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

OFFICE NOTE 259

An Objective Method to Modify NMC/NWP Model Mean Sea Level Pressure Progs

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JUNE 1982

AN OBJECTIVE METHOD TO MODIFY NMC/NWP MODEL MEAN SEA LEVEL PRESSURE PROGS

1. Introduction

Almost since the very beginning of the mean sea level pressure (MSLP) analysis scheme many years ago in the U.S. and elsewhere, man has attempted to forecast this field at some time in the future using an educated guess, dead-reckoning, kinematics, weather types, analogs, persistence, CAVT computations, etc. Some of the more skilled forecasters using such techniques were quite successful in routinely making fairly accurate MSLP progs out to 24 hours and occasionally out to 48 hours and beyond.

It did not take long after the advent of the NMC/NWP model (especially the baroclinic) generated MSLP progs for the professional meteorologist to realize that these progs were, at least, equivalent in skill of the average forecaster out to 24 hours and generally better by 48 hours. The emphasis changed then from making MSLP progs by hand from "scratch" to modifying the NWP model MSLP progs themselves.

Even though the skill of the NWP model MSLP progs has continued to improve down through the years, not only in the short range (≤48 hours) but also in the medium range (>48 hours), man is still able to modify these progs with some degree of success. However, most of the "real" modifications, especially in the short range, are now relegated to the placement of fronts and high and low pressure centers rather than to the MSLP field itself.

Included in Appendix A is a list of some of the subjective forecast rules and ideas which have evolved over the years and are used by the forecaster to modify the NWP model MSLP progs as the situation dictates.

The success of these changes, unfortunately or fortunately, as the case may be, is simply determined by the skill of the forecaster making the changes. The technique described in this paper is basically an attempt to capture objectively the type of changes the forecaster might make subjectively based on recent model behavior and known characteristics.

2. Technique

A long term systematic review and verification of NWP model MSLP progs for days 3, 4, and 5 after initial data time (00Z), led to the realization that rather persistent model error patterns were associated with the topography, season, strength, and location of the slow moving longwave troughs and ridges.

In 1979 a concerted effort was made to apply these persistent errors to the NWP model MSLP progs in order to modify and improve them. Out of this attempt arose the rather conservative approach, to preclude large changes/fluctuations to/in the modified progs, of simple linear regression based on the previous 30 (days) verified forecasts.

Figure 1 depicts the 625 grid points at which the MSLP linear regression (LR) coefficient and forecast values (see Appendix B) are calculated. Figure 2 depicts the 130 grid points covering NOAM and vicinity where the MSLP correlation score (see Appendix C) is calculated.

Figure 3 is a plot of the NOAM correlation score for the days 3, 4, and 5 LR and NWP model MSLP progs for the period January 1980 through January 1981. The computational formula used during this period is essentially that listed as equation 3 in Appendix B. During the period February 1981 through April 1982, results not shown, attempts were made to "tune" equation 3. However, these attempts met with only limited success.

It should be noted that the calculations are carried out using the anomalous MSLP values (Forecast/Observed - Normal). Prior to output the normal MSLP for the date the forecast verifies is added to the computed grid point values (e.g., Figure 4). In Figure 4 the (1000-500mb) thickness values are also a result of this technique.

3. Comments

Figure 3 shows that generally (except for March and December 1980) the LR MSLP progs for days 3, 4, and 5 score higher than the corresponding NWP model progs. In particular, the day 5 LR MSLP prog score for July 1980 (31 forecasts) is higher than the day 3 NWP model prog score. Experience with the LR MSLP progs indicates that the margin of improvement over the NWP model progs increases whenever the mean flow pattern is persistent or changing slowly during the 30 day regression period.

Figure 4 is a day 4 LR MSLP prog made from the NWP model prog shown in Figure 5. The change in MSLP (and (1000-500mb) thickness) from one prog to the other is quite obvious. Figure 6 is the verifying LFM MSLP analysis. The NOAM unstandardized correlation scores for the LR and NWP model MSLP progs are 54 and 23 respectively.

Much of this increase in skill appears to be the result of a better definition of the MSLP troughs from central Alaska southeastward toward Lake Winnepeg and in the southwestern U.S. The location of the MSLP low centers in the southern Plains and south of Nova Scotia likely added to the improvement.

Figures 7 and 8 are the ECMWF model and MRFG man/machine mix MSLP progs for the same valid time and scored 57 and 40 respectively. The man/machine prog retained the improvement found in the LR prog in western

Canada and enhanced (correctly) the low center south of Nova Scotia. The main (apparent) error in the NWP model, LR, and man machine mix MSLP progs is in "moving out" too much low pressure into the Upper Mississippi Valley where only a (1000-500mb) thickness ridge is found in the verifying analysis. It is difficult to determine whether the ECMWF model MSLP prog low center found in Kansas is equivalent to the NWP model low in Minnesota or to the analysis low in New Mexico.

Figure 9 is a plot of the NOAM correlation score for days 3, 4, and 5 for the NWP model, LR, man/machine mix and ECMWF MSLP progs for May 1982. An average increase in skill of about 12 points, which is a little better than that for May 1980 (Figure 3), can be seen by comparing the LR to the NWP model MSLP prog scores for these days. (Figure 9 also suggests that perhaps the LR should be run using the ECMWF model MSLP progs.)

4. Conclusion

The rather long period of time involved and experience gained in testing the method described above quite emphatically indicates that a general increase in skill over the NWP model MSLP prog correlation scores can be gained by employing the LR technique. Some "hidden" advantages to using this method are that it runs extrememly fast on the IBM 360/195 computer, due to the type of data files employed and small program size, and it is (unlike the MOS) not NWP model dependent. Thus, within 30 days or less any change(s) made to the NWP model or change in model is soon accounted for.

Acknowledgement

The author would like to thank Mr. James Howcroft (SAB) for making the data files, Mr. Peter Henrichsen (SAB) for helping with the graphics, and the MRFG metechs for their general assistance.

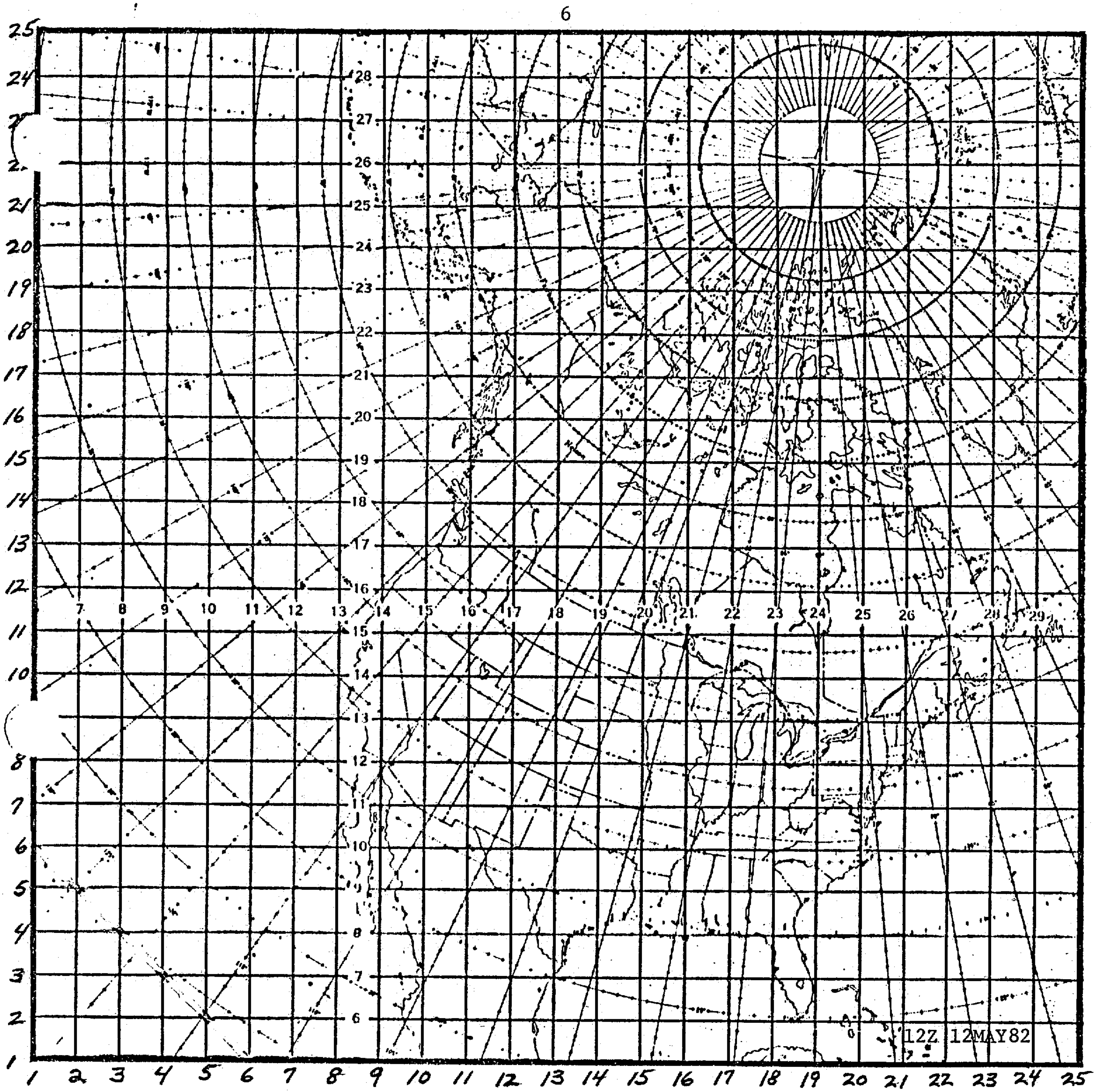


Figure 1

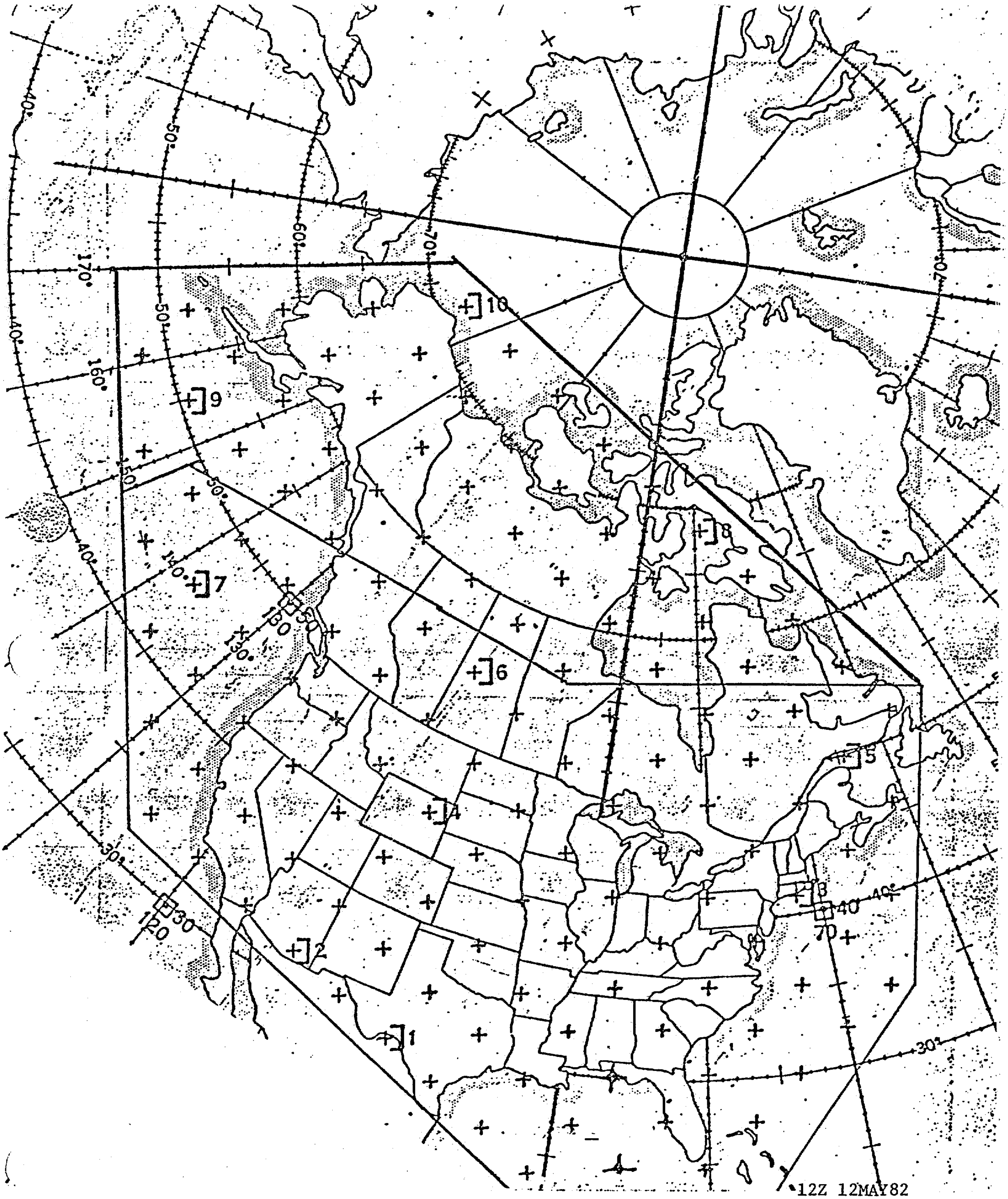


Figure 2

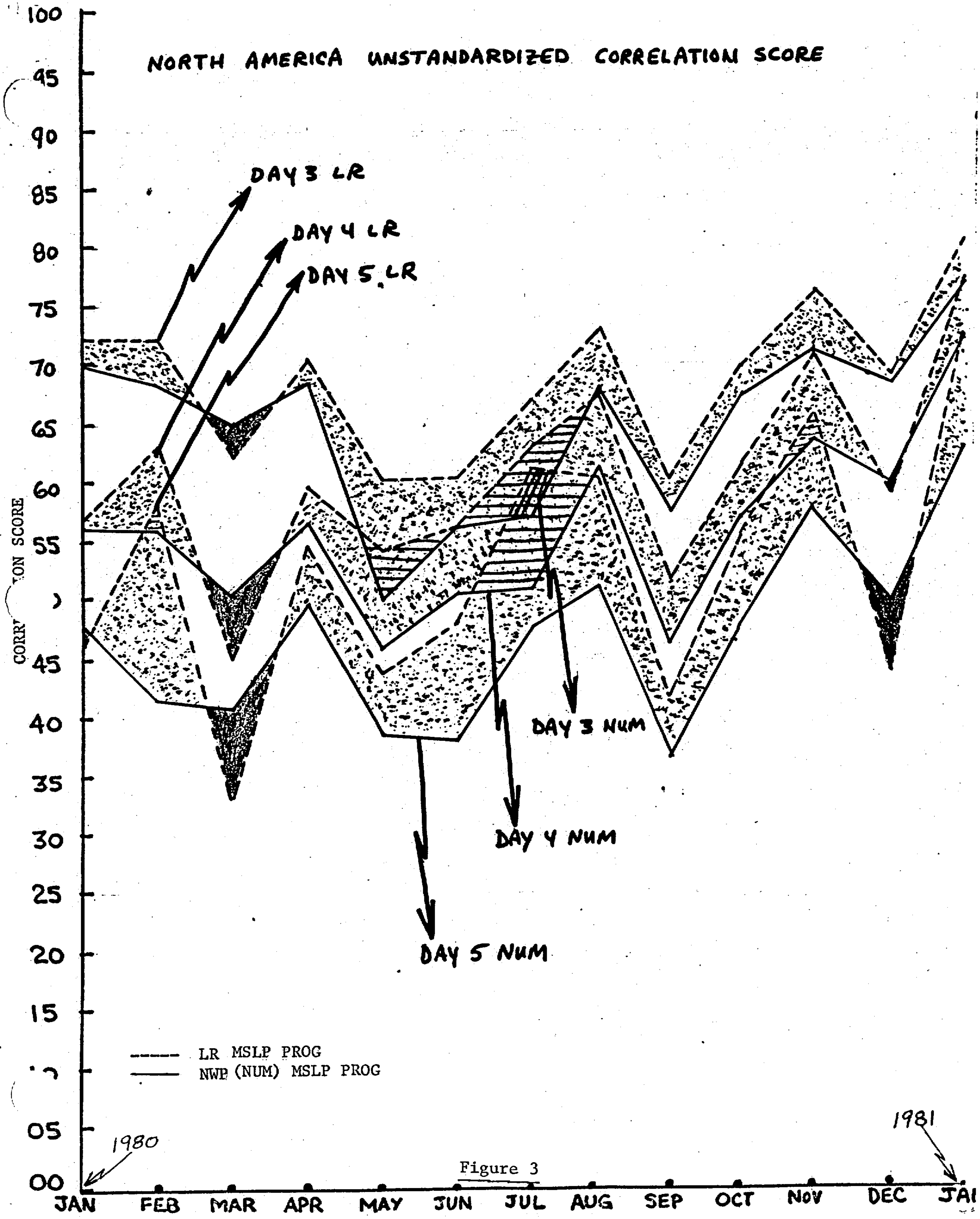

NORTH AMERICA UNSTANDARDIZED CORRELATION SCORE
CORR ON SCORE
100
95
90
85
80
75
70
65
60
55
45
40
35
30
25
20
15
05
00
DAY 3 LR
DAY 4 LR
DAY 5 LR
DAY 3 NUM
DAY 4 NUM
DAY 5 NUM
LR MSLP PROG
NWP (NUM) MSLP PROG
1980
1981
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN

Figure 3

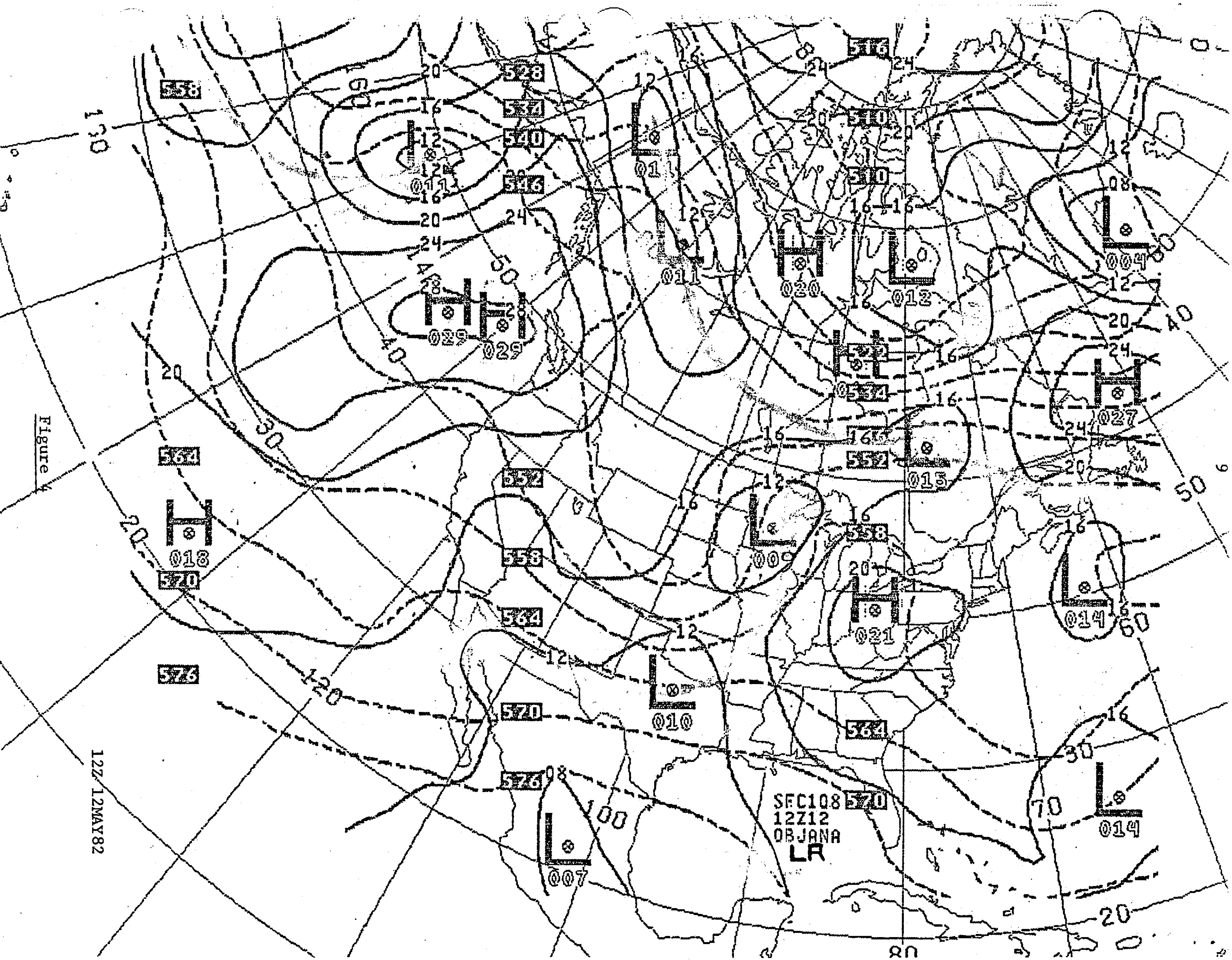


Figure 4

12Z 12MAY82

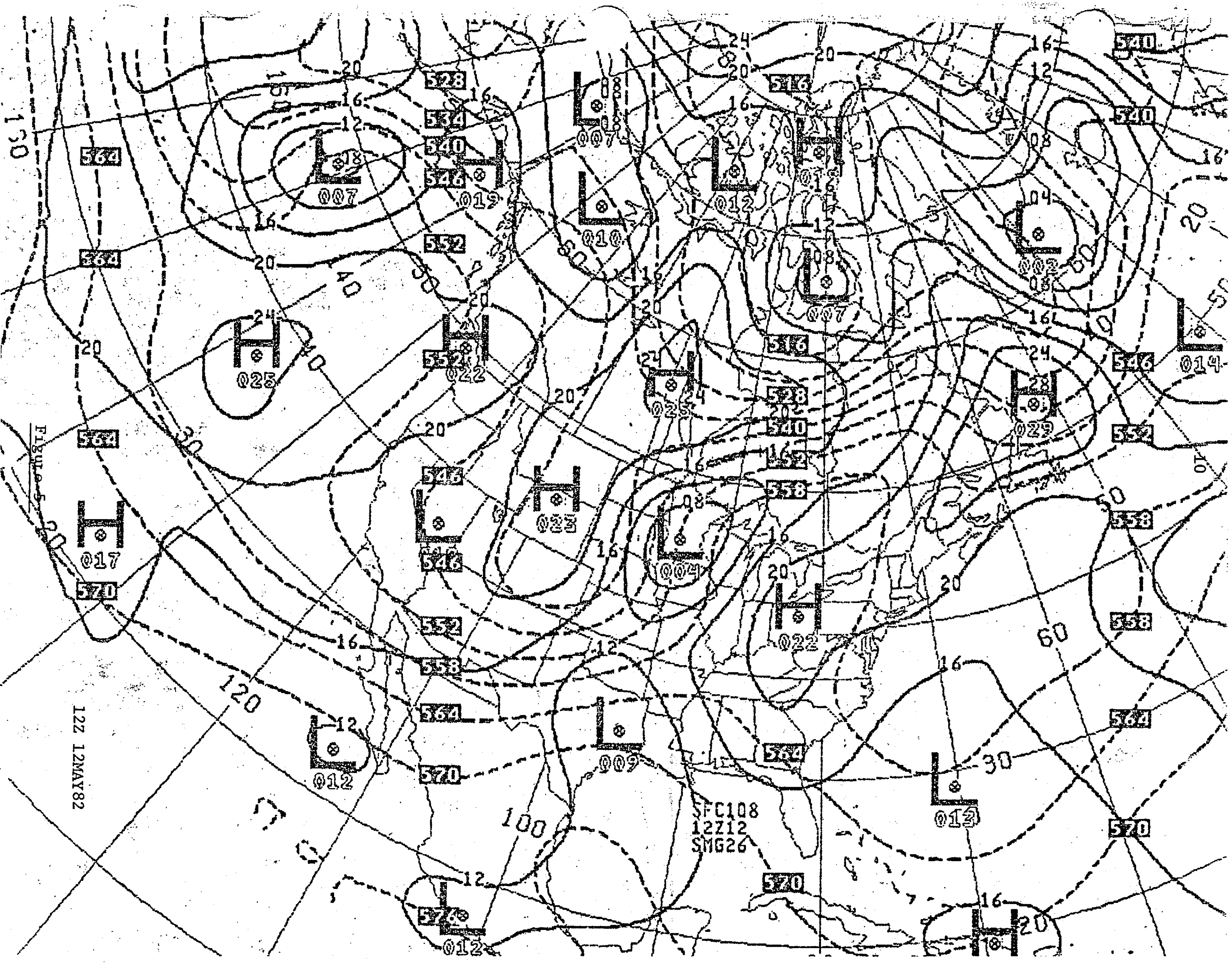
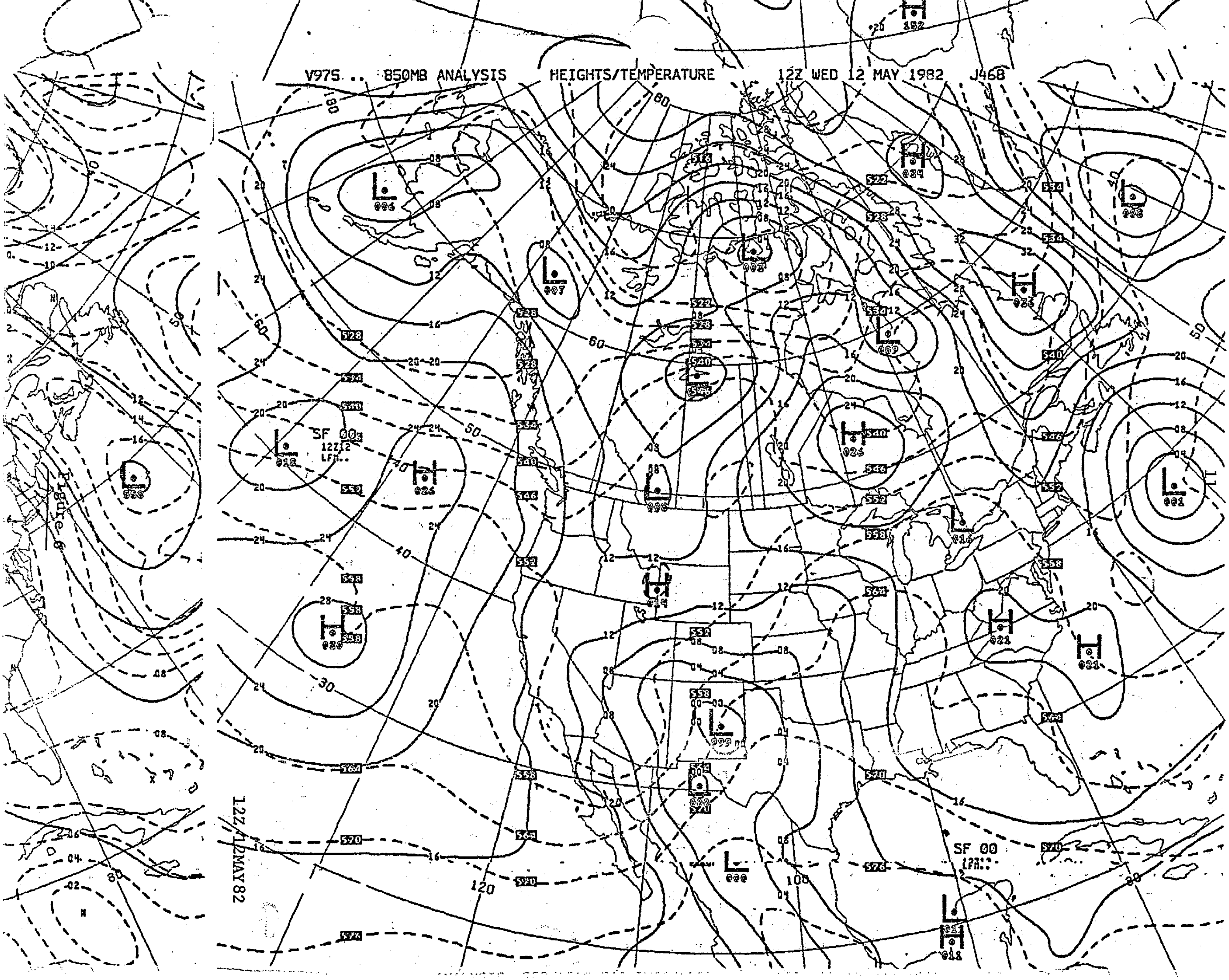


Figure 5

12Z 12MAY82


V975 .. 850MB ANALYSIS HEIGHTS/TEMPERATURE 12Z WED 12 MAY 1982 J468
SF 00
12Z 12MAY82

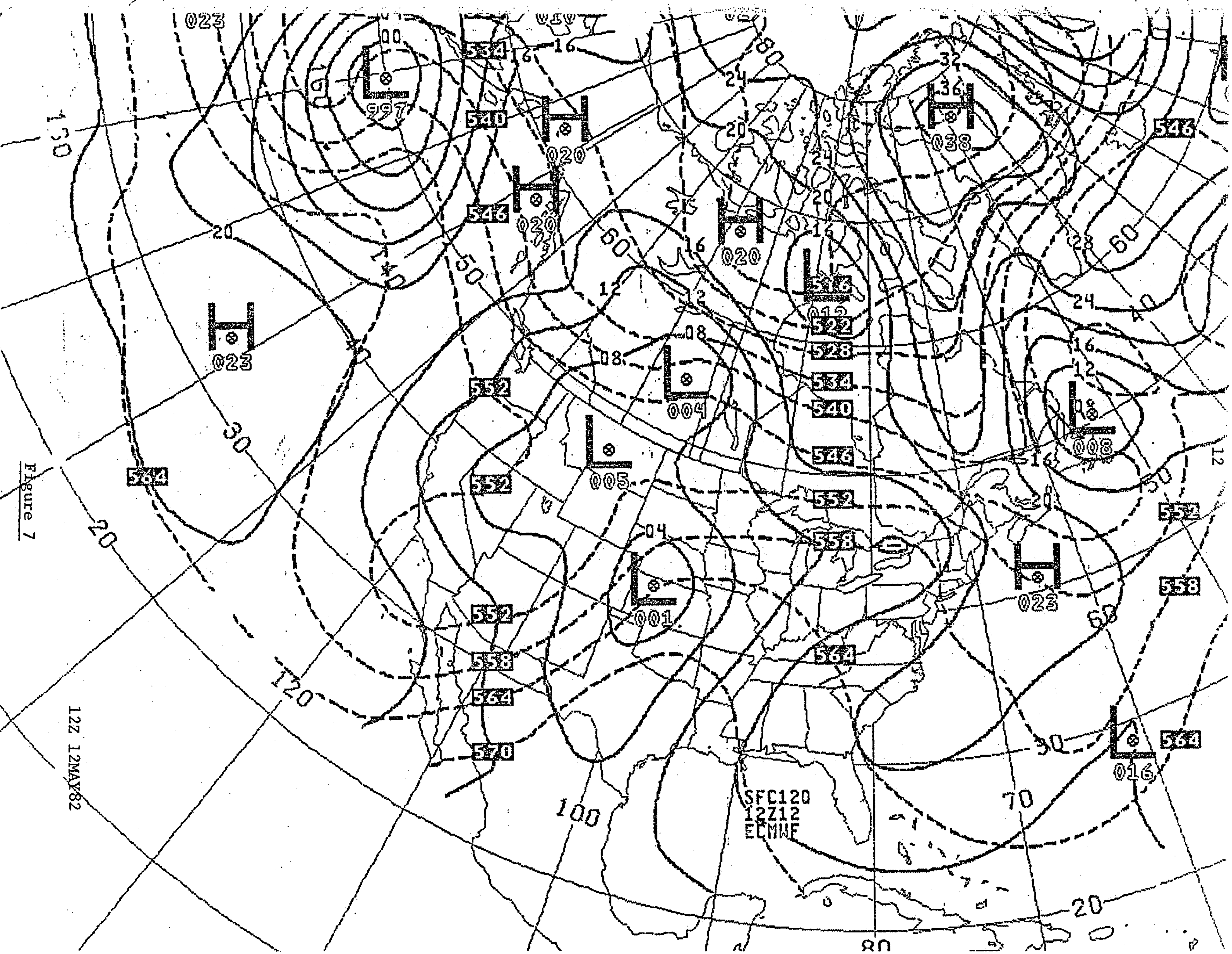


Figure 7

12Z 12MAY82

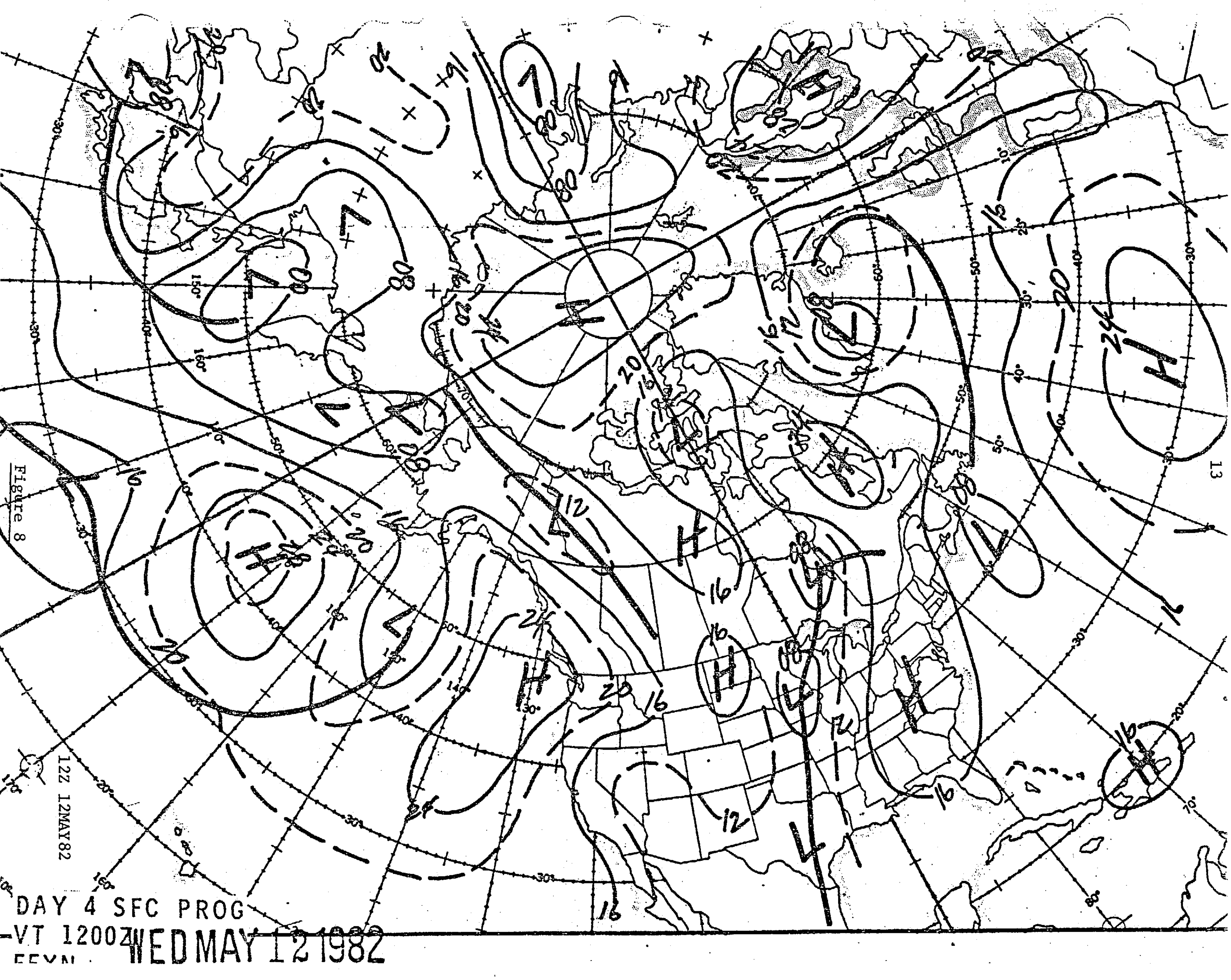


Figure 8

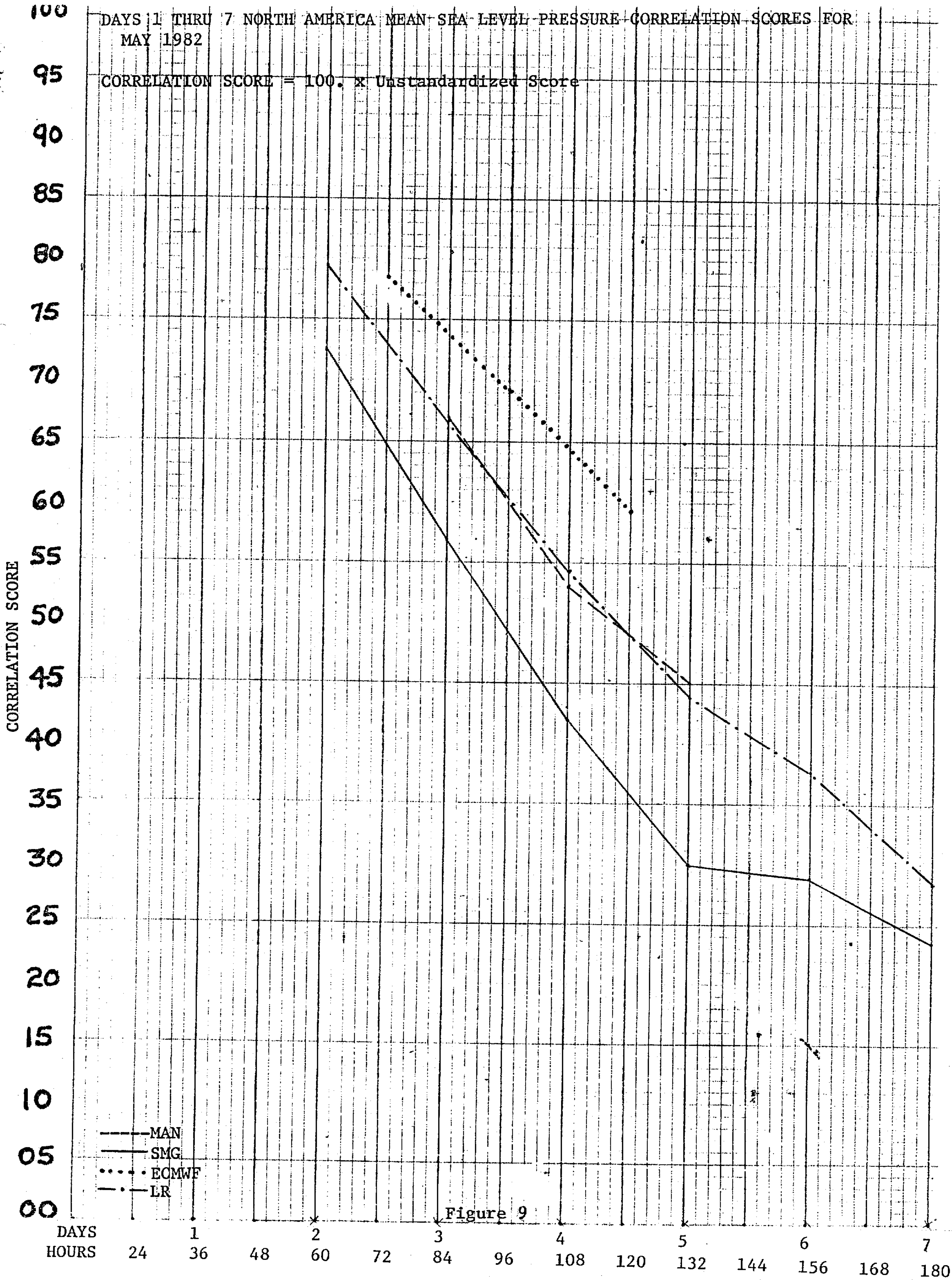

DAYS 1 THRU 7 NORTH AMERICA MEAN SEA LEVEL PRESSURE CORRELATION SCORES FOR MAY 1982
CORRELATION SCORE = 100. x Unstandardized Score
CORRELATION SCORE
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
05
00
MAN
SMG
ECMWF
LR
DAYS
1
2
3
4
5
6
7
HOURS
24
36
48
60
72
84
96
108
120
132
144
156
168
180

Figure 9

APPENDIX A

Forecast Rules Hints and Ideas
(Published and Unpublished)

1. Modification of LFM-11 Surface Progs, "FD/BWB Memorandum For The Record." Brown, November 1977.

2. Locked-in-Error in the LFM-11, "FD/BWB Memorandum For The Record." Brown, March 1980 and September 1980.

3. Modification of LFM-11 Surface Progs includes: Cyclogenesis in the Intermountain Region (Nevada), Spurious Cyclogenesis in the Plains, Secondary Cyclogenesis Along the East Coast; "FD/BWB Memorandum For The Record." Brown, April 1980.

4. Henry's Rule - A cut off low at 500mb will be kicked out when the upstream short wave in the same stream gets within 20 degrees or 1200 miles.

5. Rosenbloom Rule - deepening storms move to the left of the NWP model MSLP prog track.

6. Do not forecast a digging trof to "come out" until it finishes digging.

7. Remember 24mb in 24 hours (1mb/1hr) is usually an "upper limit" when deepening a MSLP low center except over water in the cool season. Even an East Coast developing wave generally follows this rule until it reaches the Canadian Maritimes.

8. In late fall and early winter MSLP high centers usually "avoid" the Great Lakes.

9. An 8mb deepening in MSLP can be expected in a low center (8mb/60m) located under a 60 meter height fall at 500mb.

10. A Rocky Mountain MSLP lee trof begins to develop when the 500mb ridge gets within 5° or 300 miles west of the lee slopes. The MSLP lee trof or low center generally remains stationary and deepens until the 500mb ridge is 5° or 300 miles east of the divide. Then the MSLP trof moves "out" with the speed of the upstream 500mb trof.

11. Inverted MSLP "heat" trofs in California occur with a building 500mb ridge. The MSLP trof occurs under that part of the 500mb ridge that is south of the 500mb jet and is most pronounced in the 500mb ridge area where the winds are less than 25kts. Often during the warm season the MSLP trof may extend into Oregon and Washington.

12. Modify blown-up MSLP high centers located under cold upper troughs over mountain regions (western U.S.).

13. Modify spurious deepening of MSLP low centers (especially in the Plains) due to excessive warming (warm 1000-500mb thickness advection).

14. Modify under forecast MSLP high centers (over land) in the cold season located in the rear of a cold upper trough or ahead of a warm upper ridge.

15. Introduce MSLP cyclogenesis or anticyclogenesis in preferred locations under favored conditions.

16. Move MSLP low and high centers (as near as possible) along favored (monthly) tracks.

17. Modify MSLP systems forecast to have excessive departures from climatological (normal) values in areas of small variability in the absence of strong synoptic mechanisms.

18. Place the arctic front, the polar front and pressure troughs where they are supported by the forecast (1000-500) mb thickness, upper air support, RH, etc. Generally the arctic front is located near the 528M and the polar front in the western Atlantic ocean and eastern half of NOAM near the 564-570M and in the eastern Pacific Ocean and western half of NOAM near the 552-558M (1000-500mb) forecast thickness values.

19. MSLP low centers generally move on a course parallel to the mean jet at 500mb which is usually located near the 552-558M contours.

20. Short wave trofs at 500mb moving into the long wave trof position deepen - short wave trofs moving into the long wave ridge position fill. Short wave trofs at 500mb and associated MSLP low centers approaching a long wave trof position usually are forecast too fast (far east) and not deep enough. (Works best in western NOAM and the eastern Pacific Ocean areas). (Vice versa also works but to a lesser extent).

21. Short wave ridges at 500mb and associated MSLP high centers approaching a long wave ridge position usually are forecast too fast (far east) and not built-up enough. (Vice versa also works but too a lesser extent).

22. There is an overall trend in the NWP model forecast to decrease (or not forecast enough) amplitude. Rules 20 and 21 above reflect this problem.

23. With a cold MSLP high center moving off the northeast U.S. coast and a 500mb trof approaching the central U.S. surface trofiness will commence just off the southeast U.S. coast sooner and stronger than the NWP model indicates.

24. Nevada Wintertime Cyclogenesis, "FD/BWB Memorandum For The Record." Brown, March 1971. A Nevada MSLP low center forms when a digging 500mb trof approaches the west coast of the U.S. Poorly forecast by NWP models. (See Rule 3)

25. Hage Low, "Western Region Technical Attachments." Brenner and Hage, July 1974, 1971. NWP models forecast this rapid and intense summertime MSLP low center in the lee of the Canadian Rockies in Alberta and Western Saskatchewan quite well.

26. A Study of the Distribution of Weather Accompanying Colorado Cyclogenesis, "Monthly Weather Review." Fawcett and Saylor, June 1965. (See Rule 3). NWP models generally "catch" this MSLP low center development but are usually not deep enough and move the low out of the lee trof position too quickly.

27. When the NWP model forecast vorticity maximum moves within 7^{o} latitude of the lee trof MSLP low center (Colorado low or other) the low begins to move out to the (north) east but at a speed no faster than that of the upstream short wave ridge at 500mb.

28. The NWP model will "wipe out" too quickly a MSLP low center off the North Pacific U.S. Coast reflecting a vortice at 500mb. The vortice is usually filling and drifting.

29. An East Coast U.S. secondary MSLP low center forms just south of the polar jet (right rear quadrant of the jet maximum) after the 500mb short wave ridge has moved offshore. Usually a MSLP high center will be over New England or just off the Northeast U.S. Coast. (See Rule 3).

30. While a 500mb trof is still digging in the Western U.S./Eastern Pacific Oceans areas the NWP models may eject a MSLP low center(s) northeastward out of the Rockies and into the Plains too deeply. (See Rule 13).

31. A Rocky Mountain lee MSLP high center begins to develop when the 500mb trof comes within 5o or 300 miles west of the lee slopes. The MSLP high center or ridge develops until the 500mb trof is 5o or 300 miles east of the Divide. Then the MSLP ridge moves "out" with the speed of the upstream 500mb ridge. (See Rule 10).

32. Cold fronts move southward east of the Divide (Western Plains) faster than the NWP model indicates due to the shallowness of the cold air.

33. Apply the monthly stratified NWP model MSLP prog errors judiciously as the mean flow pattern dictates.

34. Decrease excessive erosion of the west side of the MSLP Bermuda High in the warm season and at rare times in the cool season.

35. Speed up MSLP high and low centers embedded in fast westerly flow, especially under a northwest jet in the cool season.

36. Plateau MSLP high center tends to break down quickly with fast zonal westerlies above it.

37. An ill-defined complex MSLP low center in the Plateau "moves out" with the speed of the 700 or 500mb 12hr prog height fall center.

38. A Plateau MSLP high center without an associated thickness gradient is stationary, otherwise it moves parallel to it.

39. A Question of Southern Plains Low or Gulf Coast Cyclogenesis, "FD/BWB Memorandum For The Record." Brown, April 1970.

APPENDIX B

Objective Method to Modify NMC/NWP Model MSLP Progs

NORMi = Normal MSLP value at grid point i (new and old)
Fi = Forecast MSLP value at grid point i (old)
FNi = (Fi - NORMi) Departure from normal (DN) forecast MSLP value at grid point i (old)
Oi = Observed MSLP value at grid point i (old)
ONi = (Oi - NORMi) Departure from normal (DN) observed MSLP value at grid point i (old)
fNi = DN forecast MSLP value at grid point i (new)
LRNi = DN linear regression forecast MSLP value at grid point i (new)
YNi = Objectively modified DN forecast MSLP value at grid point i (new)
yi = (YNi + NORMi) Objectively modified forecast MSLP value at grid point i (new)
bi = Linear regression coefficient at grid point i (old)
ri = Correlation coefficient at grid point i (see appendix C for formula) (old)
N = 30 number of forecasts (old)

$$bi = \frac{(\Sigma_1^N \text{FNi} \times \text{ONi}) - (N \times \overline{\text{FNi}} \times \overline{\text{ONi}})}{\Sigma_1^N \text{FN}_i{}^2 - (N \times \overline{\text{FNi}}^2)}$$

1. $\text{LRNi} = \overline{\text{ONi}} + \text{bi} \times (\text{fNi} - \overline{\text{FNi}})$

2. $\text{YNi} = \text{LRNi} \times (1.0 - \text{ri}) + \text{fNi} \times (\text{ri})$
   if ri is negative
   $\text{YNi} = \text{LRNi} \times (1.0 - \text{absolute value ri}) + \text{fNi} \times (\text{ri})$

3. $\text{yi} = \text{YNi} + \text{NORMi}$

Observed values are from the NMC LFM analysis
(Old/New) Forecast values are from the NMC Spectral Model

APPENDIX C

Unstandardized MSLP Correlation Score

Fi = Forecast MSLP value at grid point i
Oi = Observed MSLP value at grid point i
N = 130 number of grid pints across NOAM and vicinity

$$W = (N \times \Sigma_1^N Fi^2) - (\Sigma_1^N Fi \times \Sigma_1^N Fi)$$

$$Y = (N \times \Sigma_1^N Oi^2) - (\Sigma_1^N Oi \times \Sigma_1^N Oi)$$

$$Z = N \times (\Sigma_1^N Fi \times Oi) - (\Sigma_1^N Oi \times \Sigma_1^N Fi)$$

$$r = \frac{Z}{\sqrt{W \times Y}} \times 100.$$

$r \leq 100.$ to $\geq -100.$ Correlation Score.

Observed values are from the LFM analysis.
Forecast values are from the LR technique.

THE ATTACHED IS A CHANGE TO NMC OFFICE NOTE 259

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MODEL MEAN SEA LEVEL PRESSURE PROGS

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JUNE 1982