EASTERN REGION TECHNICAL ATTACHMENT
NO. 90-6B
JULY, 1990

VERIFICATION OF THE OHIO 3 TO 5 DAY FORECAST FOR 1988

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1. INTRODUCTION

In the fall of 1987, a Cleveland area newspaper wrote an article on 3 to 5 day forecasts. The paper obtained the 3 to 5 day forecasts from several TV stations and the National Weather Service and they did a simple verification on each product. The verification included an evaluation of the temperature forecasts and whether rain occurred when a chance of precipitation was mentioned. According to the results, there was no clear winner because the forecasts were only accurate about 50% of the time. Since the newspaper may have caught the product during a bad month, I conducted another verification project by using Ohio data for calendar year of 1988.

2. THE 3 TO 5 DAY PRODUCT

A. Background

The 3 to 5 day forecasts issued by the Cleveland forecast office are primarily a subjective interpretation of the data provided in the 3 to 5 day guidance charts (93P, 94P, 95P, 9JH, 9KH, 9LH). These charts are produced by the Medium Range Forecast Group at NMC by manually modifying the statistical output from the MRF/AVN runs, based upon other guidance available to the unit (see Weather and Forecasting, Vol 4, No. 3, 359-362).

Charts 93P, 94P, and 95P give point forecasts of the min/max/PoP along with the corresponding deviations (in percent) from climatology (see Figure 1). Point forecasts for Cleveland and Columbus are provided, while other surrounding points include Detroit, Fort Wayne, Indianapolis, Louisville, Charleston, and Pittsburgh. Generally, a forecast range of 10 °F is used, but there are times when only a 5 °F range, or even a single digit value is used. The PoPs are evaluated in conjunction with the surface progs, 9JH, 9KH, and 9LH; however, most of the weight is given to the synoptic situation rather than to the PoP. If there is the potential for precipitation, the word "chance" is often used as the qualifying term. There are times, however, when "likely" is used, but rarely are any specific categorical amounts provided.

A typical forecast would read as follows:

A chance of rain Monday. Fair and cooler Tuesday and Wednesday. Highs 75 to 85 °F Monday, cooling into the 60s Tuesday and Wednesday. Lows in the 50s Monday, cooling to 35 to 45 °F Tuesday and Wednesday.

B. Verification

The techniques used in this study were quite simple. However, the verification process itself was rather lengthy and time consuming due to the tremendous amount of data involved. This is because every period for each 3 to 5 day product was verified. In other words, the 365 extended forecast products were multiplied by three, which provided about 1,095 days worth of data. The 12 stations used in this study

were Cleveland, Columbus, Cincinnati, Akron-Canton, Dayton, Mansfield, Toledo, Youngstown, Findlay, Lunken, Zanesville, and Huntington. Huntington, which is on the West Virginia side of the Ohio river, was used to represent Ohio zone 9 in south central Ohio.

The weather, temperature, and precipitation forecasts for days three, four, and five were recorded for each extended forecast issued with the afternoon forecast package (Figure 2). As shown in Figure 2, the first column has the date that the 3 to 5 day product was issued; column two indicates the dates and days of the forecast period; column three has the forecast and observed weather conditions; and column four shows 1) the max temperature forecast, 2) the number of stations out of 12 that fell within the forecast range, and 3) the observed temperature range if the predictions for less than nine stations verified. Similar information is given for the min temperatures in column five; column six lists the precipitation forecasts and observations. Each period of a forecast was verified by using the 12 NWS and FAA reporting stations in Ohio.

Verification of the precipitation portion of the forecast was done on a hit/miss basis. Most forecasts use the qualifying term "chance" to denote the probability of precipitation, but the public's perception of this term in the 3 to 5 day product is often that of a categorical forecast. Therefore, the verification was done on this basis, rather than with the use of Brier scores. If the forecast mentioned a chance of precipitation for a particular period, then a minimum of 4 out of the 12 reporting stations were required to observe measurable precipitation for the forecast to be a hit. If less than 4 stations observed precipitation, then the forecast was considered a miss. If NO precipitation was forecast, then nine out of the 12 reporting stations had to report NO measurable precipitation for the forecast to be a hit. If four or more stations reported measurable precipitation, then the forecast was a miss. For example, Figure 2 shows the 3 to 5 day forecast issued on April 1, 1988, for Monday, Tuesday, and Wednesday the 4th, 5th and 6th, respectively. Scattered showers were forecast for Monday, while fair weather was indicated for Tuesday and Wednesday. Highs were to be in the 60s each day with lows in the 40s. Looking at the weather column and precipitation columns, one can see that Monday and Tuesday were fair, while showers prevailed Wednesday. None of the 12 reporting stations observed measurable precipitation on Monday or Tuesday, while all 12 observed rain on Wednesday. Thus, the weather and precipitation forecasts for Monday and Wednesday were misses, while the forecast for Tuesday was a hit. In column six, the single M (or H) under the 'OH' represents a miss (or hit) for the state in general. The percentages of hits and misses for each period were also totaled on a monthly and annual basis and are displayed in Figure 3 (precipitation forecast) and Figure 4 (precipitation not forecast).

Two verification products were produced for the temperature forecasts. The first, and probably the most important, was the verification of the highs and lows. The temperature forecasts were verified by counting the number of stations with highs (or lows) that fell within the predicted range. For example, if the forecast called for highs in the 60's, then stations with highs within the range of 60 to 69 °F verified. If only a single value was given as a forecast (high around 60 °F), then a station verified if its high was between 58 and 62 °F, inclusive. Let's look again at Figure 2, the max temperature forecast of in the 60's for Monday, April 4, was correct (OK) with 9 of the 12 stations falling into the forecast range. On the other hand, the guidance was too cool Tuesday and Wednesday. None of the stations verified the forecast for Tuesday, while only four did on Wednesday. The minimum temperature forecast was correct for each period, since most of the stations reported lows in the 40s. The total number of stations out of 12 that fell within a forecast range were logged and totaled for each period on a monthly and an annual basis (Figure 5). I realize that this is not the standard method

for verifying temperature forecasts, but it should provide an indication of general accuracy.

The second part of the temperature verification focused on whether there was a significant warm or cold bias for the forecast highs or lows for a monthly basis. For each period, if less than half the stations were correct, then a qualitative + or - was assigned to that period indicating that the forecast had a warm or cold bias. The +'s and -'s were totaled for the highs and lows independently for each month. The resultant sum was the net qualitative bias. Figure 6 provides a breakdown of the qualitative temperature bias. For example, for day three for the month of January for HIGH temperatures, the 11/31 means that 6 or more of the 12 reporting stations were outside of the forecast range for 11 days of the month. The forecast was too warm five of those 11 days and too cold six of those 11 days, which averaged out to -1. A substantial bias would be one where at least a third of the month was outside of the forecast range, and of that third, the majority of days had a warm or cold bias. An example of a significant bias would be the day five predictions for the February HIGH temperatures. Sixteen of the 29 days were outside of the forecast range, and of those 16 days, 14 had a cold bias giving a net bias of -12. Figure 7 shows the observed monthly temperature averages for the state and the departures from normal; these values were used for comparison with the results in Figures 5 and 6.

3. RESULTS

Overall, the Ohio 3 to 5 day forecast product did not perform particularly well during 1988. High temperatures (Figure 5) for day three fell within the forecast range on an average of 51% of the time for the year. The day four and five annual averages were even lower at 46 and 42%, respectively. The best verification months for high temperatures were late summer (August - September). The high temperature forecasts had a mean annual cold bias (Figure 6), with day four being the coldest.

Low temperature verification results (Figure 5) were only slightly better than those for the high temperatures. Again, day three was the best with an annual average of 54%. Days four and five came in at 51 and 47%, respectively. The best overall verification months were April, July, and August. The forecasts had a mean annual warm bias (Figure 6), with day three being the warmest.

The verification results for the precipitation portion of the 3 to 5 day forecast were better than those for the temperatures. When precipitation was forecast (Figure 6), the state in general verified at an annual average of 72% for day three, with 62 and 54% for days four and five. In other words, for day three, four or more stations observed measurable precipitation 72% of the time when precipitation was mentioned in the forecast.

The overall precipitation verification results were best when NO precipitation was mentioned in the forecast (Figure 4). Again, as one would expect, day three was most accurate followed by days four and five, which were essentially the same.

4. CONCLUSIONS

The Ohio 3 to 5 day temperature and precipitation forecasts were verified for the entire 1988 calendar year. These forecasts were based on a direct subjective interpretation of the AFOS guidance graphics 93P, 94P, 95P, 9JH, 9KH, and 9LH.

As the temperature forecast results show, the day three highs were accurate 51% of the time, while the lows were correct 54% of the time for the entire year. The forecasts for days four and five for both the highs and lows were less accurate.

The forecast and mean temperatures were plotted to see if any patterns would emerge (Figure 8). One thing that stood out, was that the 3 to 5 day guidance was occasionally out of phase with observed temperatures. As shown in Figure 8, the

forecasts were too slow in bringing in a cold airmass, during January 13-18, 1988. This pattern seemed to repeat iteself on several occasions throughout the year. Indeed, the temperature forecasts were in the ball-park much of the time, but because of the timing problems; the verification scores were low.

The other problem occasionally noted was that the forecasts did not handle extreme warm-ups or cold invasions very well. Predicted temperatures would occasionally be off by 15 to 25 °F. There apparently was a reluctance to drastically depart from climatic averages.

Both of these problems may have contributed to a cool bias overall for the forecast high temperatures, and a warm bias for the low temperatures. As shown in Figure 6, the most severe cold bias for high temperatures for each period occurred during the month of November. Figure 7 shows that the average observed high temperatures during November were 2.4 °F above normal. The most extreme warm bias for the highs occurred in October when the average observed highs were 7.7 °F below normal.

There were two periods during 1988 when temperatures departed significantly from normal. In the late spring and summer months of May, June, July, and August, high temperatures averaged 3 to 6 °F above normal. During this time, daily highs were frequently in the 90s and on several occasions above 100 °F. The forecasts did a fairly good job during this period as no significant temperature bias was noted, except for a slight cool bias in June. In fact, August was the best verification month for high temperatures with 57% correct. The temperature forecasts again did a pretty good job in July and August, which were two of the best verification months for low temperatures (64% and 60%, respectively). July had a slight cool bias, but August showed little bias overall.

Another interesting period for the observed temperatures was during the month of October. This month was exceptionally cool and had the greatest deviation from normal for both the high (-7.7 °F) and low (-5.9 °F) temperatures. The forecasts during this month had a very strong warm bias for both highs and lows.

The results of the precipitation verification were better than those of the temperatures. The forecasts verified best when precipitation was not forecast. In this stratification, the day three verification results (Figure 4) were the most accurate (70%), while the scores for days four and five were only slightly behind. The verification results weren't quite as good when precipitation was mentioned in the forecast.

In general, the precipitation forecast results were encouraging. The drought of 1988 was a significant weather event. This drought began in March, with observed precipitation of 0.88 inches below normal, while June was 2.88 inches below normal. It's not surprising that June was the best month for verification when precipitation was NOT forecast (87%). Here, the forecast did very well. In contrast, January was the worst month of verification when precipitation was NOT forecast (57%). Ironically, January was the best month when precipitation was forecast (80%).

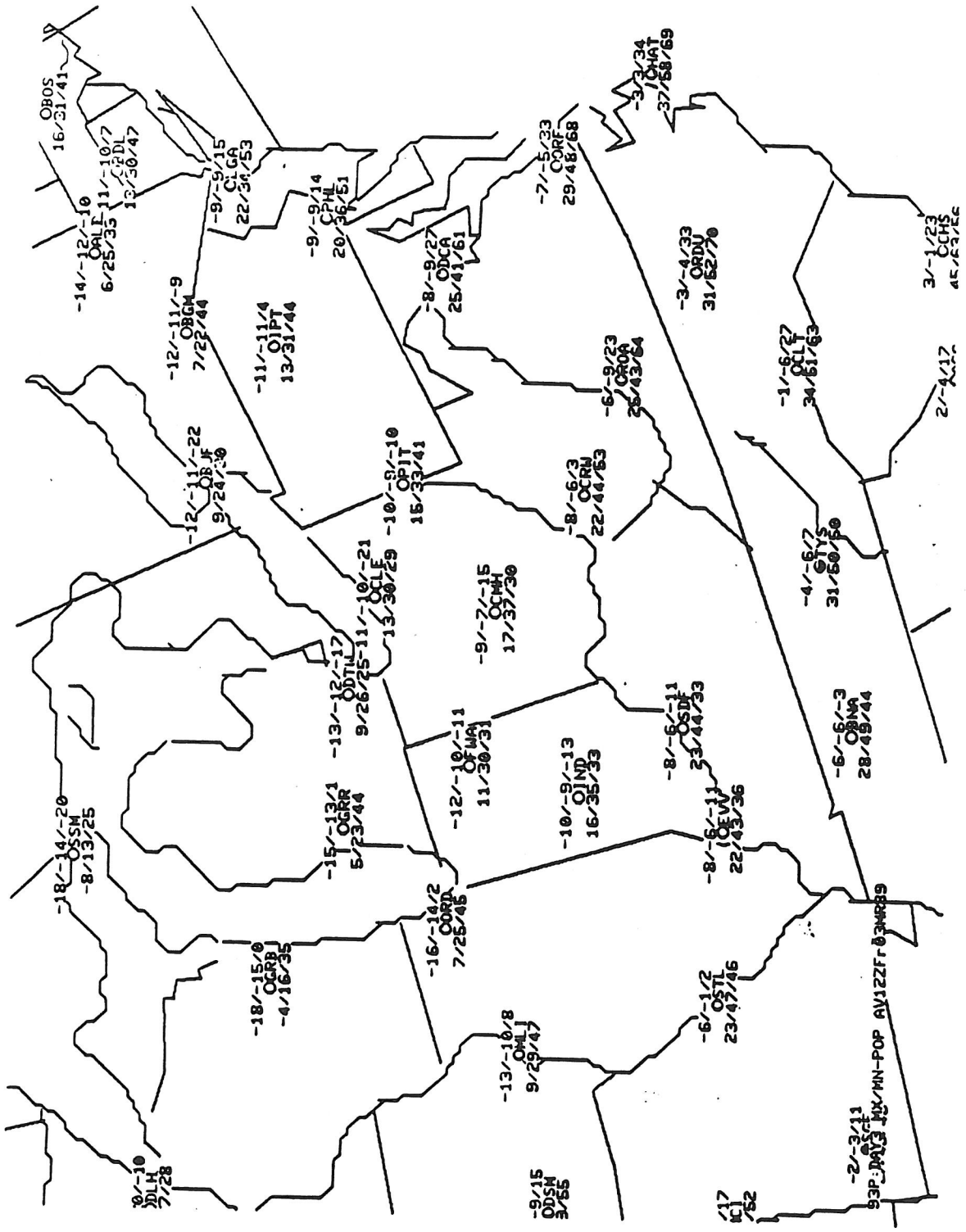

FIGURE 1: 3-5 day guidance graphic from the AVN run.

APRIL 1988

1	2 DATE	3 WEATHER		4 MAX	5 MIN	6 PRECIP	OH
4/1	4 MON	SCT RW	FAIR	60s: 9/12 OK	40s: 11/12 OK	Y: 0/12	M
	5 TUE	FAIR	OK	60s: 0/12-(75-85)	40s: 11/12 OK	N: 0/12	H
	6 WED	FAIR	SHWRS	60s: 4/12-(65-75)	40s: 9/12 OK	N: 12/12	M
4/2	5 TUE	FAIR	OK	65-75:0/12(75-85)	40-50:11/12 OK	N: 0/12	H
	6 WED	CHC RW	OK	70s: 7/12 (65-75)	45-55: 9/12 OK	Y: 12/12	H
	7 THU	CHC RW	OK	70s: 0/12+(40-50)	50-60: 0/12 +(35-45)	Y: 12/12	H
4/3	6 WED	RW LKLY	OK	UPR-MID 60s&70s:8/12(65-75)	NR50:7/12 (45-55)	Y:12/12	H
	7 THU	CHC RW	OK	55-65:2/12+(40-55)	40s:6/12 (35-45)	Y:12/12	H
	8 FRI	CHC RW	FAIR	UPR-MID 40s 50s:6/12(45-60)	35-45:9/12(30-40)	Y: 0/12	M
4/4	7 THU	SCT RW	OK	50s:5/12+(40-55)	NR 40 11/12(35-45)	Y: 12/12	H
	8 FRI	CHC RW	FAIR	50s:6/12 (45-60)	NR 40: 2/12(30-40)	Y: 0/12	M
	9 SAT	FAIR	OK	50s:6/12 (50-65)	NR 40: 0/12+(25-35)	N: 0/12	H
4/5	8 FRI	FAIR	OK	50s:6/12 (45-60)	30s: 9/12 OK	N: 0/12	H
	9 SAT	FAIR	OK	60s:6/12 (50-65)	30s: 9/12 (25-35)	N: 0/12	H
	10 SUN	FAIR	OK	60s:10/12 OK	40s: 0/12+ (30s)	N: 0/12	H
4/6	9 SAT	FAIR	OK	60s:6/12 (50-65)	40s: 0/12+(25-35)	N: 0/12	H
	10 SUN	CHC RW	FAIR	60s:10/12 OK	40s: 0/12+(30s)	Y: 0/12	M
	11 MON	CHC RW	FAIR	60s:9/12 OK	40s: 4/12+(30s mid 40s)	Y: 0/12	M
4/7	10 SUN	FAIR	OK	60s:10/12 OK	40s:0/12+ (30s)	N: 0/12	H
	11 MON	CHC RW	FAIR	50s:2/12 - 60s	30s:8/12 (30s mid 40s)	Y: 0/12	M
	12 TUE	FAIR	OK	50s:1/12 - 60s	30s:7/12 (35-45)	N: 0/12	H

FIGURE 2: Typical record sheet of forecasts and observations.

PERCENT OF "HITS" WHEN PRECIPITATION WAS FORECAST

MONTHLY (%)

OHIO	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAY 3	92	60	87	67	71	100	88	64	62	46	71	60
DAY 4	76	75	71	54	50	67	63	71	21	56	69	69
DAY 5	72	55	60	40	60	0	67	60	36	69	71	63
MEAN	80	63	73	54	60	56	73	65	40	57	70	64

ANNUAL AVERAGE (%)

PERIOD	DAY 3	DAY 4	DAY 5
OHIO	72	62	54

FIGURE 3: Ohio monthly and annual statistics for "HITS" when precipitation was forecast.

PERCENT OF "HITS" WHEN NO PRECIPITATION WAS FORECAST

MONTHLY (%)

OHIO	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAY 3	55	60	65	94	63	92	74	53	75	73	64	77
DAY 4	53	59	59	83	60	89	61	64	56	77	59	71
DAY 5	64	63	52	70	58	81	65	56	68	64	73	64
MEAN	57	61	59	82	60	87	67	58	66	71	65	71

ANNUAL AVERAGE (%)

PERIOD	DAY 3	DAY 4	DAY 5
OHIO	70	66	65

FIGURE 4: Ohio monthly and annual statistics for "HITS" when no

PERCENT OF TEMPERATURES OBSERVED WITHIN THE 3-5 DAY FORECAST RANGE

MONTHLY (%)

HIGHS

PERIOD	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAY 3	41	48	46	49	45	46	53	65	58	58	53	52
DAY 4	40	38	44	41	42	36	47	59	53	55	43	52
DAY 5	38	35	42	46	37	34	50	48	56	37	40	43
MEAN	40	40	44	45	41	39	50	57	56	50	45	49

LOWS

PERIOD	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAY 3	47	43	51	66	56	57	60	70	46	50	51	54
DAY 4	38	43	45	63	57	57	65	58	41	49	43	52
DAY 5	38	33	53	54	45	50	68	51	35	36	53	51
MEAN	41	40	50	61	53	55	64	60	41	45	49	52

ANNUAL AVERAGE (%)

PERIOD	HIGHS	LOWS
DAY 3	51	54
DAY 4	46	51
DAY 5	42	47
MEAN	46	51

FIGURE 5: Percent of temperatures observed within the 3-5 day forecast range.

MONTHLY QUALITATIVE TEMPERATURE BIAS

NO. OF DAYS WHEN > 6 STATIONS WERE OUTSIDE THE FORECAST RANGE | (NO. OF WARM(+), COLD(-) BIAS DAYS) NET MONTHLY BIAS

HIGHS

PERIOD	JAN	FEB	MAR	APR	MAY	JUN
DAY 3	11/31 | (+5,-6) -1	13/29 | (+3,-10) -7	4/31 | (+4,0) +4	14/30 | (+6,-8) -2	16/31 | (+8,-8) 0	11/30 | (+4,-7) -3
DAY 4	19/31 | (+9,-10) -1	16/29 | (+5,-11) -6	12/31 | (+4,-8) -4	15/30 | (+5,-10) -5	15/31 | (+6,-9) -3	17/30 | (+6,-11) -5
DAY 5	20/31 | (+8,-12) -4	16/29 | (+2,-14) -12	9/31 | (+2,-7) -5	13/30 | (+6,-7) -1	18/31 | (+9,-9) 0	16/30 | (+5,-11) -6

PERIOD	JUL	AUG	SEP	OCT	NOV	DEC
DAY 3	12/31 | (+6,-6) 0	7/31 | (+4,-3) +1	11/30 | (+6,-5) +1	12/31 | (+7,-5) +2	12/30 | (+2,-10) -8	12/31 | (+5,-7) -2
DAY 4	14/31 | (+6,-8) -2	9/31 | (+6,-3) +3	12/30 | (+7,-5) +2	11/31 | (+8,-3) +5	13/30 | (+2,-11) -9	13/31 | (+5,-8) -3
DAY 5	10/31 | (+5,-5) 0	14/31 | (+8,-6) +2	9/30 | (+3,-6) -3	19/31 | (+14,-5) +9	15/30 | (+3,-12) -9	16/31 | (+10,-6) +4

LOWS

PERIOD	JAN	FEB	MAR	APR	MAY	JUN
DAY 3	15/31 | (+7,-8) -1	13/29 | (+4,-9) -5	5/31 | (+4,-1) +3	7/30 | (+5,-2) -3	11/31 | (+8,-3) +5	9/30 | (+6,-3) +3
DAY 4	17/31 | (+7,-10) -3	17/29 | (+5,-12) -7	7/31 | (+4,-3) +1	10/30 | (+8,-2) +6	10/31 | (+7,-3) +4	13/30 | (+10,-3) +7
DAY 5	16/31 | (+7,-9) -2	17/29 | (+6,-11) -5	5/31 | (+1,-4) -3	13/30 | (+9,-4) -5	16/31 | (+9,-7) +2	12/30 | (+9,-3) +6

PERIOD	JUL	AUG	SEP	OCT	NOV	DEC
DAY 3	7/31 | (+3,-4) -1	4/31 | (+3,-1) +2	13/30 | (+9,-4) +5	15/31 | (+14,-1) +13	14/30 | (+6,-8) -2	10/31 | (+6,-4) +2
DAY 4	7/31 | (+2,-5) -3	11/31 | (+5,-6) -1	17/30 | (+9,-8) +1	14/31 | (+11,-3) +8	17/30 | (+6,-11) -5	12/31 | (+8,-4) +4
DAY 5	5/31 | (+1,-4) -3	14/31 | (+7,-7) 0	17/30 | (+10,-7) +3	18/31 | (+13,-5) +8	14/30 | (+6,-8) -2	11/31 | (+9,-2) +7

ANNUAL NET QUALITATIVE TEMPERATURE BIAS

PERIOD	HIGHS	LOWS
DAY 3	-15	+21
DAY 4	-28	+12
DAY 5	-25	+ 6

FIGURE 6: Monthly and annual qualitative temperature bias.

OBSERVED STATE TEMPERATURE AVERAGES AND DEPARTURES FROM NORMAL

	JAN	FEB	MAR	APR	MAY	JUN
AVERAGE HIGH	33.8/+.4	35.6/-.8	48.3/+1.6	60.3/ 0	74.0/+3.3	83.3/+3.6
AVERAGE LOW	16.8/-1.2	17.7/-2.6	28.7/ 0	37.5/-1.5	48.7/ 0	55.1/-2.6
AVERAGE TEMP	25.3/-.4	26.7/-1.7	38.5/+.8	48.9/-.8	61.4/+1.7	69.2/+.5

	JUL	AUG	SEP	OCT	NOV	DEC
AVERAGE HIGH	89.1/+5.8	85.4/+3.6	74.3/-1.1	56.0/-7.7	51.9/+2.4	38.9/+.9
AVERAGE LOW	63.9/+1.9	63.7/+3.0	53.4/-.4	36.8/-5.9	34.5/+1.4	22.1/-1.4
AVERAGE TEMP	76.5/+3.9	74.6/+3.3	63.9/-.8	46.4/-6.8	43.2/+1.9	30.5/-.3

FIGURE 7: Ohio monthly temperature averages and their departures from normal for 1988.

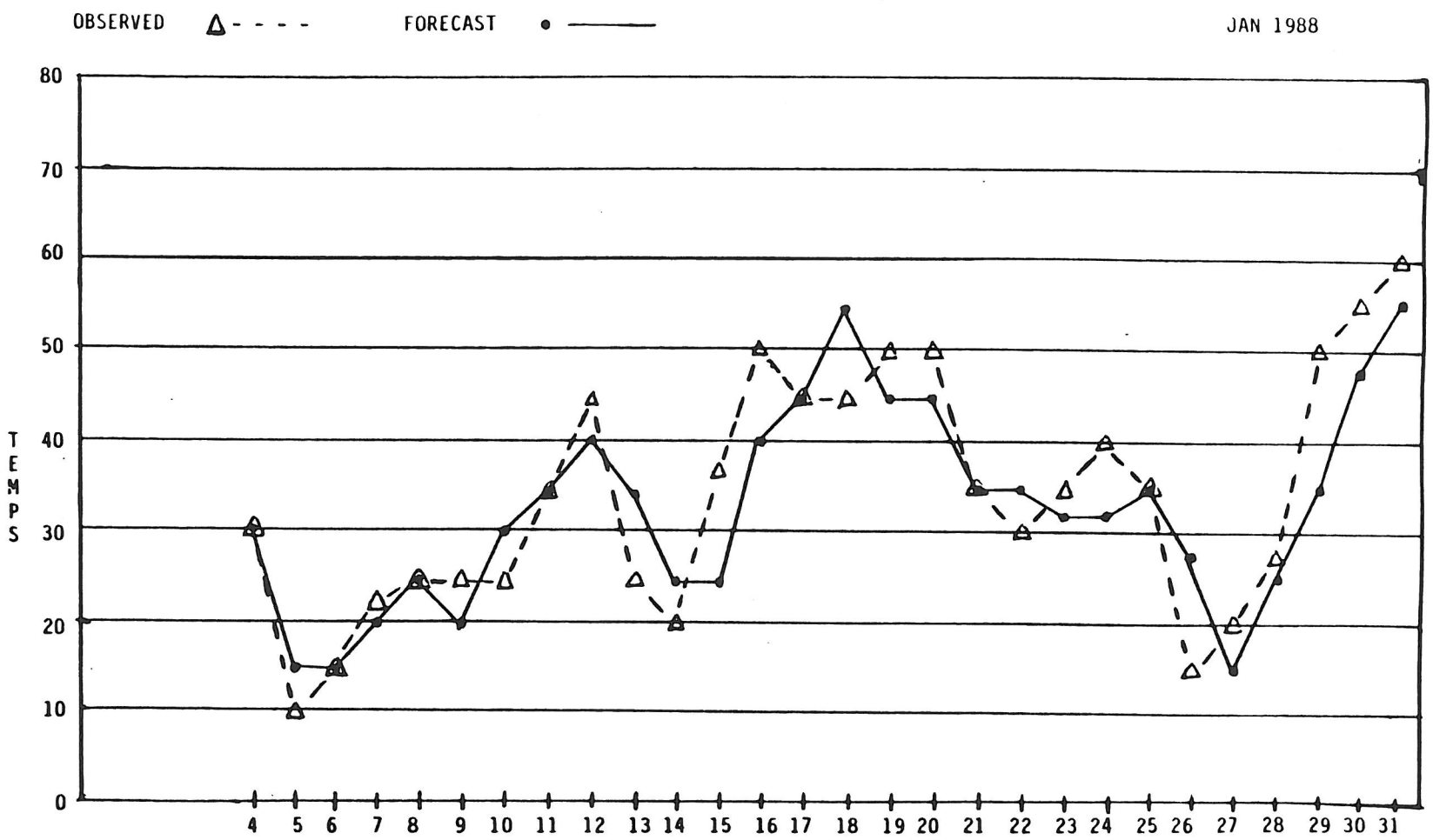

FIGURE 8: MEAN Day three max temperatures for January 1988 (observed vs. forecast)