U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL WEATHER SERVICE
SYSTEMS DEVELOPMENT OFFICE
TECHNIQUES DEVELOPMENT LABORATORY

TDL OFFICE NOTE 82-6

AN EVALUATION OF MOS MAXIMUM/MINIMUM TEMPERATURE FORECASTS FOR THE EASTERN UNITED STATES DURING TWO ARCTIC OUTBREAKS

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June 1982

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1. INTRODUCTION

During the month of January 1982, the eastern half of the United States experienced two unusually cold Arctic outbreaks within the span of 1 week. These two visits of the "Siberian Express" broke numerous daily low maximum and minimum temperature records for cities from the Midwest through the Southeast (U.S. Department of Commerce, 1982a). For both cases, the frigid air was extraordinary in terms of the area where large negative deviations from normal daily temperatures were recorded.

The purpose of this paper is to present an analysis of the objective forecasts of maximum (max) and minimum (min) temperature (National Weather Service, 1980b) which were valid for these cases. Maps of algebraic error (forecast minus observed temperature) are presented for some of the guidance.

2. OBSERVED TEMPERATURES

The first outbreak of frigid air occurred across the northern tier of the United States on January 9. By January 10, Arctic air plunged southeastward and had covered most of the eastern United States (U.S. Department of Commerce, 1982b). Figs. 1a and 1b show isotherms of observed calendar day maximum and minimum temperatures, respectively, for January 10. The values plotted at selected locations are departures from the normal (1941-1970) max and min temperatures.

For the max (Fig. 1a), note the extensive area of sub-zero temperatures; some of these reports were 40°F or more below normal. Sub-freezing temperatures reached well into the South. Many of the max readings, especially in the East, were actually recorded just after midnight on January 10, while the daytime 12-h (7 a.m.-7 p.m. local time) max temperatures were even colder (not shown).

For the January 10 min (Fig. 1b), approximately two-thirds of the eastern United States, including parts of the South, fell below zero. Single digit values were observed throughout most of the South, while freezing temperatures were registered everywhere except southern Florida and extreme southeastern Texas. As with the max, note the extensive area of large negative departures from normal.

The second outbreak of frigid air on January 16 took much the same route as the cold air during the previous week. The Arctic air spread rapidly south and east covering the entire eastern United States by January 17 (U.S. Department of Commerce, 1982c).

On January 17, the calendar day max temperatures (Fig. 2a), although not quite as cold as those observed on January 10, failed to reach zero in areas adjacent to the Great Lakes. Similar to January 10, the 12-h afternoon max

temperatures in the East were colder than the calendar day reports since many locations observed their maximum near midnight. Min temperatures (Fig. 2b) were quite similar to those observed on January 10 and were, in fact, colder in parts of the East and Midwest.

3. PREPARATION OF THE GUIDANCE

Max/min temperature forecasts based on the Model Output Statistics (MOS) technique (Glahn and Lowry, 1972) are disseminated via facsimile, and the FOUS12 (National Weather Service, 1980a) and FOUS22 (National Weather Service, 1981) teletype messages. The forecasts of calendar day extrema are valid at approximately 24, 36, 48, and 60 hours after the initial model run times at 0000 GMT and 1200 GMT. A description of the MOS max/min temperature guidance system is given in Technical Procedures Bulletin No. 285 (National Weather Service, 1980b). The guidance is based on output from the Limited-area Fine Mesh (LFM) model (Newell and Deaven, 1981; Gerrity, 1977).

4. FORECAST EVALUATION

We decided to verify the guidance max/min temperatures that were valid on January 10 and January 17. The forecasts were prepared from data on January 8, 9, or 10 and January 15, 16, or 17, respectively. As verifying observations, we used the 0600 GMT synoptic report on January 11 or January 18. This observation gives the max/min temperature for the previous 24 hours and so closely represents a calendar day value. Forecasts were verified in terms of algebraic error (forecast value minus observed value). In this study, we've shown algebraic error maps for only the 24- and 48-h forecasts.

The isopleths of algebraic errors for the 24-h max temperature forecasts from 0000 GMT on January 10 and the 48-h forecasts from 0000 GMT on January 9 are presented in Figs. 3 and 4, respectively. The error patterns indicate the 24-h guidance was too cold (negative algebraic error) near the Great Lakes, across New England, over Florida, and across the southern half of Texas. The 48-h forecasts also were too cold along the southern Appalachians and a large portion of the Gulf Coast states. Elsewhere, the guidance forecasts were too warm, especially for the 24-h forecasts over a large section of the Plains.

Isopleths of algebraic errors for the 1200 GMT cycle 24-h and 48-h minimum forecasts, valid on January 10, are presented in Figs. 5 and 6. Both sets of forecasts were too cold throughout most of the Northeast and Florida. The 24-h guidance was also too cold over parts of the Northern Plains and Florida. The guidance was too warm elsewhere, especially at 48-h, with large errors in the southern Appalachian region and in most of Texas.

Table 1 shows a comparison of the guidance verifying on January 10 for a few representative locations. For many of the stations listed in the table, the guidance predicted the max better than the min. Also, the MOS forecasts did not always improve as the projection decreased.

The isopleths of algebraic errors for the 24- and 48-h max temperature forecasts verifying on January 17 are presented in Figs. 7 and 8, respectively. The 24-h forecasts were too cold just to the east of the Continental Divide and across sections of the South. The 48-h forecasts were

too cold throughout a large section of the northern Plains and along all of the East Coast from New England to Florida. Note the large (-10°F to -20°F) errors over northern New England and near the Continental Divide. Elsewhere, the guidance was too warm, particularly over Tennessee, Kentucky, and much of Kansas at 24 hours and throughout a large portion of the Midwest at 48 hours.

Isopleths of errors for the 24- and 48-h minimum forecasts are presented in Figs. 9 and 10, respectively. Both the 24- and 48-h forecasts were too cold in Florida and in parts of the northern Plains. The forecasts were too warm elsewhere, especially along and to the west of the Appalachians and in parts of the Midwest.

Table 2 is a comparison of the guidance for selected cities for January 17. For this case, the min was predicted better than the max. For most stations, as expected, the forecasts improved as the length of the projection decreased.

5. SUMMARY

We have presented an evaluation of the MOS max/min temperature guidance for the two extreme cold air outbreaks of January 10 and 17, 1982. Observed max temperatures on January 10 were generally colder than those observed on January 17, while the observed min temperatures were colder in the Northeast and Midwest for the latter case.

Comparison of these two cases indicates the max was forecast better on January 10 than on January 17, whereas, the min was forecast better on January 17 than on January 10. In general, for both cases, the guidance was too cold in the Northeast and Southeast, and too warm elsewhere, particularly over parts of the Midwest and the mid-Atlantic states. As might be expected, the MOS forecasts tended to underestimate the strength of the cold air where the departures from normal of the observed temperatures were greatest.

We believe most of the errors in these MOS max/min forecasts are directly related to the performance of the LFM model. It seems likely that the errors along the East Coast, particularly the Northeast, are due to the timing of the frontal passage which ushered in the cold air. Also, it appears that the LFM overforecast the southern extent of the cold air resulting in large errors across much of the Southeast.

6. REFERENCES

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_____, 1982b: Daily weather maps, weekly series January 4-10, 1982.

_____, 1982c: Daily weather maps, weekly series January 11-17, 1982.

Table 1. Observed max/min temperature (OBS), departure from normal (DPN), and the corresponding MOS guidance error (forecast minus observed temperature) at indicated projections for the January 10 case. All values are in °F.

	Maximum Temperature						Minimum Temperature					
	OBS	DPN	60-h	48-h	36-h	24-h	OBS	DPN	60-h	48-h	36-h	24-h
PWM	12	-19	-3	-6	0	-1	-3	-15	-6	-6	-7	-4
BTV	1	-25	0	-4	2	-1	-7	-15	-9	-11	-10	-8
BOS	19	-14	-8	-2	0	-3	6	-13	-3	-4	-3	0
SYR	5	-27	-2	0	2	0	-5	-21	-3	-7	1	1
LGA	16	-22	-5	-5	0	-3	6	-21	-1	-3	-1	4
PIT	0	-35	4	-3	6	-2	-9	-30	-4	-1	2	2
DCA	12	-31	9	5	9	6	2	-26	2	7	2	6
SDF	2	-40	10	9	8	8	-11	-35	8	8	9	6
CMH	-4	-40	11	7	8	6	-11	-32	0	3	5	1
DTW	3	-29	6	5	8	2	-8	-27	-2	0	0	6
SSM	16	-6	-13	-12	-6	-13	-36	-43	16	13	14	18
ORF	25	-24	-1	-2	1	-1	7	-25	13	13	6	2
RDU	24	-27	6	1	-4	2	4	-26	6	8	3	2
AVL	15	-33	16	1	1	5	-6	-33	16	16	13	7
MCN	30	-28	14	8	2	14	9	-28	18	12	10	6
JAX	55	-11	-5	-11	-15	11	29	-15	-1	0	-2	-3
TPA	59	-11	-2	-5	-7	-4	40	-10	-2	-5	-5	-6
MOB	40	-21	-7	-10	-6	7	14	-27	17	11	0	7
BHM	35	-19	5	-7	-7	14	1	-33	18	11	9	5
JAN	36	-22	-1	-13	-16	3	5	-31	17	12	5	9
MEM	23	-26	4	-3	-6	7	3	-28	14	11	5	6
SHV	41	-17	-6	-13	-7	-1	12	-25	19	9	5	10
MSY	45	-12	-6	-15	-9	3	21	-22	13	8	3	8
IAH	48	-14	1	-15	-4	0	23	-18	10	8	1	3
SAT	47	-14	3	-7	-1	-1	18	-21	21	17	10	10
ISN	-14	-33	12	8	5	8	-35	-32	14	12	2	1
FAR	-6	-21	-1	-1	0	0	-29	-25	2	-1	-4	-3
GRB	-2	-26	-1	6	3	0	-25	-32	2	4	3	4
RAP	-7	-41	17	10	-6	11	-24	-33	20	12	7	4
FSD	-10	-38	16	1	0	9	-26	-33	5	-4	-5	-2
MLI	-3	-33	-2	4	8	6	-23	-36	6	3	8	2
DDC	11	-31	13	1	0	7	-6	-24	21	14	13	8
TOP	0	-37	13	4	4	16	-15	-32	11	7	3	2
STL	-1	-40	8	5	3	10	-15	-37	8	7	10	0
EVV	7	-34	6	5	0	0	-10	-34	8	6	3	0
OKC	20	-27	14	4	-1	15	0	-26	22	17	10	9
AMA	28	-21	16	2	-2	6	2	-20	21	21	13	8
DFW	41	-14	8	-6	-7	4	7	-27	26	19	13	12

Table 2. Observed max/min temperature (OBS), departure from normal (DPN), and the corresponding MOS guidance error (forecast minus observed temperature) at indicated projections for the January 17 case. All values are in °F.

	Maximum Temperature						Minimum Temperature					
	OBS	DPN	60-h	48-h	36-h	24-h	OBS	DPN	60-h	48-h	36-h	24-h
PWM	24	-7	-14	-22	-18	-5	-6	-18	0	5	4	-3
BTV	8	-18	-8	-10	-5	6	-16	-24	-3	11	8	-3
BOS	30	-3	-27	-14	-16	-4	0	-19	8	8	7	0
ROC	-4	-35	6	2	9	9	-10	-27	-7	-6	-3	6
LGA	18	-20	-9	-6	-7	4	-1	-28	11	9	9	0
PIT	-3	-38	6	6	8	11	-18	-39	0	11	9	7
DCA	9	-34	7	11	7	10	-5	-33	14	15	12	15
SDF	7	-35	4	18	9	18	-10	-34	-1	9	8	9
CMH	3	-33	3	7	0	6	-16	-37	-3	4	6	5
DTW	-1	-31	10	11	8	7	-15	-30	-2	-3	4	8
SSM	-9	-31	8	13	10	8	-24	-31	-7	-4	2	-4
ORF	36	-13	-18	-14	-10	-4	10	-22	11	7	1	2
RDU	35	-16	-12	-9	-9	-6	10	-20	1	1	0	1
ATL	35	-13	-2	0	-3	-1	0	-27	16	10	15	12
MCN	39	-19	2	2	3	6	15	-22	9	0	7	4
JAX	58	-8	-18	-13	-13	-8	31	-13	4	-7	-3	0
TPA	69	-1	-20	-9	-10	-8	50	0	-3	-23	-10	-7
MOB	45	-16	-15	-6	2	2	17	-24	7	3	5	11
BHM	30	-24	0	2	5	6	-1	-33	16	16	18	16
JAN	41	-17	-9	-3	1	-3	12	-24	0	-1	2	5
MEM	22	-27	9	12	12	7	0	-31	11	11	17	12
SHV	39	-19	-12	4	8	-3	13	-24	-1	-3	7	10
MSY	43	-14	-11	-8	-4	7	28	-15	0	-1	-1	1
IAH	41	-21	-4	2	10	7	23	-18	-2	-3	5	8
SAT	44	-17	-10	3	8	3	17	-22	7	7	12	11
ISN	24	5	-9	-6	-6	-4	-10	-7	-2	1	9	-4
FAR	3	-12	2	-1	4	8	-20	-16	-9	0	1	-4
GRB	0	-24	-1	7	0	-1	-28	-35	-3	4	10	2
RAP	45	11	-1	-4	-9	-9	-3	-12	-4	8	6	2
FSD	25	-3	-1	-7	-10	5	-8	-15	-12	-1	-7	-4
MLI	7	-23	2	5	3	8	-15	-28	-12	-2	13	4
DDC	36	-5	10	17	12	19	12	-6	-11	1	6	0
TOP	30	-7	-4	0	4	9	3	-14	-15	-5	3	0
STL	10	-29	6	11	12	12	-5	-27	2	4	7	1
EVV	6	-35	7	18	15	15	-18	-42	3	14	13	16
OKC	38	-9	1	10	11	2	5	-21	-1	6	14	9
AMA	73	24	-16	-17	-13	-19	10	-12	-3	5	14	7
DFW	37	-18	-3	8	7	3	11	-23	-1	2	15	5

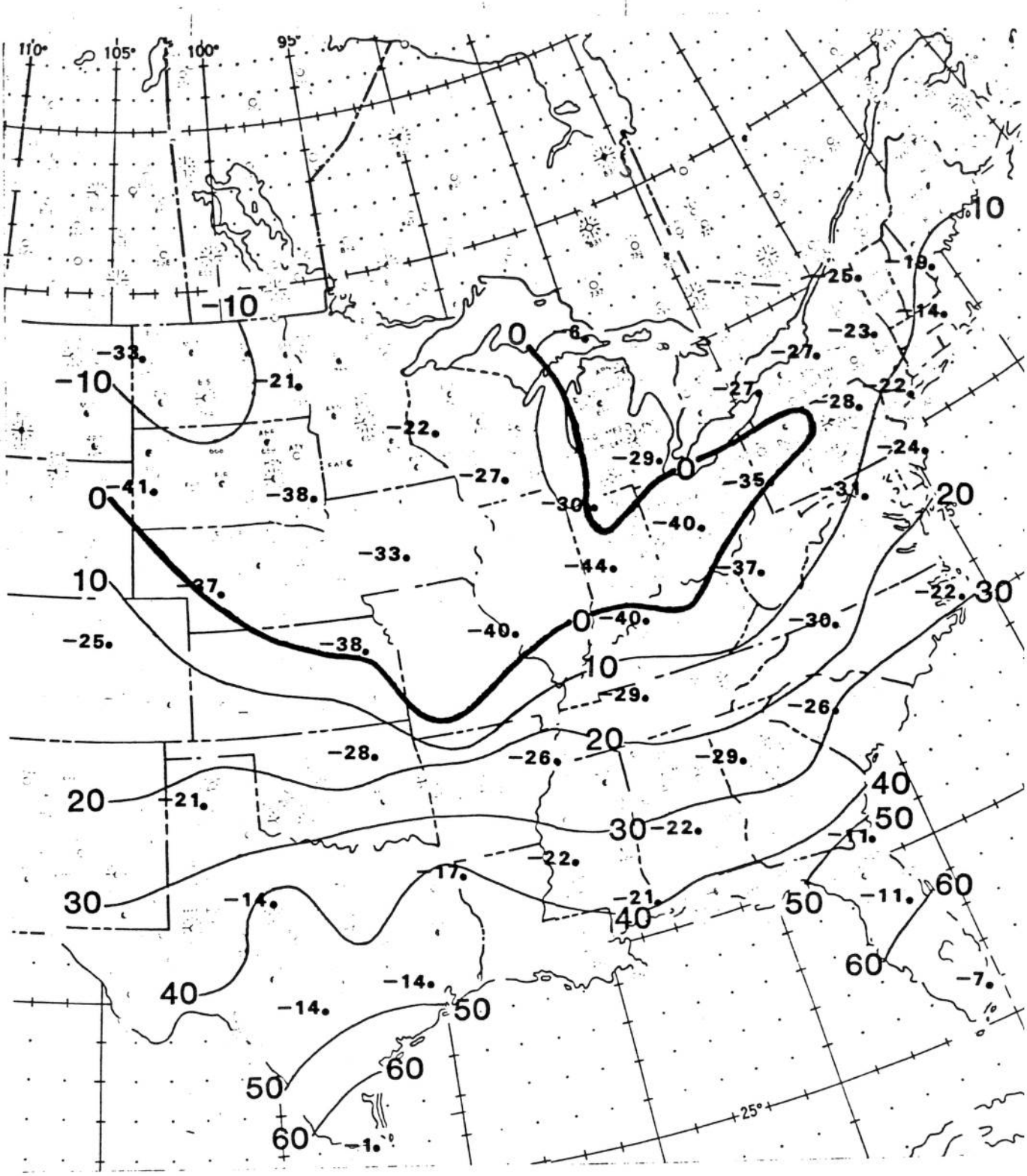

Figure 1a. Isotherms of observed calendar day maximum temperature (°F) for January 10, 1982. The values plotted at selected locations are departures from normal in °F.

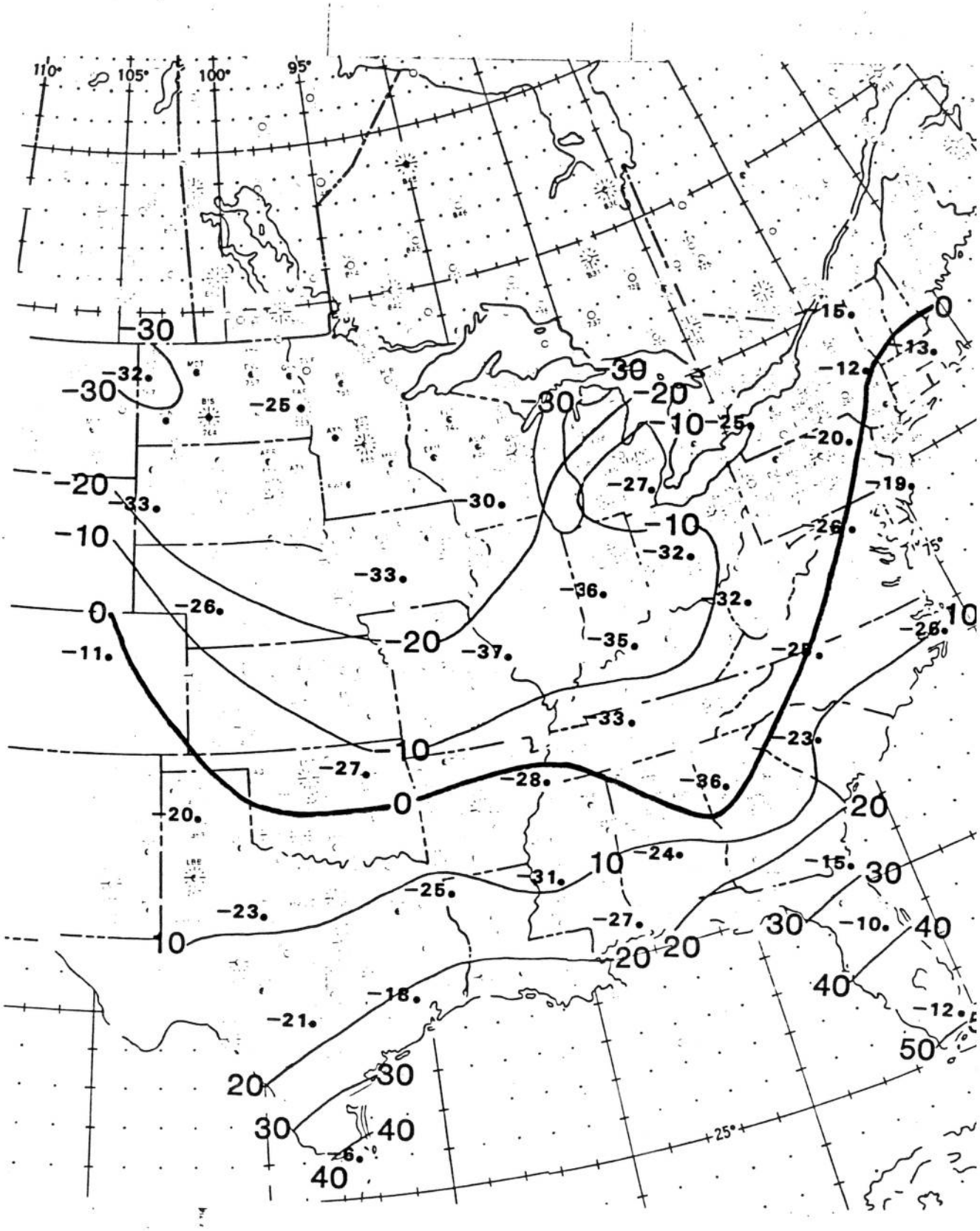

Figure 1b. Same as Fig. 1a except for minimum temperature.

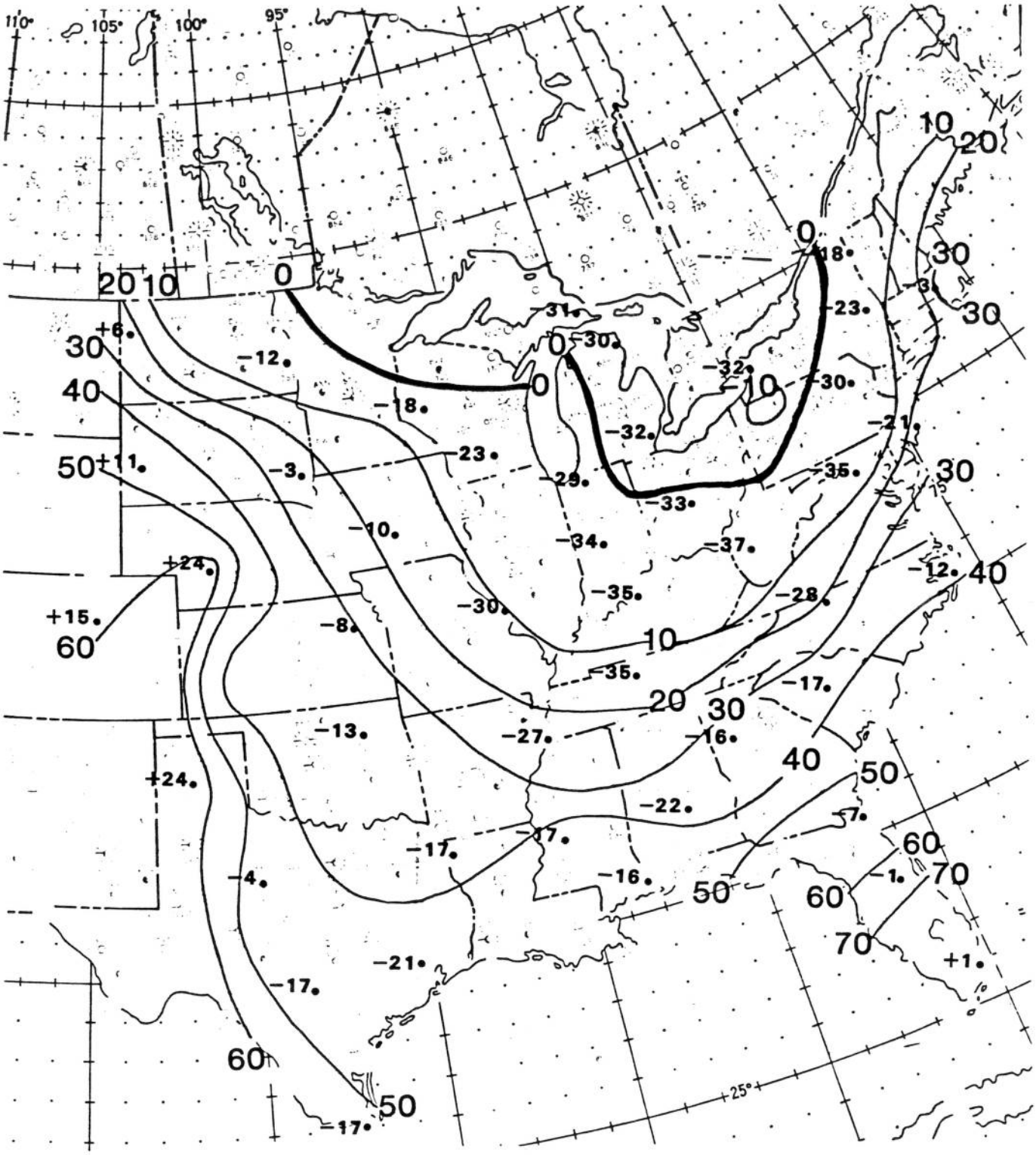

Figure 2a. Same as Fig. 1a except for January 17, 1982.

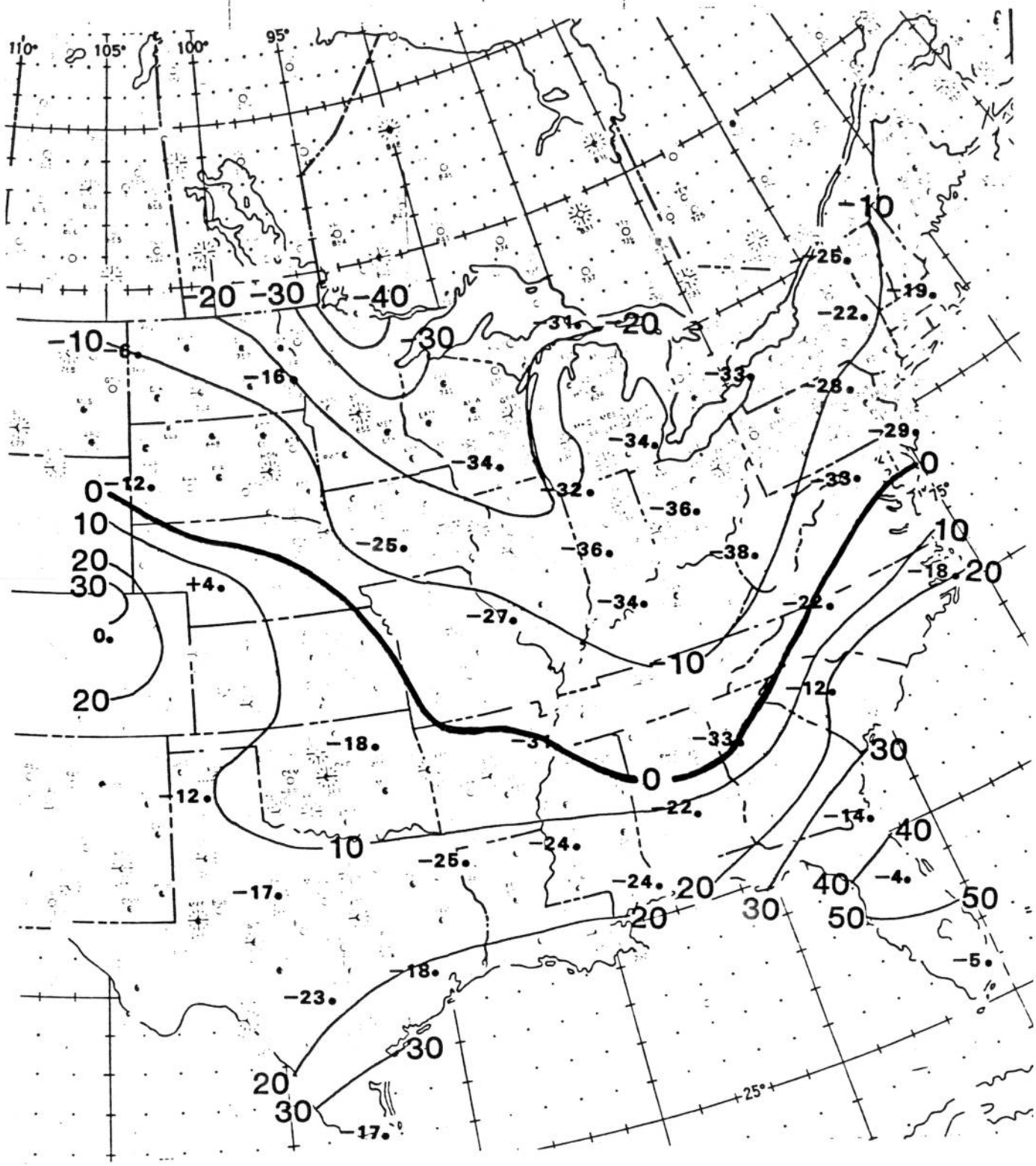

Figure 2b. Same as Fig. 1a except for minimum temperature on January 17, 1982.

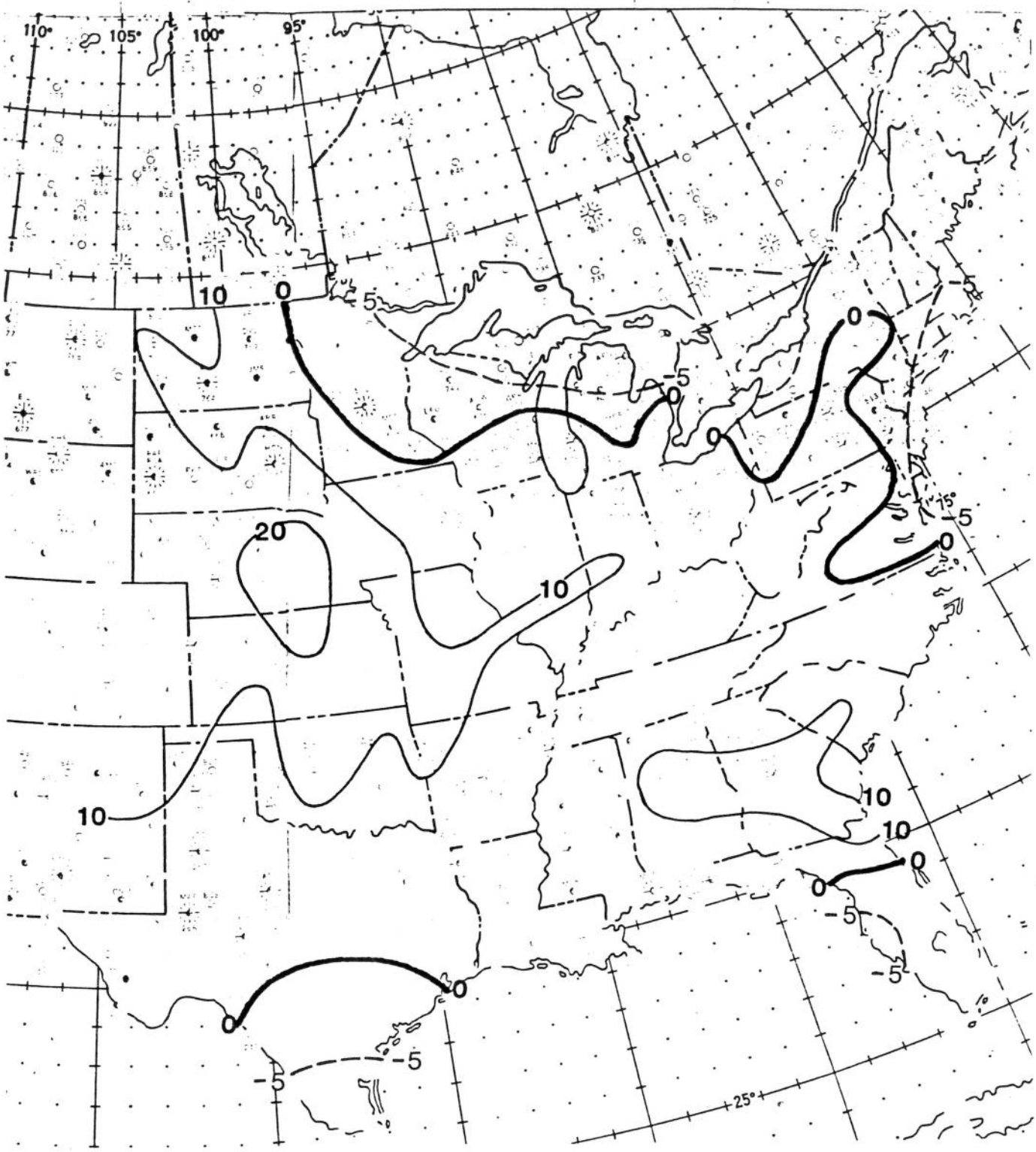

Figure 3. Isopleths of forecast minus observed temperature error in °F for the 24-h maximum temperature forecasts valid on January 10, 1982.

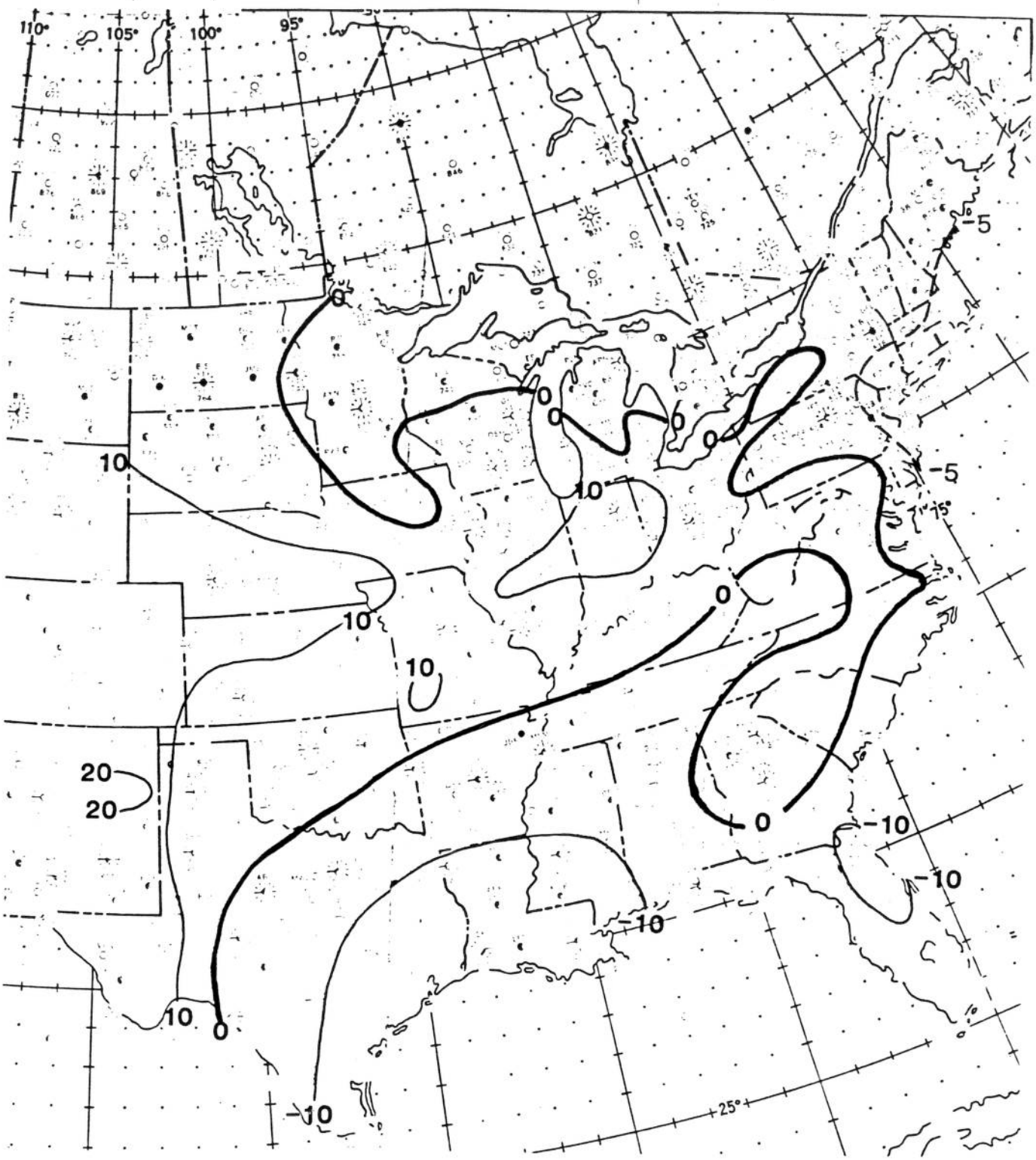

Figure 4. Same as Fig. 3 except for 48-h maximum temperature forecasts.

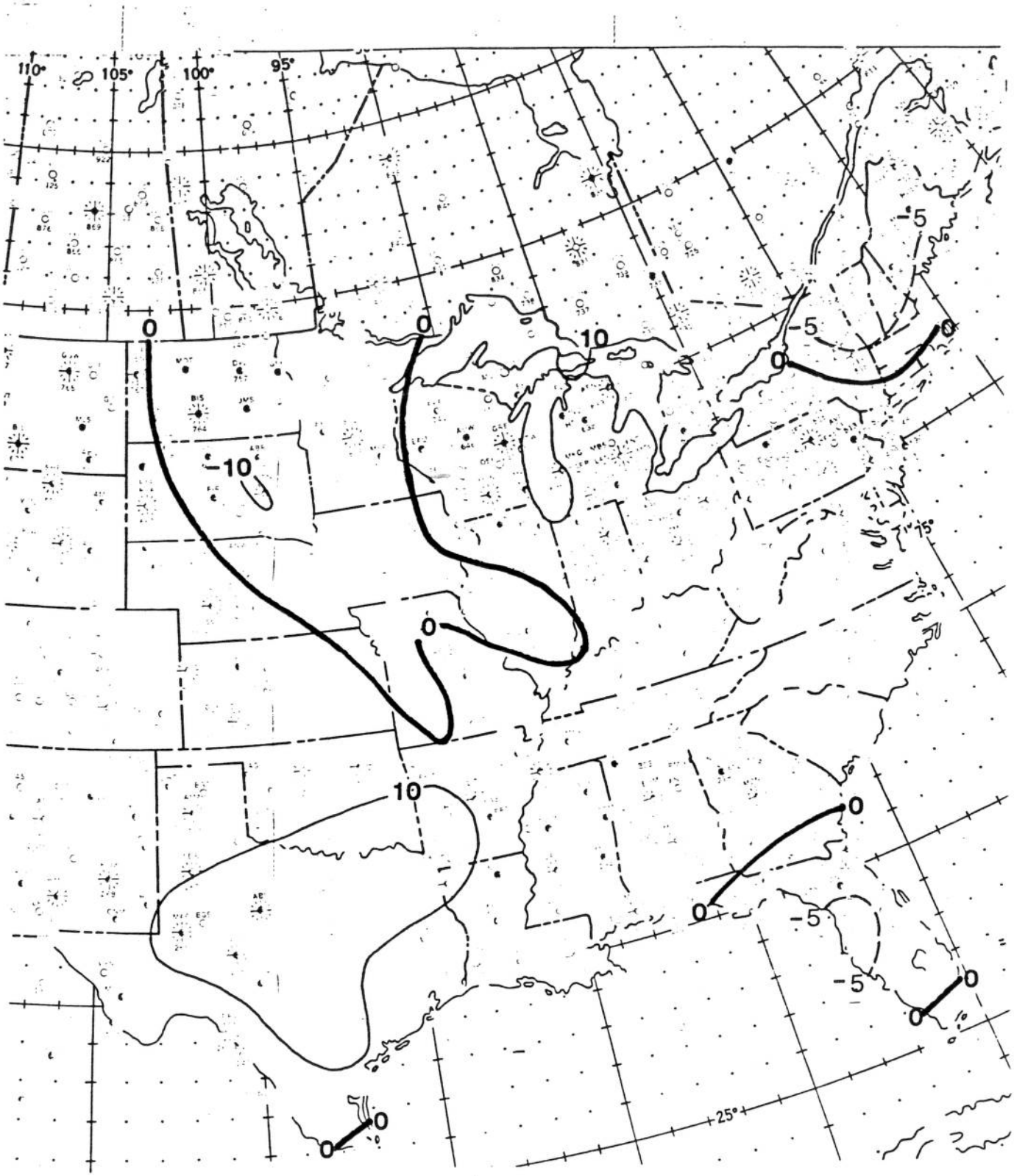

Figure 5. Same as Fig. 3 except for 24-h minimum temperature forecasts.

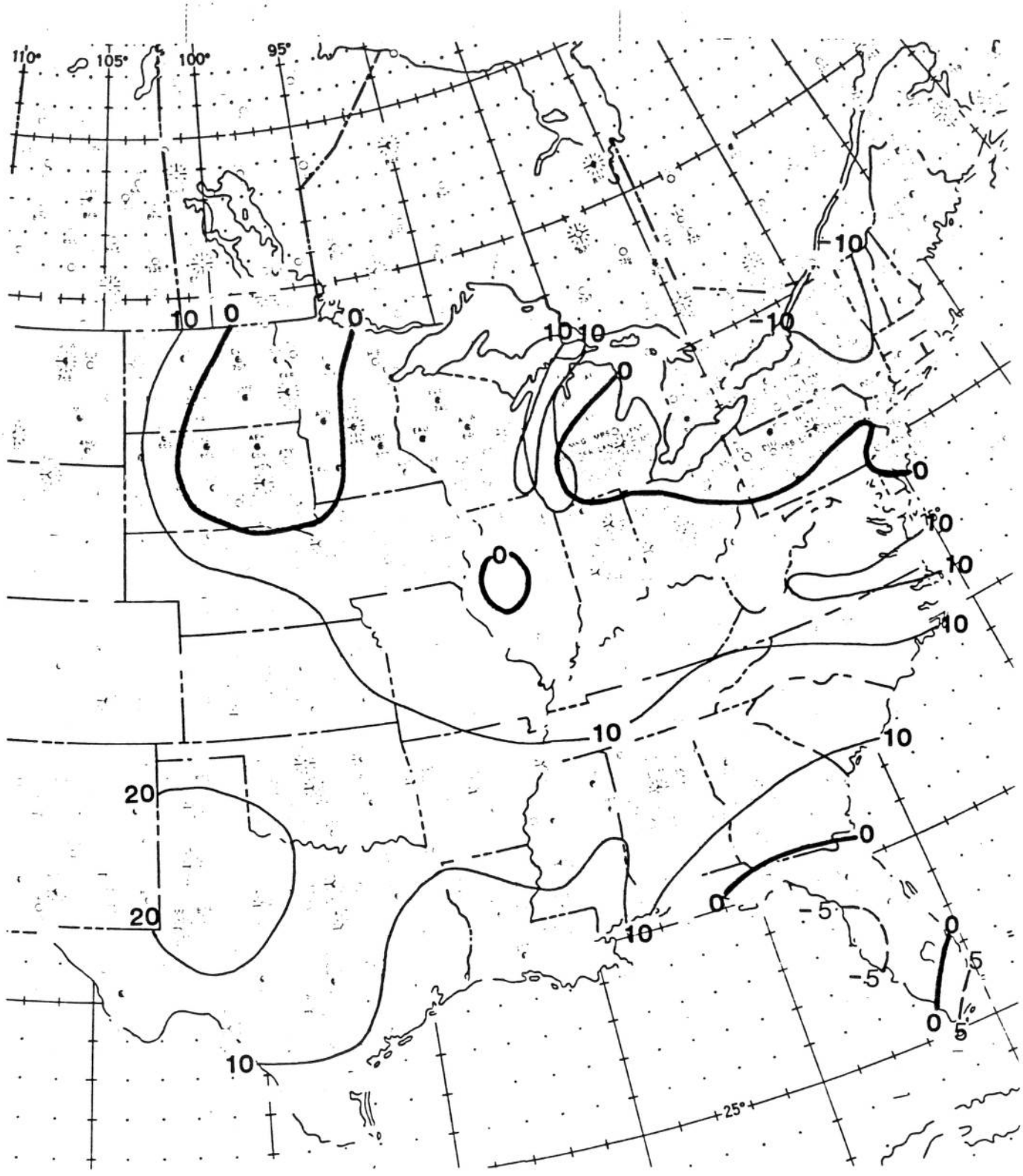

Figure 6. Same as Fig. 3 except for 48-h minimum temperature forecasts.

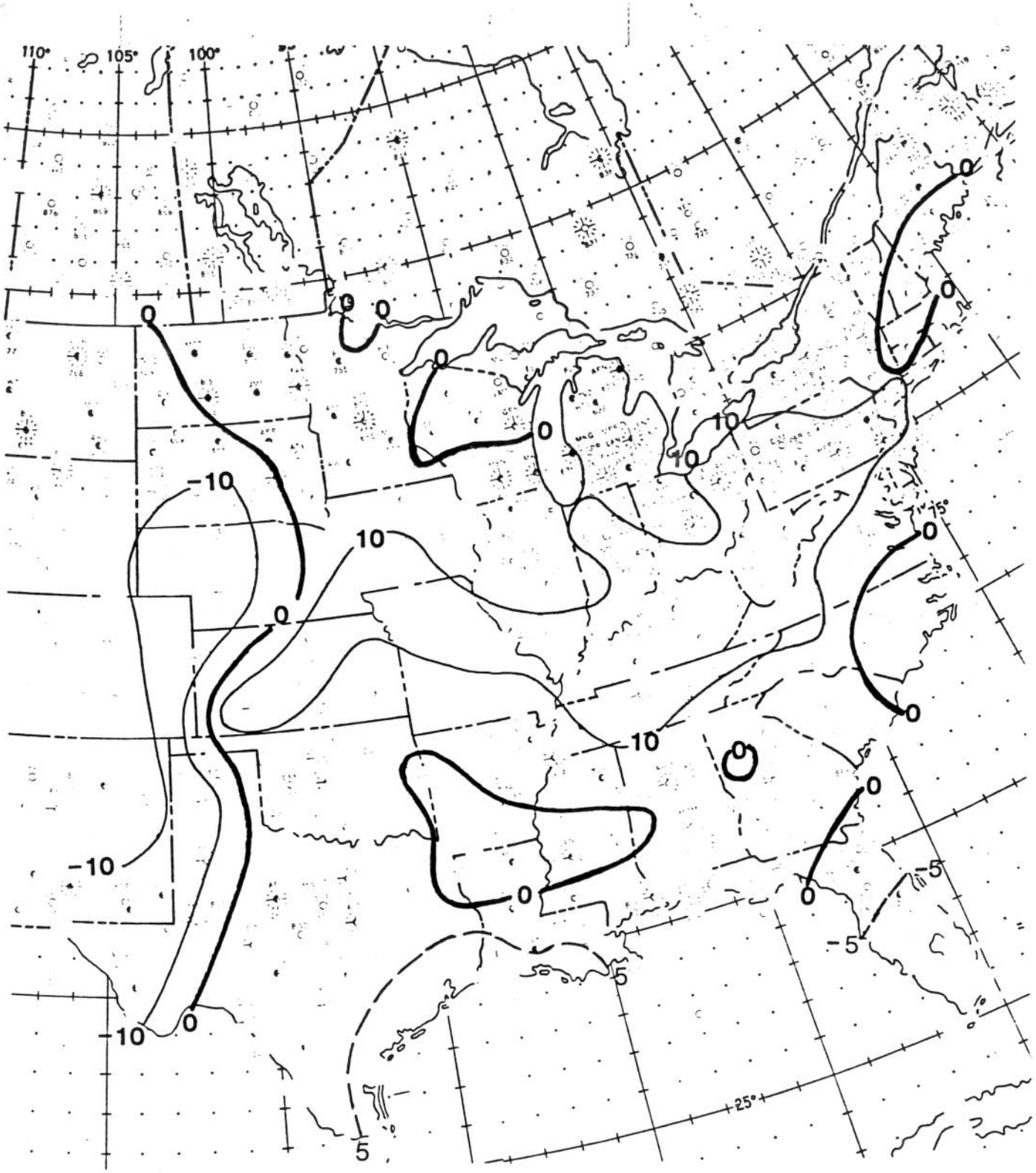

Figure 7. Same as Fig. 3 except for the 24-h maximum temperature forecasts valid on January 17, 1982.

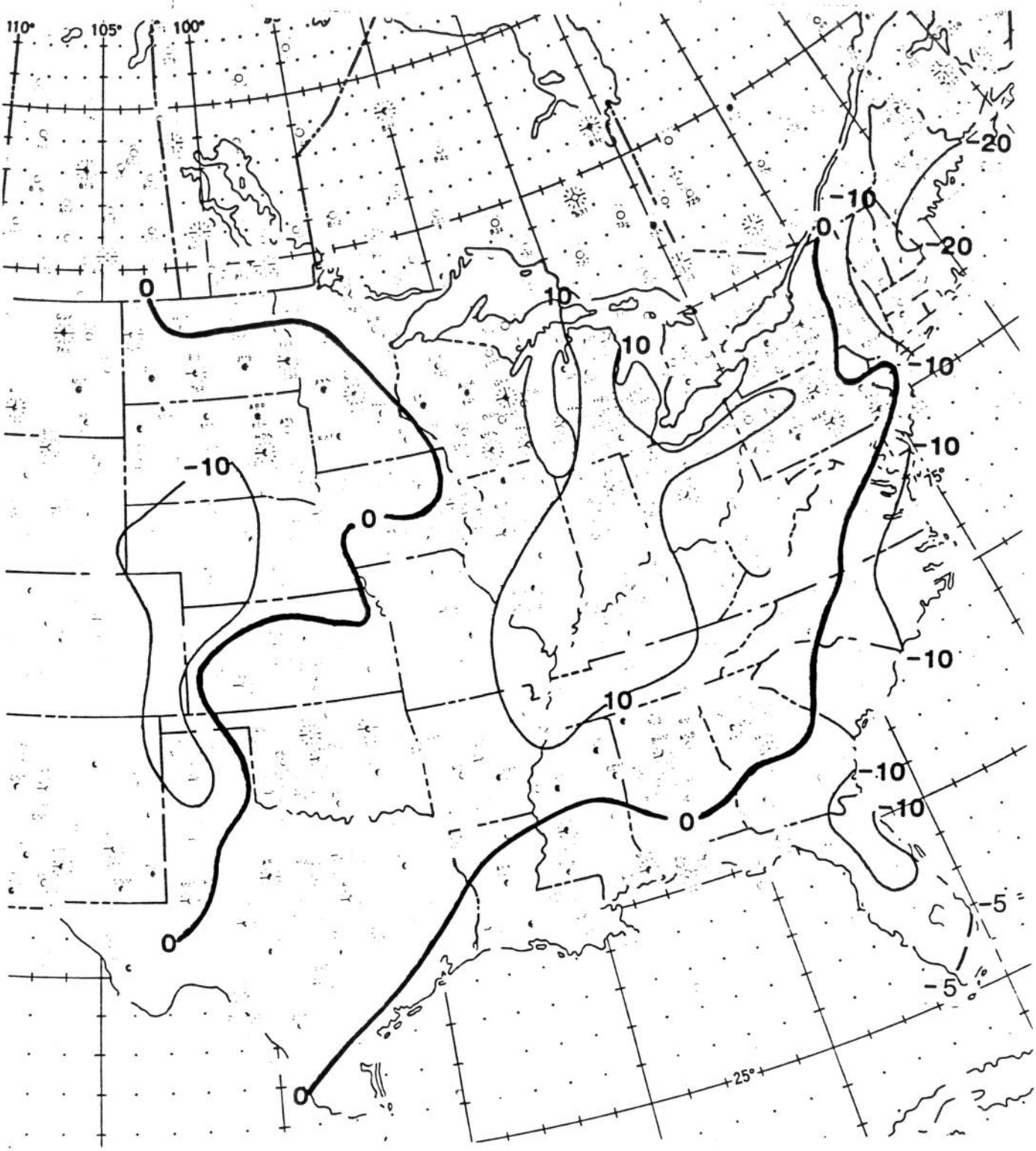

Figure 8. Same as Fig. 3 except for the 48-h maximum temperature forecasts valid on January 17, 1982.

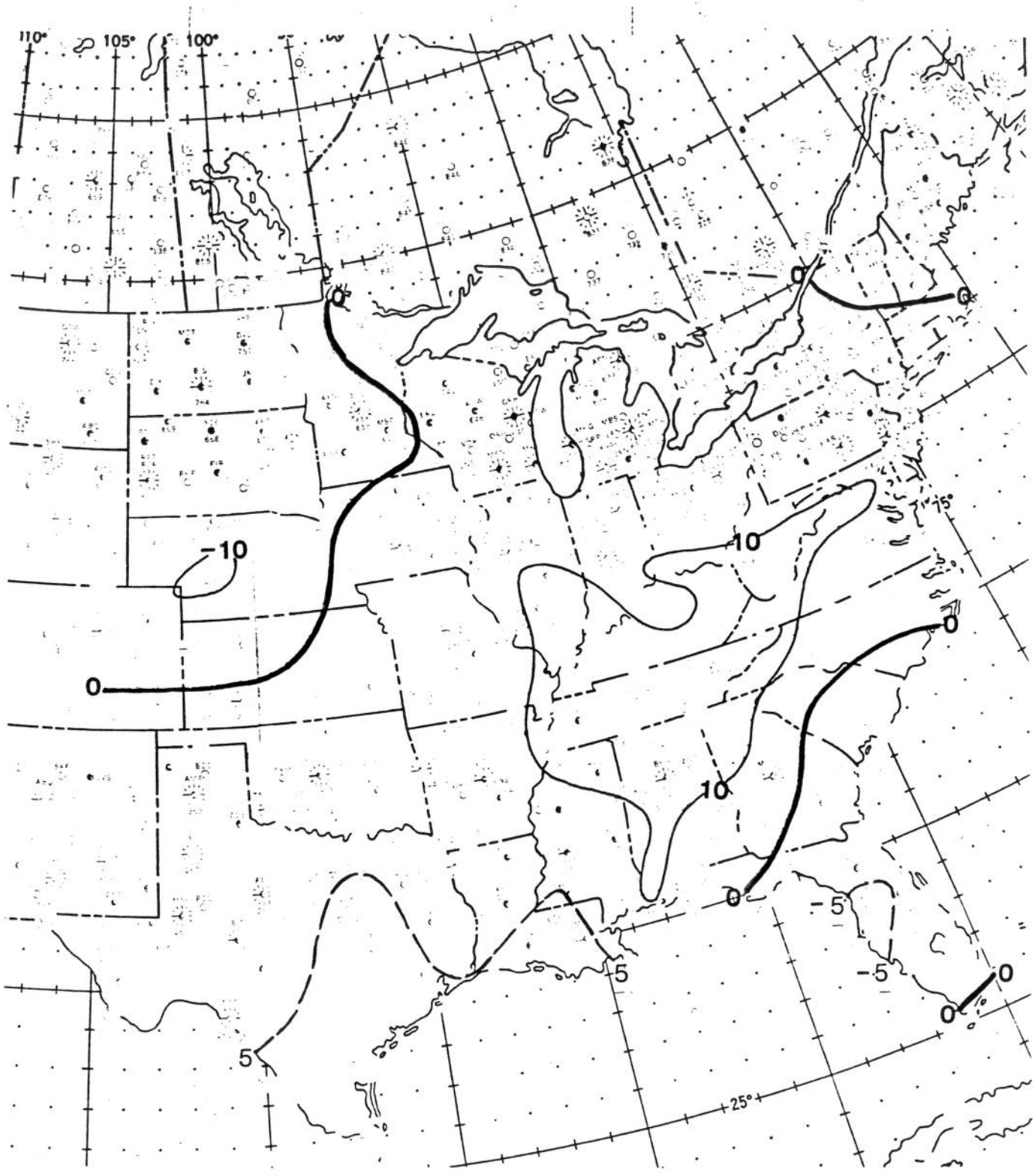

Figure 9. Same as Fig. 3 except for the 24-h minimum temperature forecasts valid on January 17, 1982.

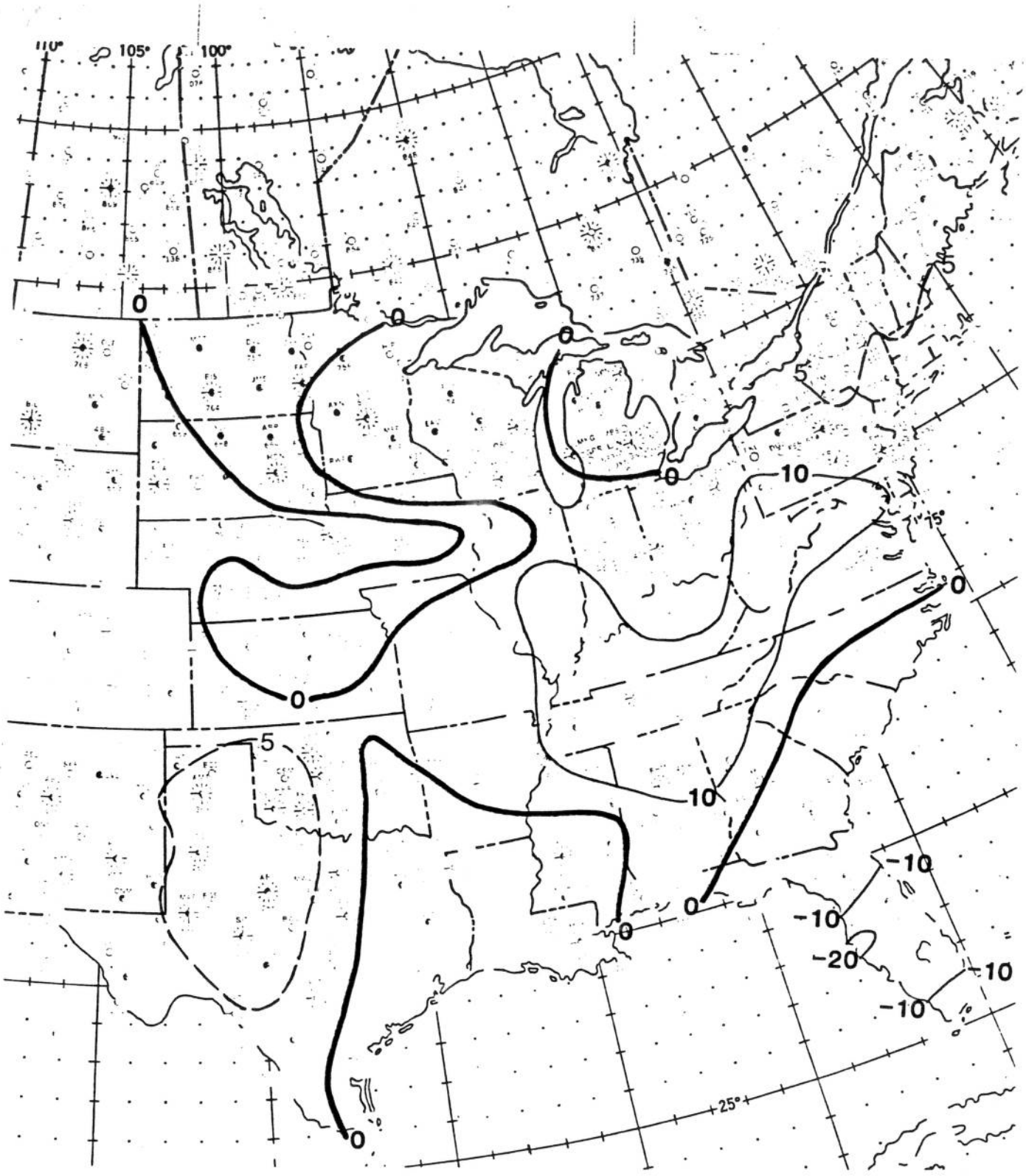

Figure 10. Same as Fig. 3 except for the 48-h minimum temperature forecasts valid on January 17, 1982.