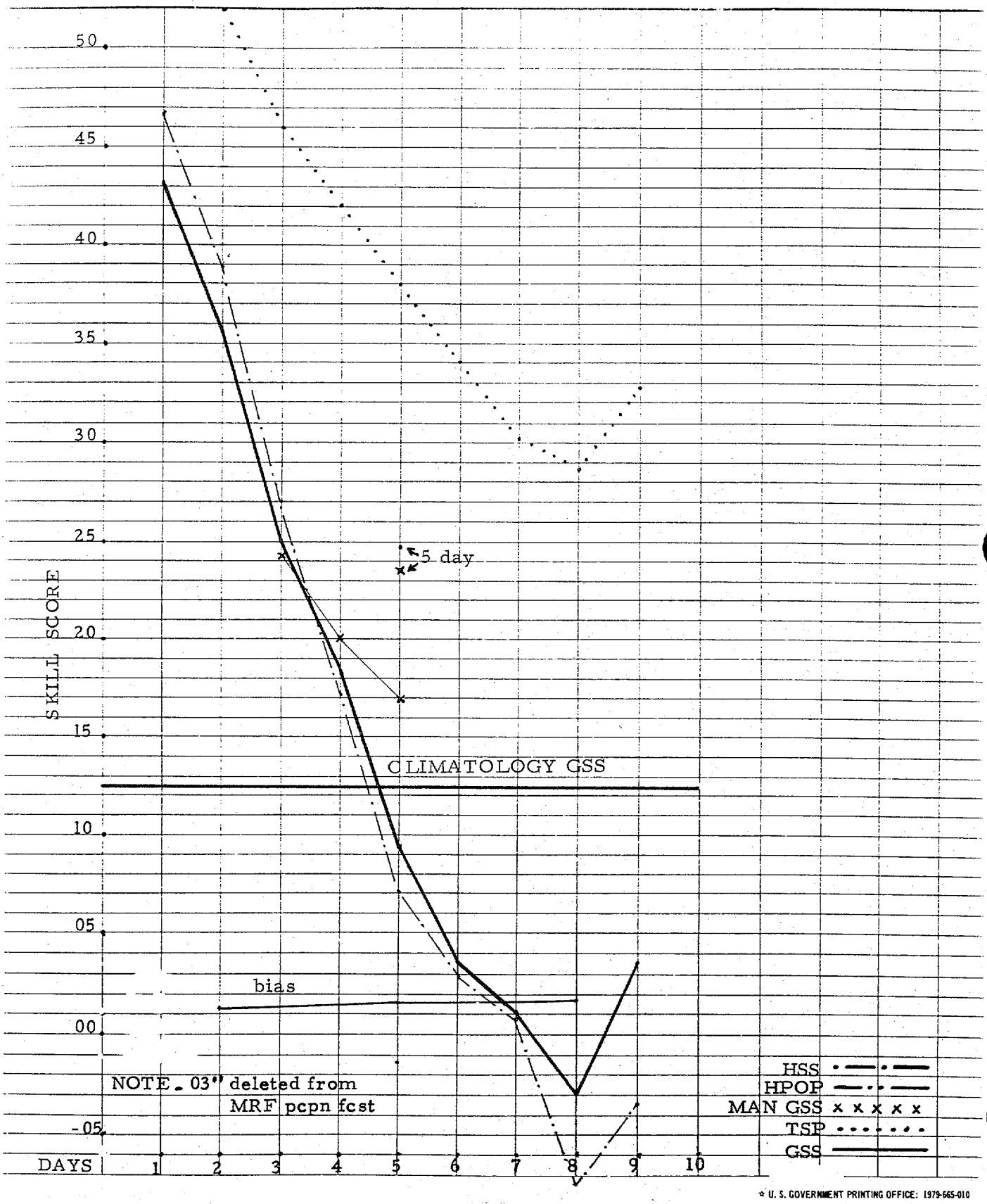

U.S. DEPARTMENT OF COMMERCE
WEATHER BUREAU
TRUE SCALE 1:22,500,000 AT LAT 60 N.
POLAR STEREOGRAPHIC PROJECTION
— N POP for Jan 1-15
-- DN POP for Jan 3

Fig. 83

NOAA FORM 59-4
2-72

DAYS 1 THRU 9 100 STATION UNITED STATES AREA PRECIPITATION
SKILL SCORES FOR JAN 1989

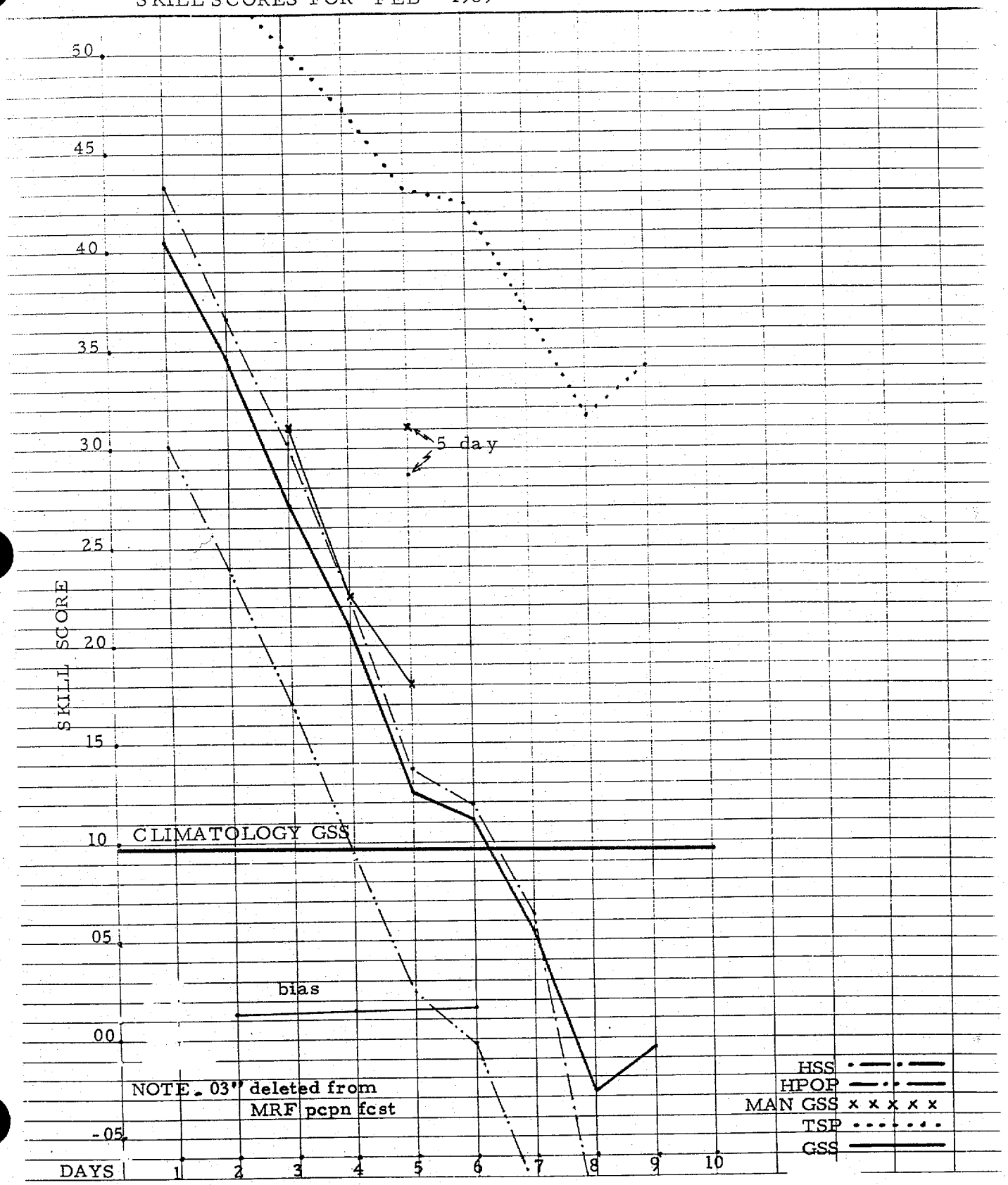


☆ U. S. GOVERNMENT PRINTING OFFICE: 1979-665-010

Fig. 85

NOAA FORM 59-4

DAYS 1 THRU 9 100 STATION UNITED STATES AREA PRECIPITATION
SKILL SCORES FOR FEB 1989



☆ U. S. GOVERNMENT PRINTING OFFICE: 1979-665-010

DAYS 1 THRU 9 100 STATION UNITED STATES AREA PRECIPITATION
SKILL SCORES FOR MAR 1989

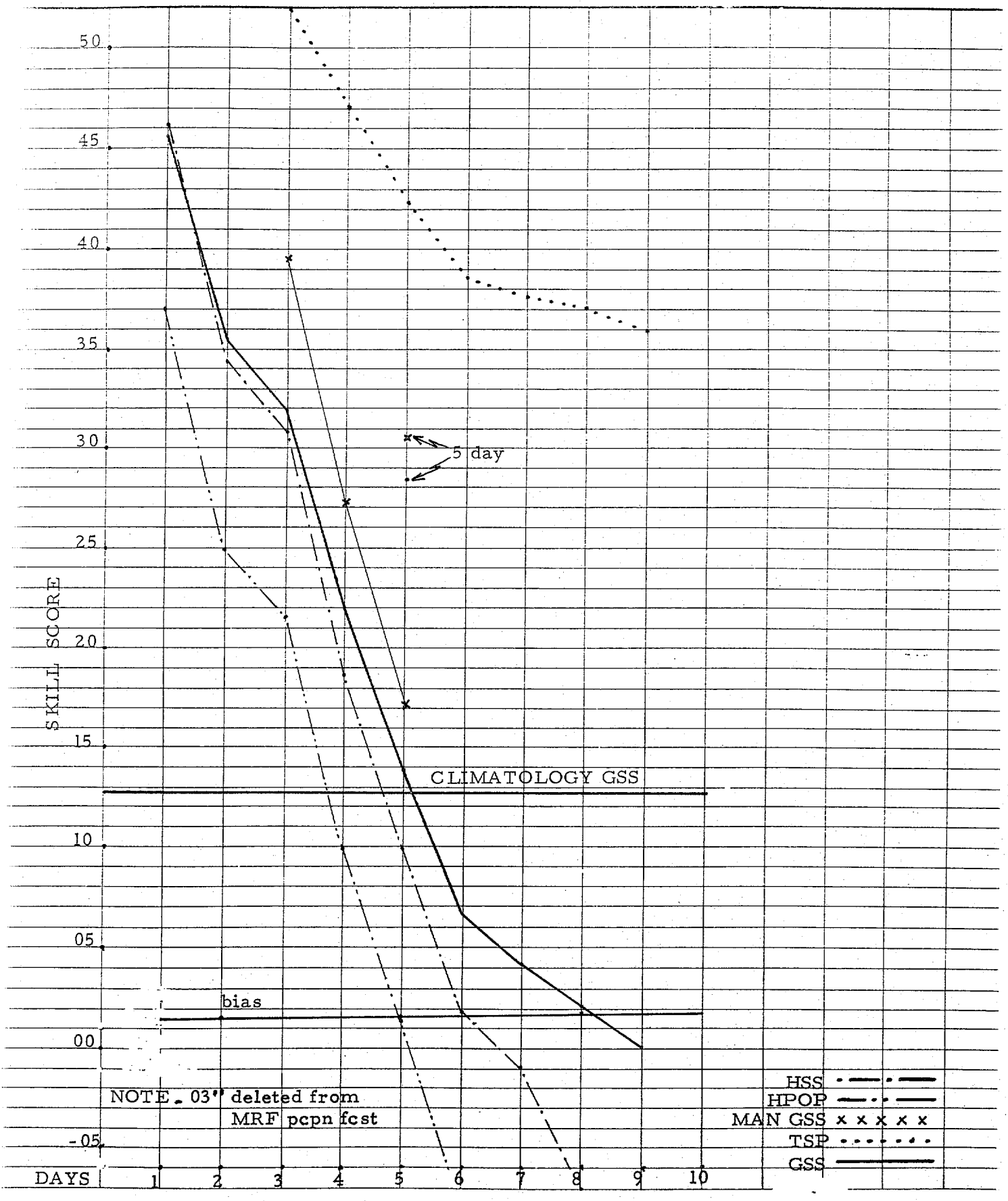
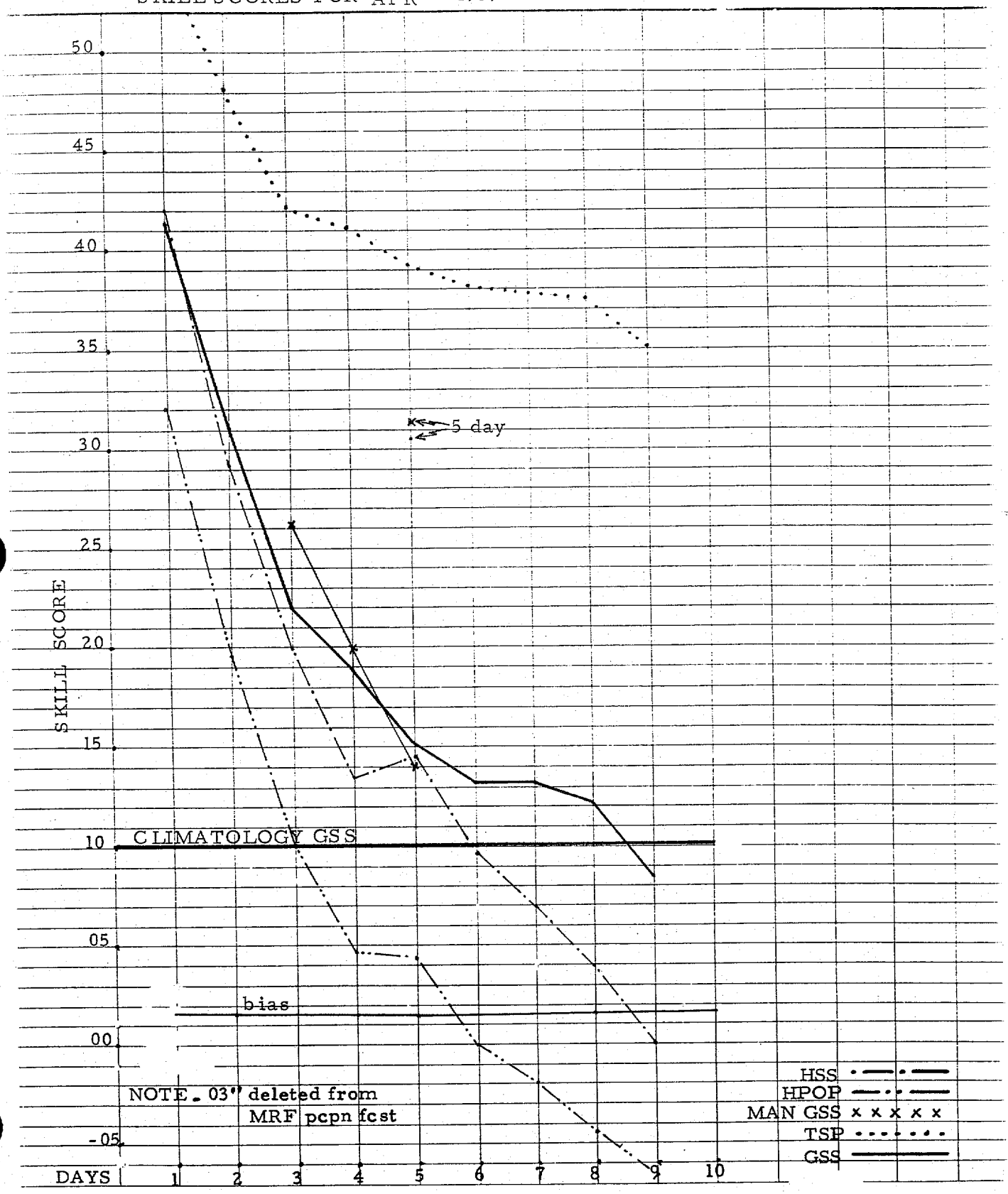


Fig. 87

NOAA FORM 59-4

DAYS 1 THRU 9 100 STATION UNITED STATES AREA PRECIPITATION
SKILL SCORES FOR APR 1989

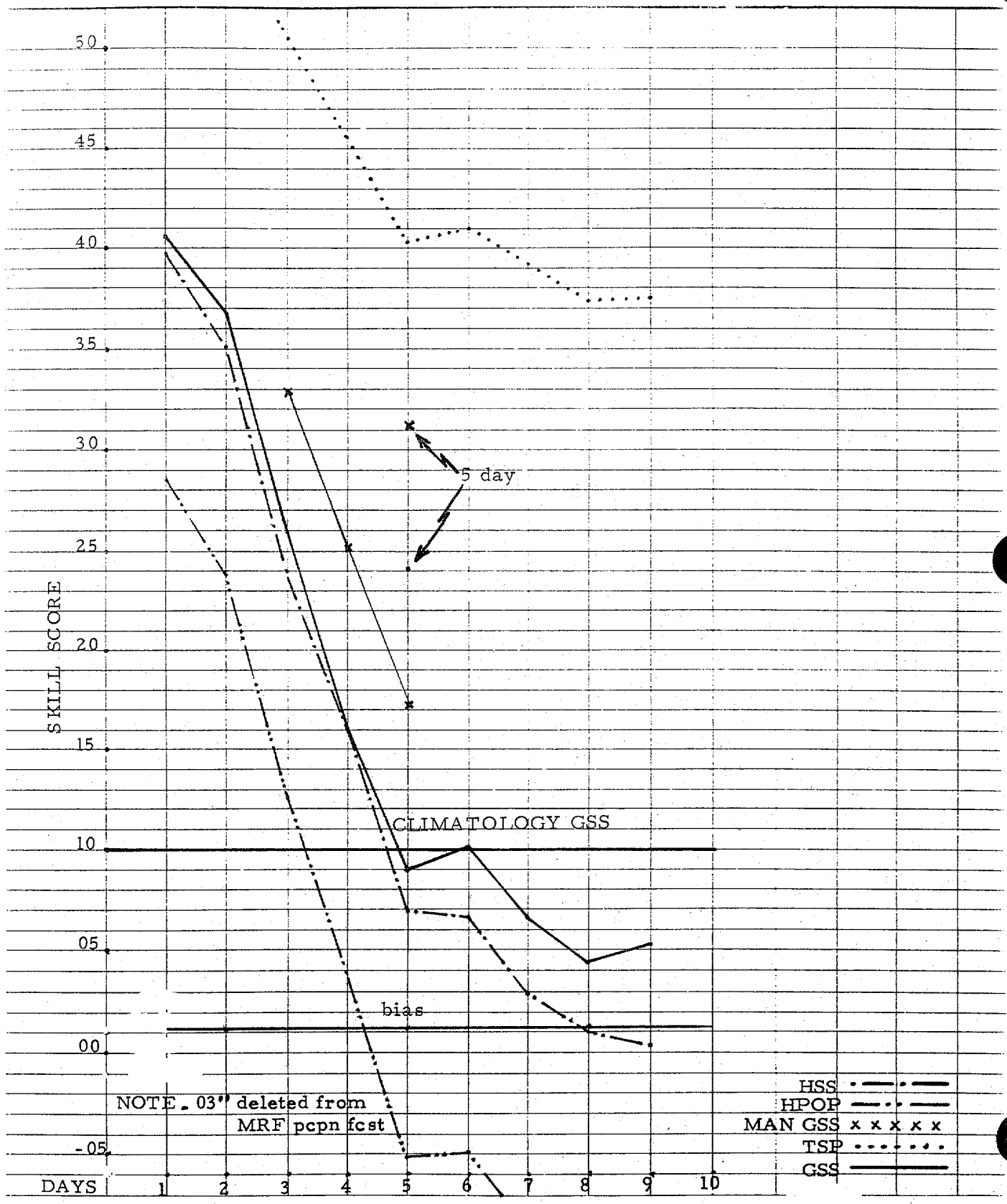


☆ U. S. GOVERNMENT PRINTING OFFICE: 1979-665-016

Fig. 88

NOAA FORM 59-4 -72

DAYS 1 THRU 9 100 STATION UNITED STATES AREA PRECIPITATION SKILL SCORES FOR MAY 1989

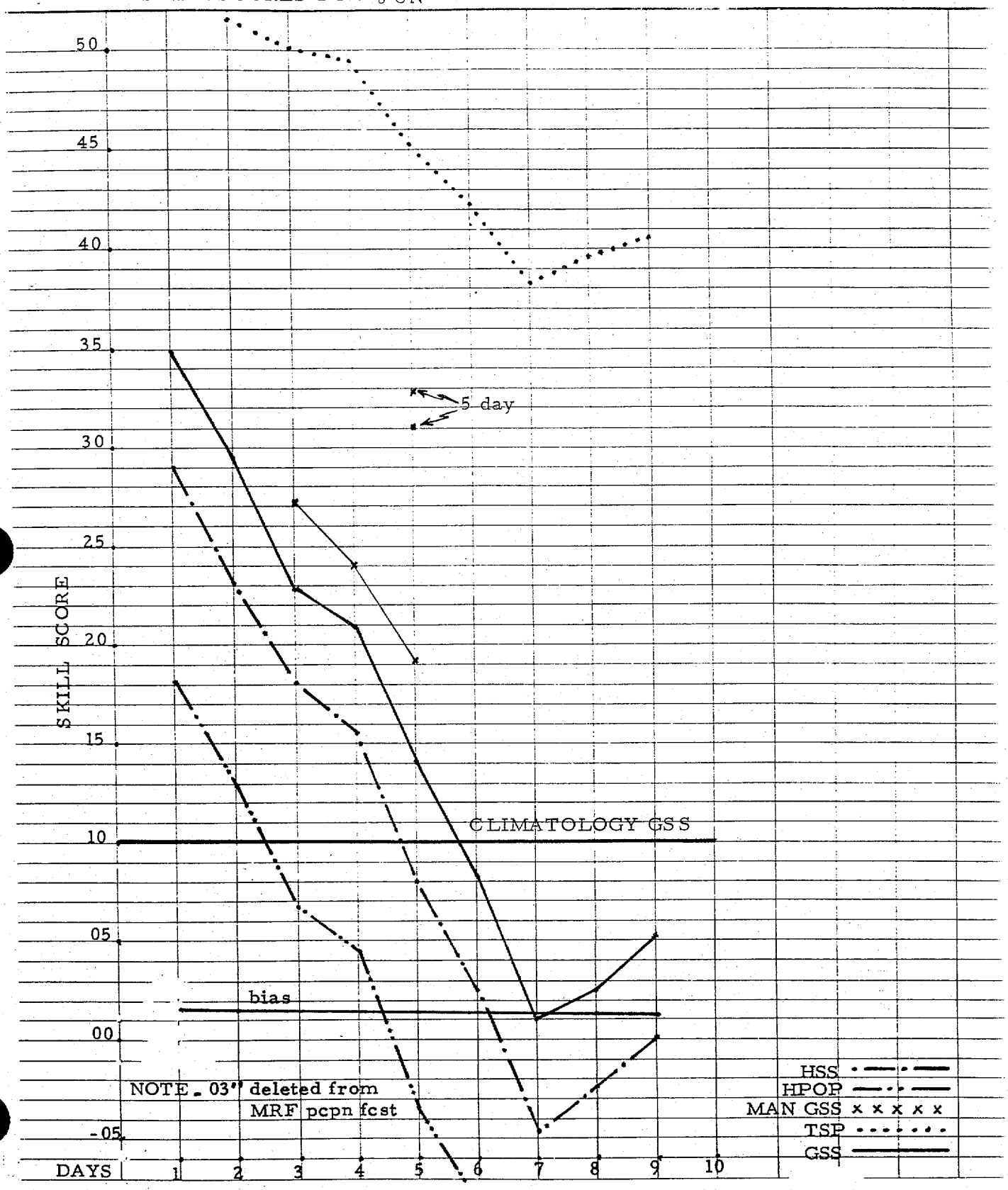


☆ U.S. GOVERNMENT PRINTING OFFICE: 1979-665-010

Fig. 89

NOAA FORM 59-4
2-72

DAYS 1 THRU 9 100 STATION UNITED STATES AREA PRECIPITATION
SKILL SCORES FOR JUN 1989

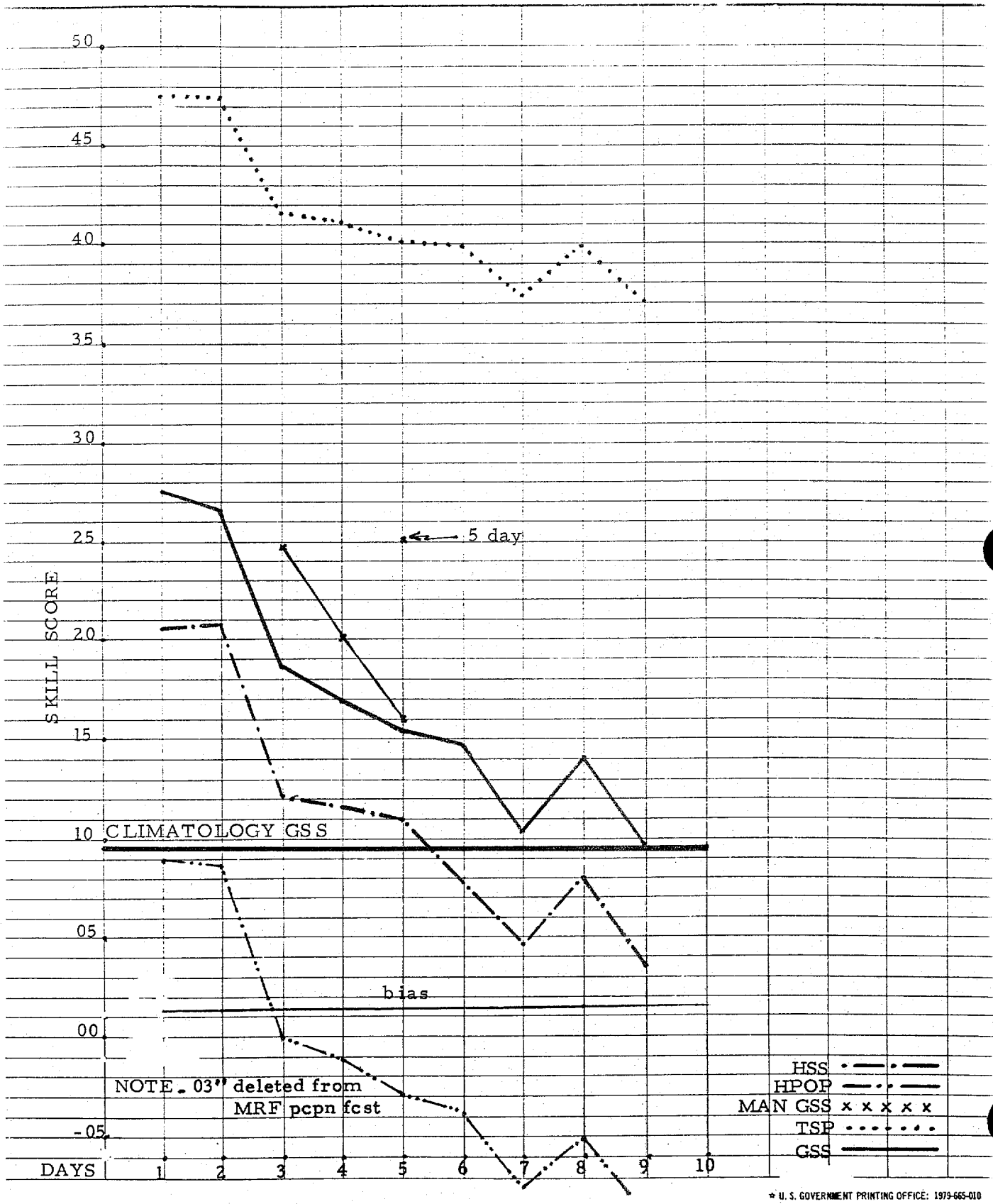


☆ U. S. GOVERNMENT PRINTING OFFICE: 1979-665-010

Fig. 90

NOAA FORM 59-4

DAYS 1 THRU 9 100 STATION UNITED STATES AREA PRECIPITATION
SKILL SCORES FOR JUL 1989

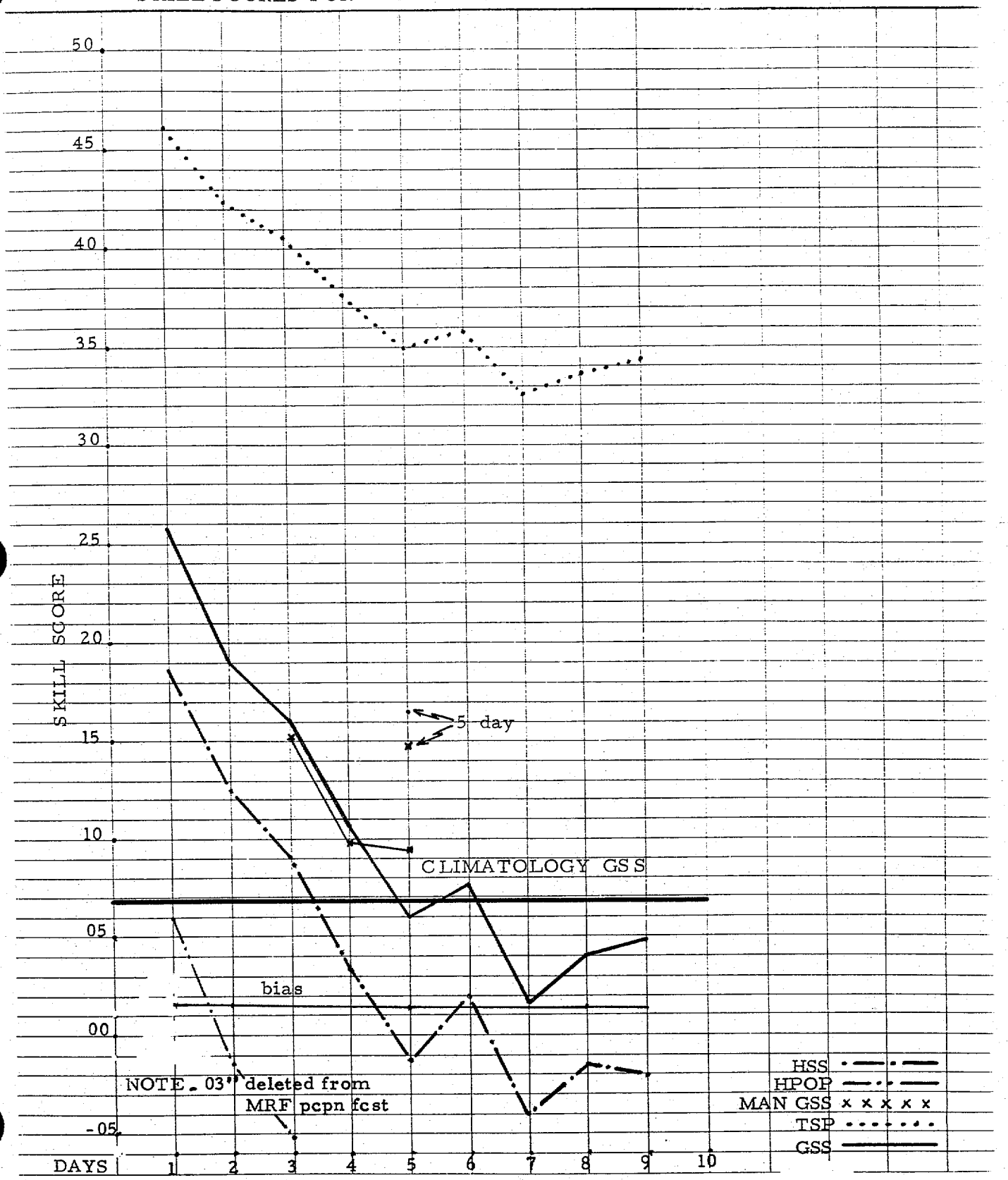


☆ U. S. GOVERNMENT PRINTING OFFICE: 1979-665-010

Fig. 91

NOAA FORM 59-4 (2-72)

DAYS 1 THRU 9 100 STATION UNITED STATES AREA PRECIPITATION SKILL SCORES FOR AUG 1989

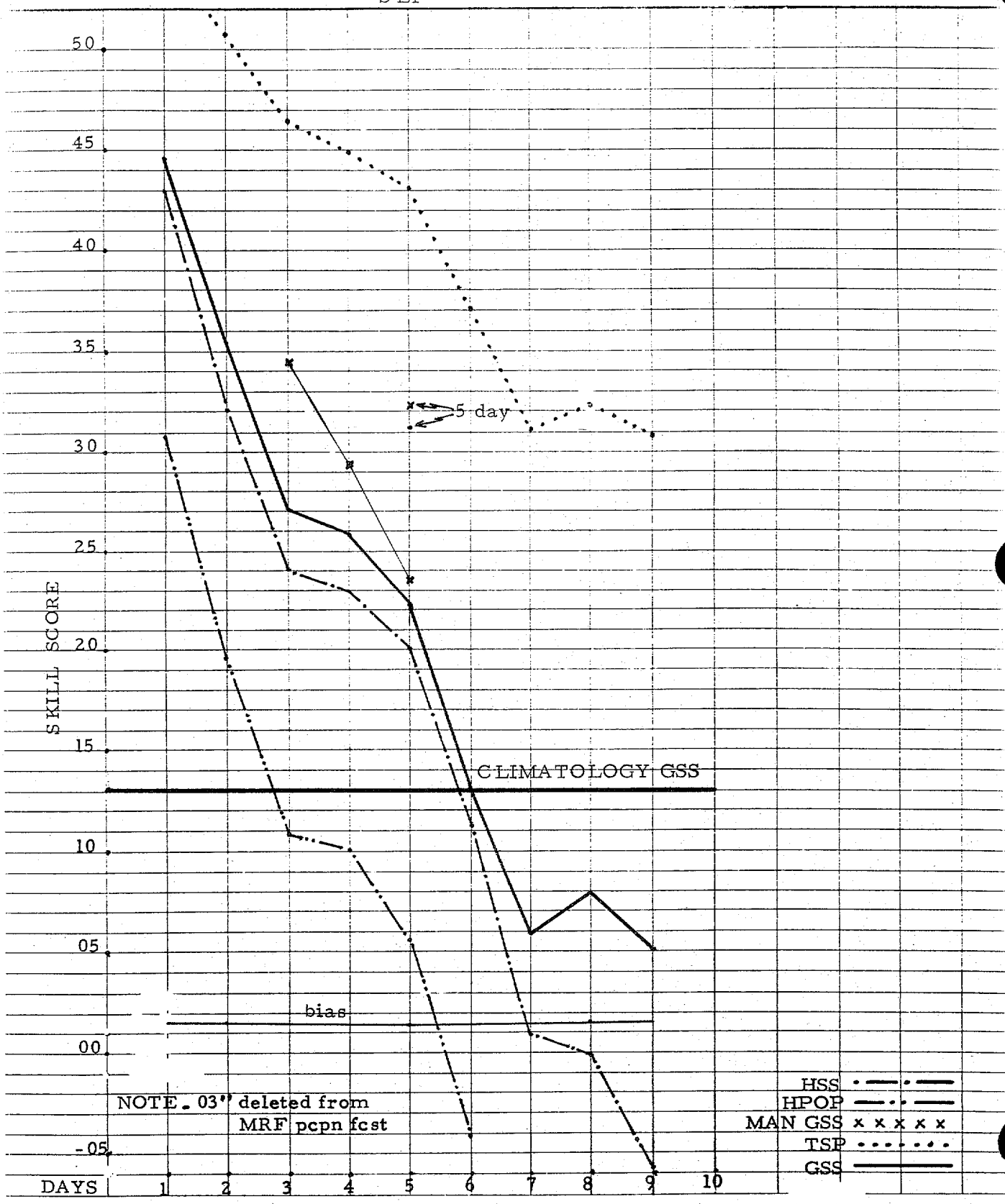


☆ U. S. GOVERNMENT PRINTING OFFICE: 1979-665-010

Fig. 92

NOAA FORM 59-4

DAYS 1 THRU 9 100 STATION UNITED STATES AREA PRECIPITATION
SKILL SCORES FOR SEP 1989

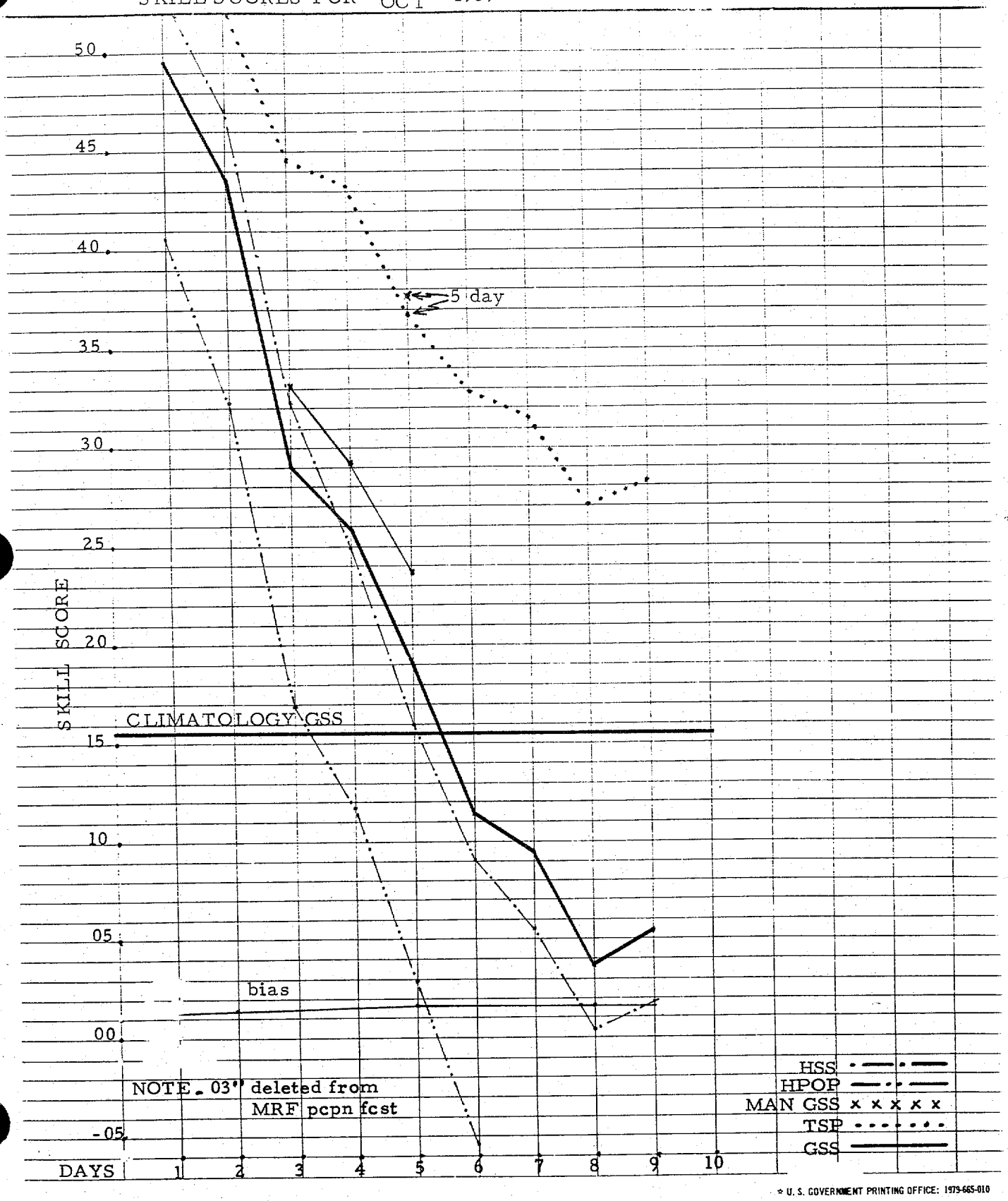


* U. S. GOVERNMENT PRINTING OFFICE: 1979-665-010

Fig. 93

NOAA FORM 59-4
(2-72)

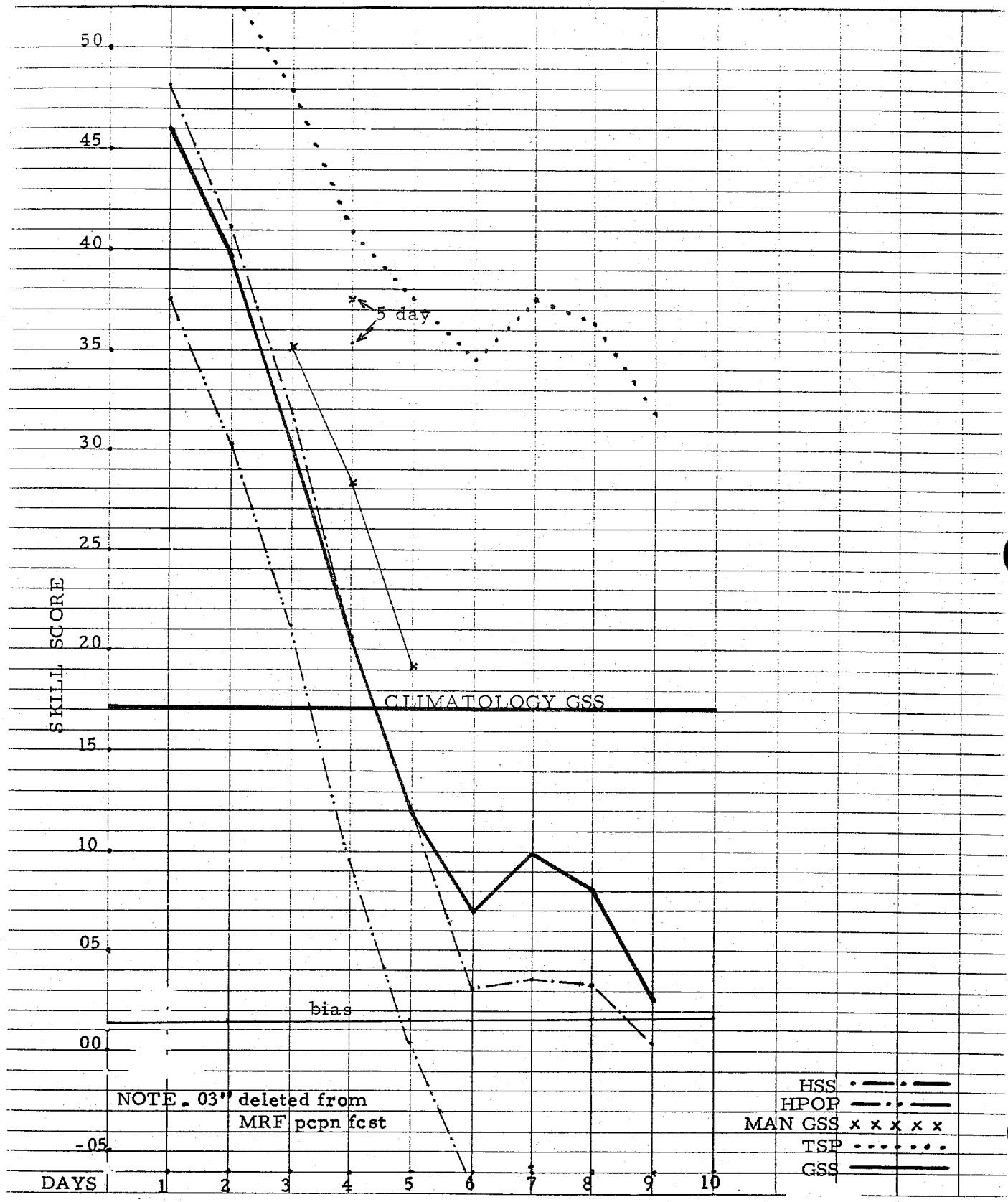
DAYS 1 THRU 9 100 STATION UNITED STATES AREA PRECIPITATION
SKILL SCORES FOR OCT 1989



☆ U. S. GOVERNMENT PRINTING OFFICE: 1979-665-010

NOAA FORM 59-4 (-721)

DAYS 1 THRU 9 100 STATION UNITED STATES AREA PRECIPITATION
SKILL SCORES FOR NOV 1989

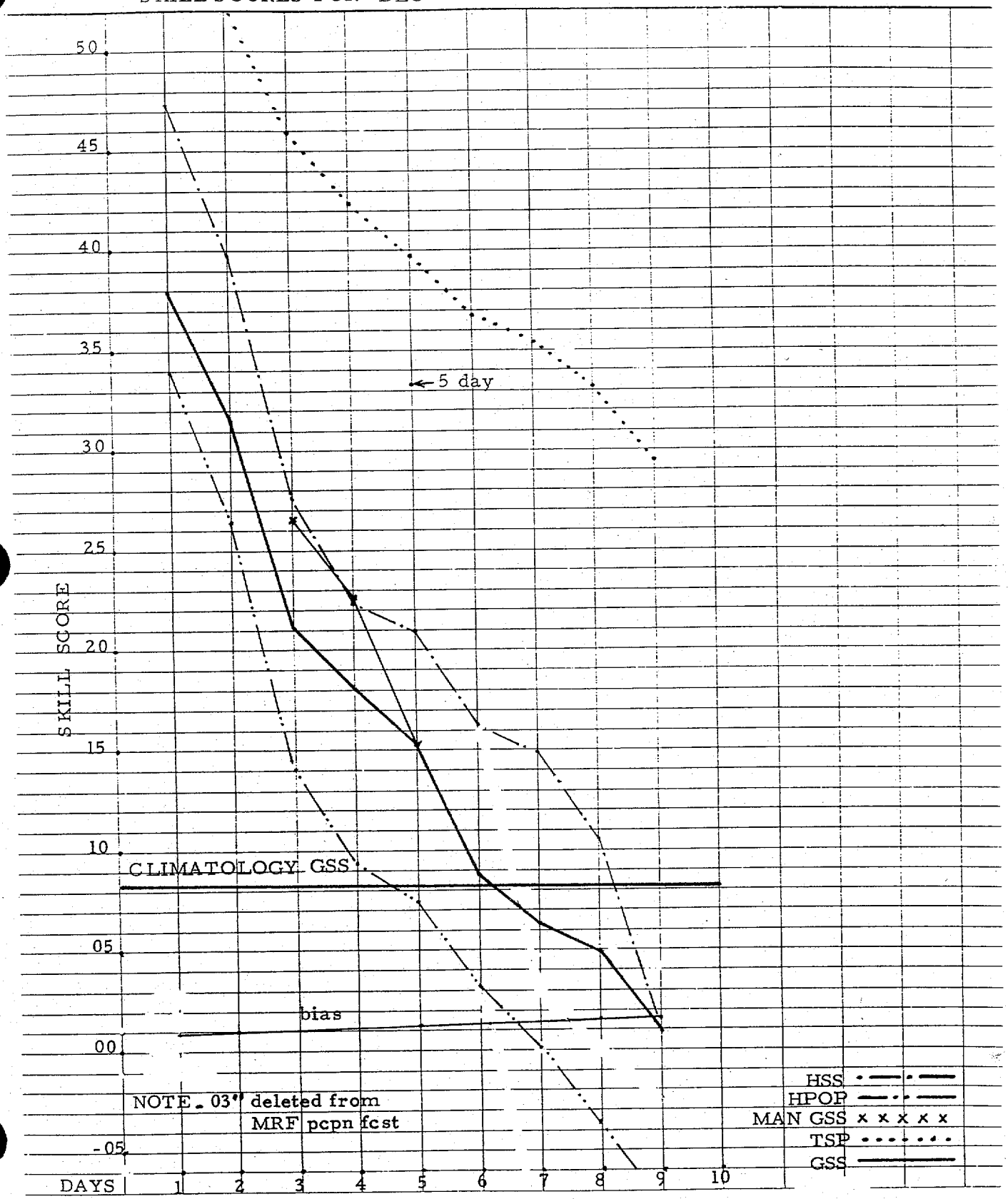


☆ U. S. GOVERNMENT PRINTING OFFICE: 1979-665-010

Fig. 95

NOAA FORM 59-4 (2-72)

DAYS 1 THRU 9 100 STATION UNITED STATES AREA PRECIPITATION SKILL SCORES FOR DEC 1989



☆ U. S. GOVERNMENT PRINTING OFFICE: 1979-665-010

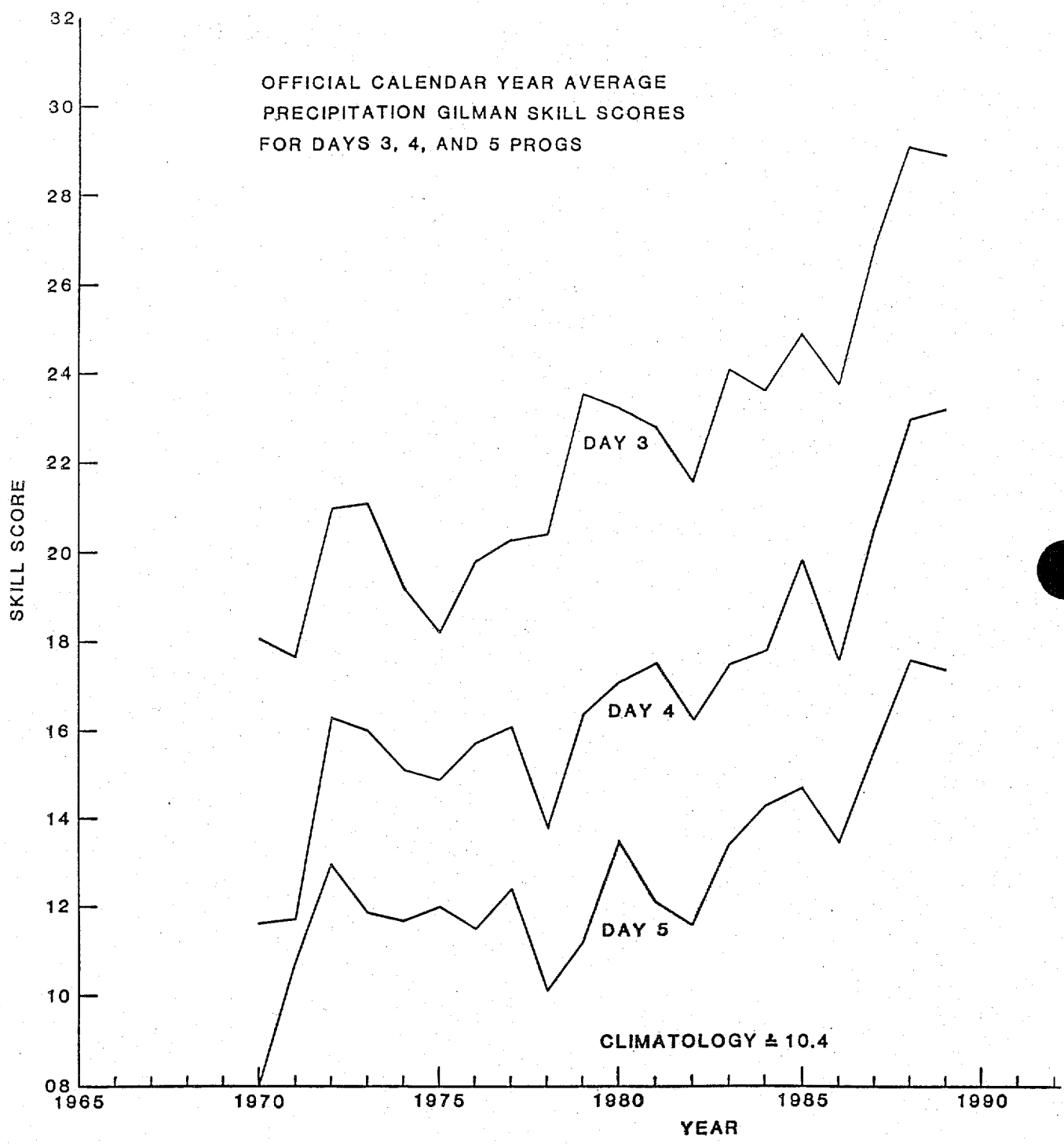

OFFICIAL CALENDAR YEAR AVERAGE
PRECIPITATION GILMAN SKILL SCORES
FOR DAYS 3, 4, AND 5 PROGS
SKILL SCORE
32
30
28
26
24
22
20
18
16
14
12
10
08
1965
1970
1975
1980
1985
1990
YEAR
DAY 3
DAY 4
DAY 5
CLIMATOLOGY ≙ 10.4

Fig. 97

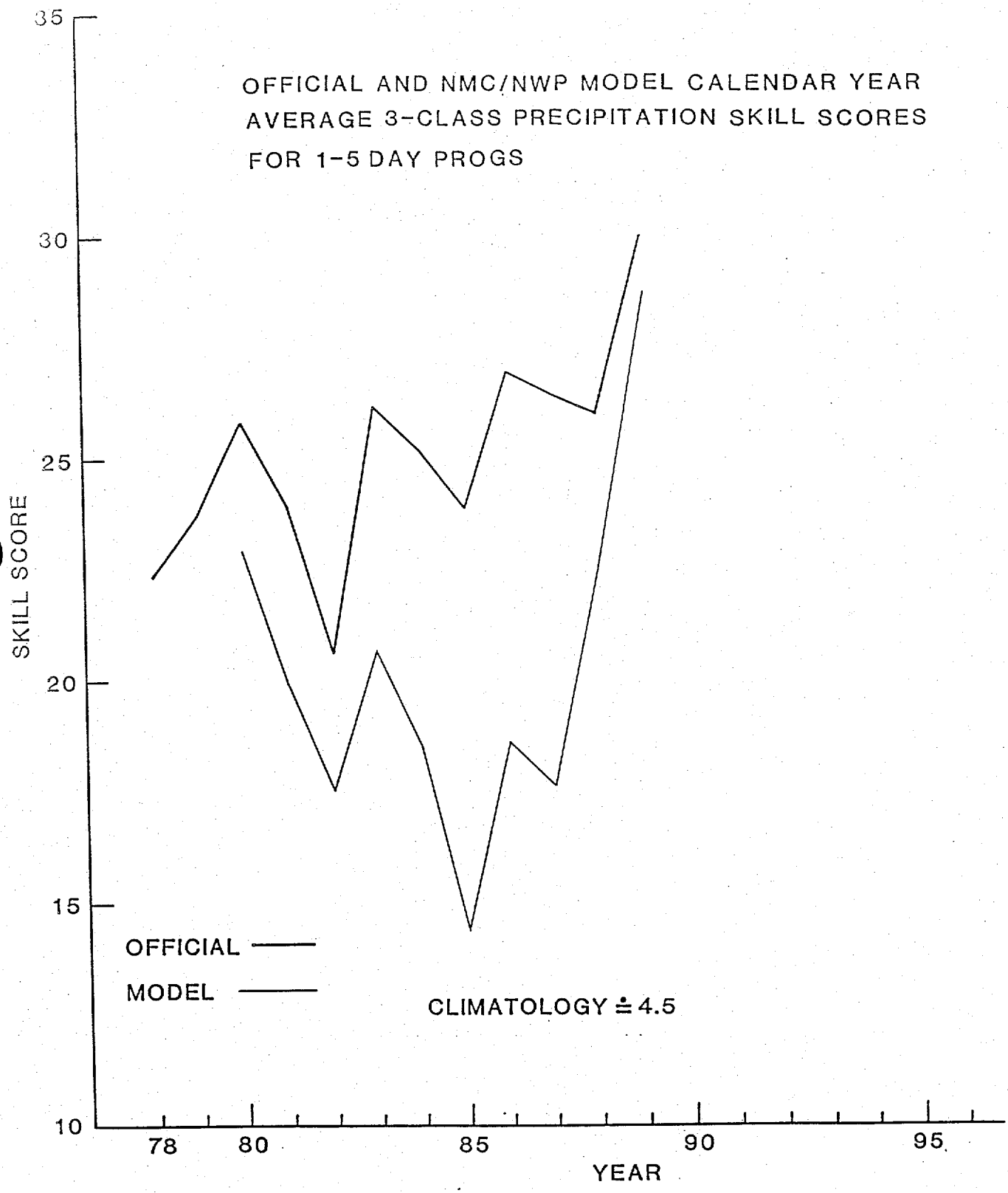
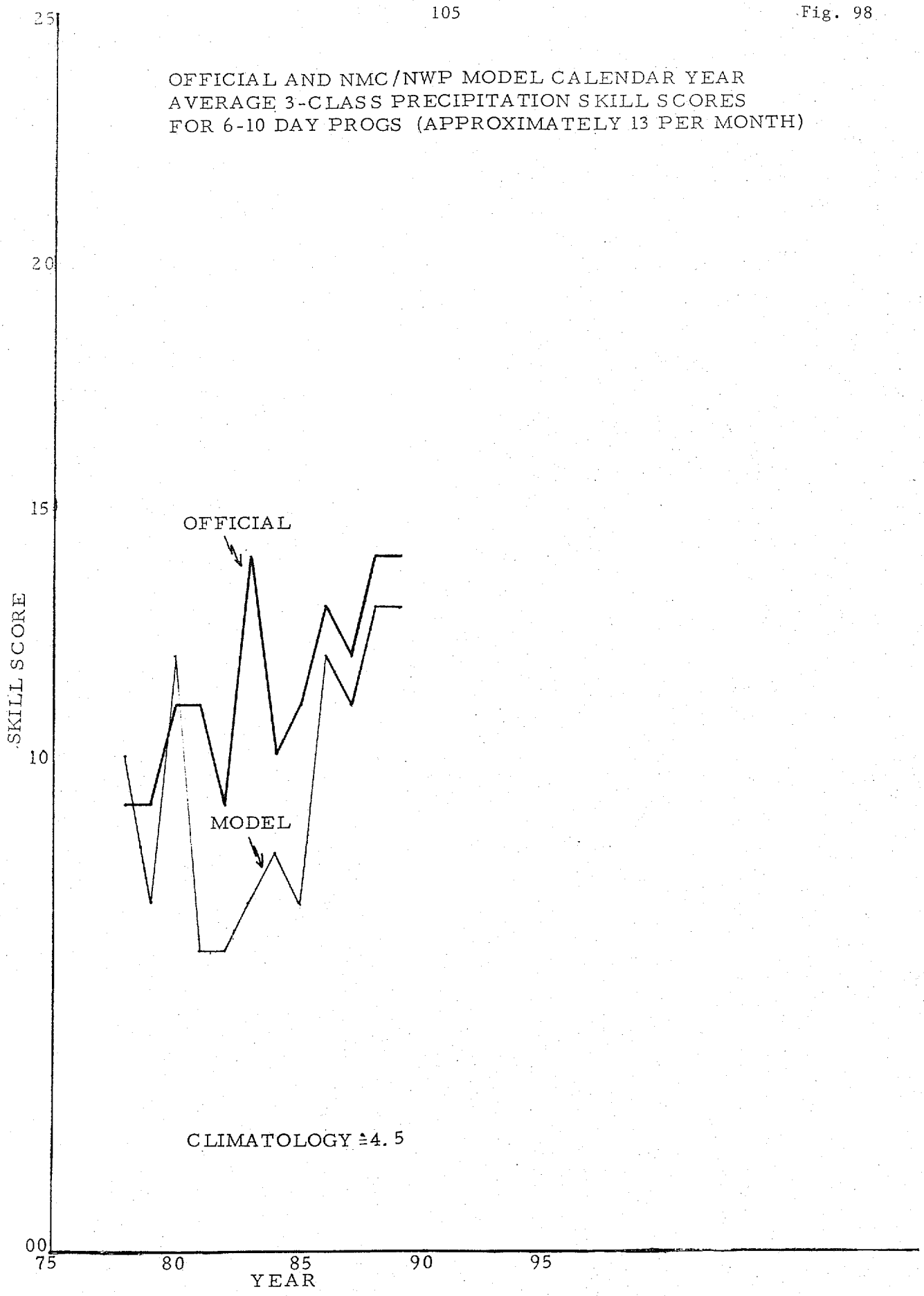

OFFICIAL AND NMC/NWP MODEL CALENDAR YEAR
AVERAGE 3-CLASS PRECIPITATION SKILL SCORES
FOR 1-5 DAY PROGS
35
30
25
20
15
10
SKILL SCORE
OFFICIAL
MODEL
CLIMATOLOGY ≐ 4.5
78
80
85
90
95
YEAR

Fig. 98


OFFICIAL AND NMC/NWP MODEL CALENDAR YEAR
AVERAGE 3-CLASS PRECIPITATION SKILL SCORES
FOR 6-10 DAY PROGS (APPROXIMATELY 13 PER MONTH)
25
20
15
10
00
SKILL SCORE
OFFICIAL
MODEL
CLIMATOLOGY ≐4.5
75
80
85
90
95
YEAR

COMMENTS

SECTION 1 MAN AND MACHINE (NMC/NWP MODEL GUIDANCE) MSLP & 500MB CORRELATION SCORES PAGES 6 TO 69

The pattern correlation score (Appendix A) has been the basic score used to verify the MSLP and 500mb progs since the start of the MRFP. The correlation score was chosen since it is more sensitive to the phasing of troughs and ridges (considered to be more important) than to the depth or heighth of these systems. The MSLP and 500mb operational analyses (HUF) were used to verify the forecast through 1976 and the LFM since 1977.

The NOAM standardized correlation score is the oldest score of record. It was assumed from the start that a MSLP standardized (anomaly divided by the standard deviation at each grid point) score of greater than 0.0 (climatology) would result in the derived forecasts of temperatures and precipitation having more skill than climatology (as a forecast). However, experience has indicated that a NOAM score of 0.17 or better is required to accomplish this.

Most of the forecasters complained from the beginning about verifying a forecast of the standardized MSLP field (which they could not "see") instead of the one they produced (the actual field). In order to appease the forecaster and to obtain a score for the normal (climatology) as a forecast the unstandardized (actual MSLP field) score was introduced in 1977 and has been used successfully ever since.

A glance at Figures 62-64 indicates that both the man (official) and NMC/NWP model guidance scores were records for 1989. No comment is made concerning the "betterment" of the man (official) progs over the guidance except that it appears to be significant. Since the scores for the circulation forecasts were records one might expect the derived forecasts of temperature and precipitation also to be at or near record levels.

SECTION II - MAN AND MACHINE (KLEIN-LEWIS PERFECT PROG) AVERAGE ABSOLUTE ERROR/SKILL TEMPERATURE SCORES PAGES 70 TO 87

Despite the record scores for the circulation forecasts only the day 3 KL average absolute error and the 3-class 6-10 day skill scores (Figures 78-81) showed any improvement over 1988 but even these were not record scores. Perhaps this can be understood in part by the fact that climatology scored the third highest average absolute error since 1971.

SECTION III - MAN AND MACHINE (NMC/NWP MODEL) PRECIPITATION SKILL SCORES PAGES 88 TO 105

Perhaps the most dramatic response to the improvement in the circulation forecasts can be seen in the 3-class skill score for the 1-5 day progs (Fig. 97). Also both the Gilman and 3-class skill scores for the days 3, 4 an 5 and 6-10 days progs respectively were at record levels (Figs. 96, 98).

CONCLUSION

1989 turned out to be a record year for the circulation progs and to a lesser extent for the precipitation forecasts but was a somewhat disappointing year with regard to the temperature forecasts.

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

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

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

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

$$\text{Correlation} = \frac{\overline{F0} - \overline{F}\,\overline{0}}{\sqrt{(\overline{F^2} - \overline{F}^2)\,(\overline{0^2} - \overline{0}^2)}} \times 100$$

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

APPENDIX A (cont'd)

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 5 day mean temperature skill score is a generalization of the Heidke skill score where the expected values are derived from the observed temperature

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

C = total correct (hits)
N = total number of forecasts (61)
E = expected number of hits

The expected value is calculated as follows from the number of stations in each of the observed temperature categories:

E = 1/8 x Much Below + 1/8 x Much Above +
1/4 x Below + 1/4 x Above + 1/4 x Normal

The 5-day mean 3-class temperature skill score simply "lumps" together the much below with the below and the much above with the above. The expected (E) then is equal to 1/4 X Below + 1/4 X Normal + 1/4 Above.

Appendix C

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 D

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 (E) then is 69 stations. If the forecast his (C) 75 stations correctly, his skill score then is (75-69)/(100-69) x 100 or 19.

APPENDIX E

The (Hughes) probability score is not a skill score yet it is quite simple to understand. A rough score (RS) is calculated for each station (N=1 to 100) as follows:

Forecast	Observed	RS
(DN POP + NPOP) ≥30	P=1	+(1 - NPOP)
(DN POP + NPOP) ≥30	P=0 and NPOP ≥50	-(NPOP)
(DN POP + NPOP) <30	P=1 and NPOP ≥50	-(NPOP)
(DN POP + NPOP) ≥30	P=0 and NPOP <50	-(1 - NPOP)
(DN POP + NPOP) <30	P=1 and NPOP <50	-(1 - NPOP)
(DN POP + NPOP) <30	P=0	+(NPOP)

Since the total rough score (TRS) for the 100 stations does not equal 100 points, a simple iterative technique is employed which uses the RS as a f(NPOP) for each station to bring the total number of points up to 100. The FORTRAN language routine is:

```
          TTY = 0
70        DO 69   I = 1, 100
          TRS = (100.0 - TRS) * ABS(RS(I)) * .01
          IF(RS(I)) 73, 74, 74
73        RS(I) = RS(I) - TRS
          GO TO 69
74        RS(I) = RS(I) + TRS
69        TTY = TTY + ABS(RS(I))
          TRS = TTY
          TTY = 0.0
          IF (TRS - 99.8) 70, 71, 71
71        CONTINUE
```

APPENDIX F

The 5-Day mean precipitation 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

For example, in January the number of stations in the area covered by the (NP/P), (NP/M/H) and (L/M/H) categories is 21, 28 and 51 respectively. The average value of the probability of NP for the stations in the (NP/P) area is 70% and 40% in the (NP/M/H) area. Now if (NP/L) is coded as 1, M as 2 and (P/H) as 3, then the number of stations expected to have coded value 1 thru 3 is as follows:

33% of (L/M/H) = 51 x .33 = 17 stations coded 1, 2, 3

40% of (NP/M/H) = 28 x .40 = 11 stations coded as 1 and 8.5 coded as 2,3

70% of (NP/P) = 21 x .70 = 14.7 stations coded as 1 and 6.3 coded as 3

Thus, code 1 = 17 + 11 + 14.7 = 42.7 stations
code 2 = 17 + 8.5 = 25.5 stations
code 3 = 17 + 8.5 + 6.3 = 31.8 stations
100.0 stations

Therefore, the expected value = .427a + .255b + .318c

where a, b and c are the number of coded values 1, 2 and 3 observed.