Verification

INDIANAPOLIS WINTER SEASON VERIFICATION 1983-1984 MOS VERSUS LOCAL TEMPERATURE FORECASTS

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ABSTRACT

During the often severe and rather erratic Winter of 1983 and 1984, forecasters at the Indianapolis Weather Service Office were able to make documented overall improvements to MOS temperature guidance.

A combination of AFOS-ERA verification results and locally generated verification data show where improvements were made to the numerical guidance. Observations and comments about the verification performance of both, MOS and local forecaster are presented.

Results compared are for three forecast periods (today, tonight and tomorrow or tonight, tomorrow and tomorrow night). Data is available for separate period analyses that can further distinguish where improvements were made to the guidance forecasts. In fact significant improvements were made by the local forecasters even in the third period. This improvement in latter forecast periods illustrates that forecasters can make adjustments to guidance beyond just the first 36 hours of the forecast.

The winter months of December 1983 through February 1984 had a variety of temperatures. It was extremely cold in the middle and late part of December, again in the middle of January, and unseasonably mild for much of February. Extremes for the winter season ranged from a record high of 66 degrees on February 12th to a record setting minus 21 on January 21st. Forecasters at Indianapolis had a very wide range of temperatures to maximize forecast errors. Overall there were seven days on which record cold temperatures occurred and one day which saw a new record maximum. The daily highs and lows, along with the 7am local time snow depths for the winter months, are shown in Figure 1. The 7am snow depth is plotted because of snowcover effects on both maximum and minimum temperatures, and the reported snow depth is used as a predictor in the MOS temperature equations.

The average maximum temperature for December was almost 12 degrees below normal and the average minimum temperature was nearly 11 degrees below normal. Ten days recorded minimums of below zero, and records were set on four of those days. For the month, twenty-three days had an average temperature below normal, and seven days averaged above normal. Christmas Eve and Christmas Day saw record cold. The minus 17 on December 24th was the coldest reading of the month.

January of 1984 brought a temporary retreat from the icy cold weather when a thaw occurred during the first week of the month. However, from January 15th through the 22nd, the mercury remained below freezing. Record cold temperatures were set on the 19th, 20th and 21st with respective temperatures of minus 17, minus 16 and minus 21. The monthly temperature averaged below normal. The average maximum temperature was 3.6 degrees below normal with the average minimum 3.0 degrees below normal.

While there was a January thaw, a much longer mild spell came in February. From the 9th through the 26th temperatures were mild. The temperature reached at least 50 degrees from February 11th through the 16th. The high temperature of 66 on February 12th was a record as well as the warmest temperature of the season. In all, twenty-two days averaged above normal with only six days averaging below normal. The maximum temperature averaged 7.4 degrees above normal. The minimum temperature averaged 7.6 degrees above normal.

While the extremes of winter challenged forecasters daily, the local forecasters at the Indianapolis WSFO were able to show significant improvements over the computer derived temperatures. In comparing the performance of the local forecasters to guidance, I used the temperatures listed in the coded cities travel weather (FPUS4), issued daily at 0430 and 1530, and the Model Output Statistics (MOS) guidance derived from the LFM output based on the 00Z and 12Z upper air soundings (2). Temperatures used from the MOS guidance were the MAX/MIN forecasts for 24, 36 and 48 hours from the issued time. It must be pointed out that these temperatures are predictions of calendar day maxima and minima. The FPUS4 forecasts are predictions for the maximum and minimum temperatures of daytime highs and overnight lows. At Indianapolis, the maximum temperature forecasts are from 12Z to 00z (7am to 7pm local) with the minimum temperatures expected between 00Z to 12Z (7pm to 7am).

In order to better define the actual areas of forecast skill, I separated the data first by month, then by period (24 hours, 36 hours and 48 hours), and then by maxima and minma predictions.

Figure 2 shows the mean absolute error for each of the first three forecast periods (maximum and minimum temperatures combined), local forecasters versus MOS for December 1983. In each period, forecasters at the local office made significant improvements to the MOS guidance.

Looking at just the minimum temperatures broken down into three periods, you will note that the local forecaster was better than MOS for each period (Figure 3). MOS average error was at least 5 degrees for each period. Also plotted on this Figure is the mean algebraic error for each period. This shows the bias of the predictions. A bias close to zero indicates that there is no trend to forecast either consistently too cold or too warm.

Figure 4 shows the substantial improvements the local forecasters were able to make to MOS guidance maximum temperatgure predictions. Note the 2 degree improvement in the first period, increasing to 3 degrees in the second period and over 4 degrees better in the 48 hour maximum temperature forecasts. Also noteworthy is the large bias for MOS to be consistently too warm with the maximum temperature forecasts. While the bias of the local forecast was also increasingly too warm with time, the MOS bias in the 3rd period was an amazing plus 9 degrees. The local bias at the same time was only plus 3.74 degrees. Clearly, these results alone show the excellent ability of the local forecasters to make significant improvements to MOS guidance in the latter forecast periods.

In a month in which temperatures were extreme, differing from normal by 15 to 30 degrees in some instances, one can make large improvements to the guidance by watching the MOS bias. With AFOS-ERA verification (3), forecasters have the capability of running the verification program at any time. This allows for the opportunity to grasp consistent problems with MOS, and make changes accordingly. Previously, post-analysis (usually a season later) only provided hindsight as to what forecasters should have seen and done.

Figure 5 shows the average error for both MOS and local forecasts for the three periods in January 1984. MOS average error was at least 5 degrees for each period, while the local forecast averaged a 4 degree error or less. Both MOS and local forecasts did slightly better in the 3rd period than in the 2nd period.

The local forecasters were able to make large improvements over MOS for each period on the minimum temperature predictions (Figure 6): nearly a three degree improvement in the first period, two and a half degrees in the second period, and over two and a half degrees in the third period. Here the 24 hour and 48 hour temperatures are based on the 12Z run of the LFM, while the 36 hour (second period) predictions are from the 00Z data.

The verification results in Figure 7 show that the January maximum temperature forecast errors for MOS and the local forecasters were fairly close. The forecasts for 24 hours and 48 hours, based on the 00Z run of the LFM were superior to the 36 hour results. MOS average error of 3.74 degrees for both the 24 hour and 48 hour forecast is over a degree and three quarters better than the 36 hour forecast. The 48 hour maximum temperature comparison shows that the local forecasters improved very little on the already fine MOS guidance (3.58 local versus 3.74 MOS). You'll agree that an average error of less than four degrees for a third period forecast in January is quite acceptable.

Recalling that February was more than seven degrees warmer than normal, you must now look for an abrupt change that the MOS bias might show in the short term. By now, the local forecasters were quite aware that MOS was consistently too warm on the maximum temperature predictions, especially in the 48 hour projection. How would the local forecasters adjust to this sudden change?

Figure 8 shows that for each period in February, the local forecasters improved over MOS. The greatest improvement was nearly one degree in the 3rd period.

In forecasting the minimum temperature for February, both MOS and local forecasts showed a bias that was now too cold for each period. MOS had a slightly better bias in the first period, but by the third period the local forecasters showed a smaller bias toward being too cold (Figure 9).

Maximum temperature forecasts for February, shown in Figure 10, reveal once again that the local forecasters improved over MOS in all three periods. MOS had a very good bias in the first period, and a better bias than the local forecaster in both the second and third periods. In all periods, the local forecasters had a bias that was too cold, which increased in size with time. Obviously forecasters carried over the thinking of the previous months and assumed guidance was likely too warm with the maximum temperature predictions.

In Table 1, you can see the numerous occasions when forecasters differed from MOS guidance and the ability of forecasters to make adjustments to improve on guidance. For each period, in each month, forecasters were correct more often than they were wrong when they differed from guidance. During the extreme cold spells of mid and late December, forecasters made daily adjustments, usually to trim back temperatures from guidance forecasts that were too warm.

Table 2 shows the number of instances that the forecasts were too warm, too cold or right on. It is no surprise that the data shows MOS was too warm with their maximum temperature predictions 87 percent of the time (81 divided by 93) during the cold month of December 1983. Also note the over-compensation that the local forecasters made in the mild month of February 1984, when they were too cold with their maximum temperature forecast 64 percent of the time (56 divided by 87).

The warm bias of MOS was recognized by the local forecasters in December and modifications to lower MOS temperatures (particularly third period maximums) contributed to a more accurate forecast. In several cases, the adjustments were most correct when the temperatures were extremely cold. But despite this warm bias in December (early winter), this pattern was not persistent through January and February. Short term biases of MOS, quickly recognized by the local forecasters allowed for correct modifications to the MOS predictions. However, one cannot assume that the MOS bias will persist, particularly when the temperature trends towards normal.

CONCLUSIONS

The winter of 1983-1984 brought extreme temperatures, both cold and warm. The verification statistics for the local office during this season were quite impressive. However, they represent only one winter season. It is quite possible that the extreme cold followed by the unusual warmth provided a rare opportunity for the local forecasters to make large improvements over guidance. Previous data printed in national verification results of the local forecast versus MOS for past cool seasons (4) supports the overall quality of MOS temperature guidance. During a normal winter regime, MOS guidance may be quite difficult to improve on, especially in the 3rd and 4th periods of the forecasts.

Recent studies by McCarthy (5), Dallavalle (6), and Hlywiak and Dallavalle (7) pointed to instances in which improvements can be made to MOS guidance. And indeed improvements can be made to latter periods of the forecast. As pointed out in NWSTPB 344 (3), in the section dealing with operational considerations of MOS, it states "MOS has difficulties in predicting extremely anomalous conditions. During extreme conditions the MOS relationships may not be completely valid and large forecast error may result". (3)

Forecasters understanding the weaknesses, first of the LFM then of the MOS guidance, can make significant improvements to the short term temperature forecasts. It becomes more risky in the periods further away from release time, but as illustrated here forecasters can make solid improvements to MOS predictions in the later periods.

Verification results for this particular winter season show that while guidance may do fairly well predicting a trend toward extreme temperatures, it does not grasp the full extent of record temperatures. During extreme temperature conditions of the record cold in December, MOS was much too warm with the maximum temperature predictions. As stated by McCarthy (5) "MOS temperature forecast errors were greatest where the mean temperature departures were the largest...error also increased with forecast lead time".

To enhance the local forecasters ability to make improvements over guidance temperature forecasts, more local studies are needed. Make no mistake, MOS guidance is normally very good. Some of the error depicted here in these statistics is a result of the MOS MAX/MIN forecasts being for the calendar day. Forecasters can make big adjustments by focusing their attention on the 3-hourly temperature forecasts made by MOS.

For some time the TDL Unit has been publishing MOS versus local forecasters verification results on a seasonal basis. Without dissecting this information, you could be lost as to where improvements could be made to guidance. With locally generated verification data along with the AFOS-ERA, verification results are easily accessible and certainly more timely. There is nothing more gratifying than a forecasters success in improving over MOS guidance and putting out quality forecasts. Forecasters at Indianapolis are proud of their record to improve over guidance and continue to look for ways to enhance the computer derived guidance.

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FOOTNOTES AND REFERENCES

1. Craig M. Edwards is the Deputy Meteorologist-in-Charge of the NWS Indianapolis Forecast Office. He received a B.S. Degree in meteorology from Northern Illinois University, DeKalb, Illinois in June 1971. He began his career with the National Weather Service as a meteorologist intern at Milwaukee in July 1972. He transfered to Indianapolis as Warning Preparedness Meteorologist in 1976. Previous to his current assignment he was a lead forecaster at Indianapolis.

2. National Weather Service, 1984: Automated Maximum/Minimum Temperature, 3-Hourly Surface Temperature, and 3-Hourly Surface Dewpoint Guidance, NWS Technical Procedures Bulletin No. 344. National Oceanic and Atmospheric Administration, U.S. Department of Commerce, 13 pp.

3. AFOS-ERA verification is a computer software program that can be run at the local weather service office to give realtime MOS and local verification results.

4. Carter, G. M., V. J. Dagostaro, J. Paul Dallavalle, G. W. Hollengaugh, and G. J. Maglaras, 1984: AFOS-era Verification of Guidance and Local Aviation/Public Weather Forecasts - No. 1 (October 1983-March 1984). TDL Office Note 84-15, National Weather Service, NOAA, U.S. Department of Commerce, 58 pp.

5. McCarthy, D. H., 1984: The 1980 and 1983 Heat Waves in Missouri-Temperature and Rainfall Patterns and Temperature Forecasts. Preprints Tenth Conference on Weather Forecasting and Analysis, Clearwater, Amer. Meteor. Soc., 75-77.

6. Dallavalle, J. P., 1984: Objective Forecasts of Some Record-Breaking Minimum Temperatures during December 1983. TDL Office Note 84-11, National Weather Service, NOAA, U.S. Department of Commerce, 15 pp.

7. Hlywiak, K. P., J. Paul Dallavalle, 1984: Two Cases Studies of MOS Temperature Forecast Inconsistencies at Brownsville, Texas during the Winter 1983-1984. TDL Office Note 84-14, National Weather Service, NOAA, U.S. Department of Commerce, 20 pp.

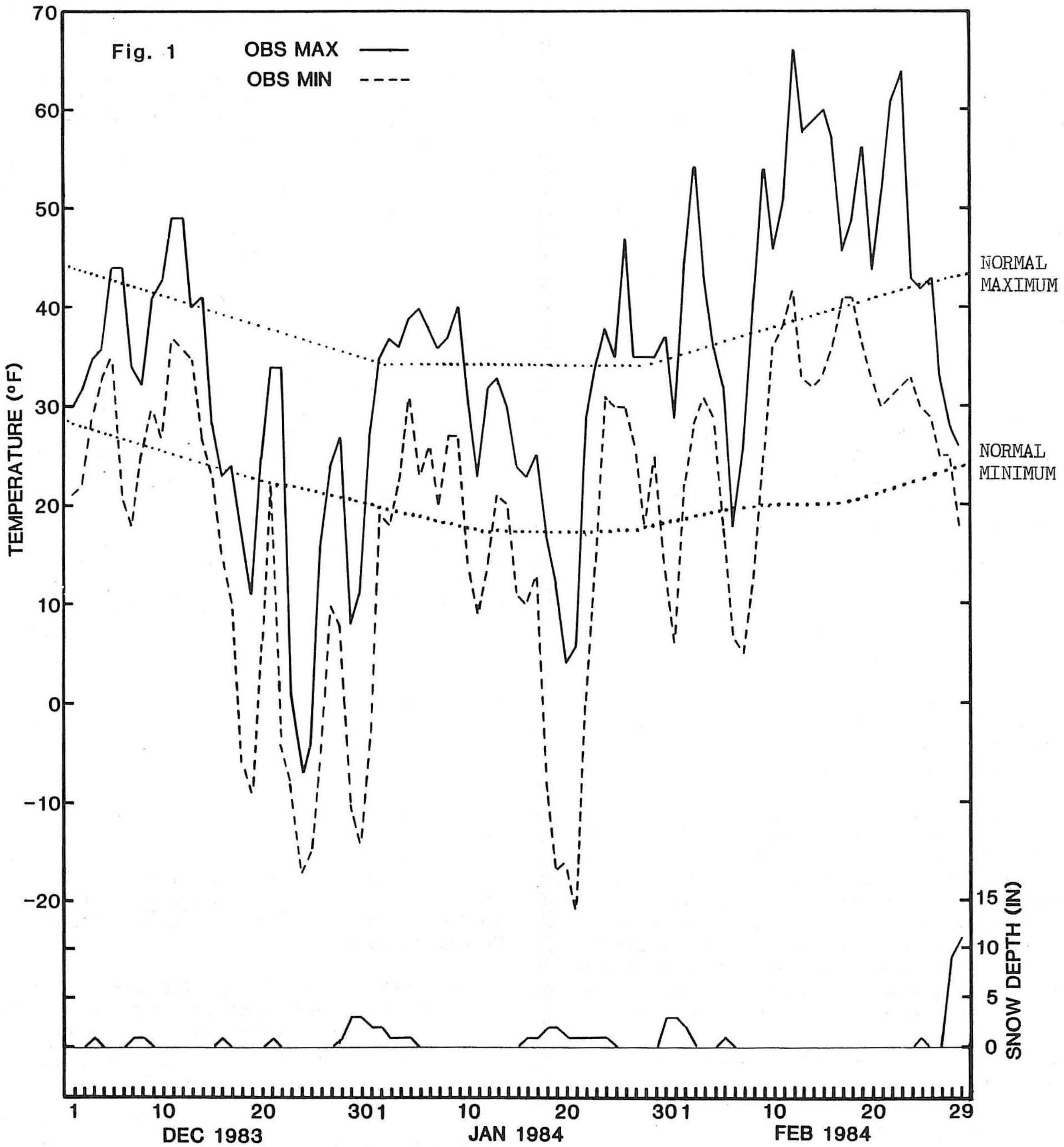
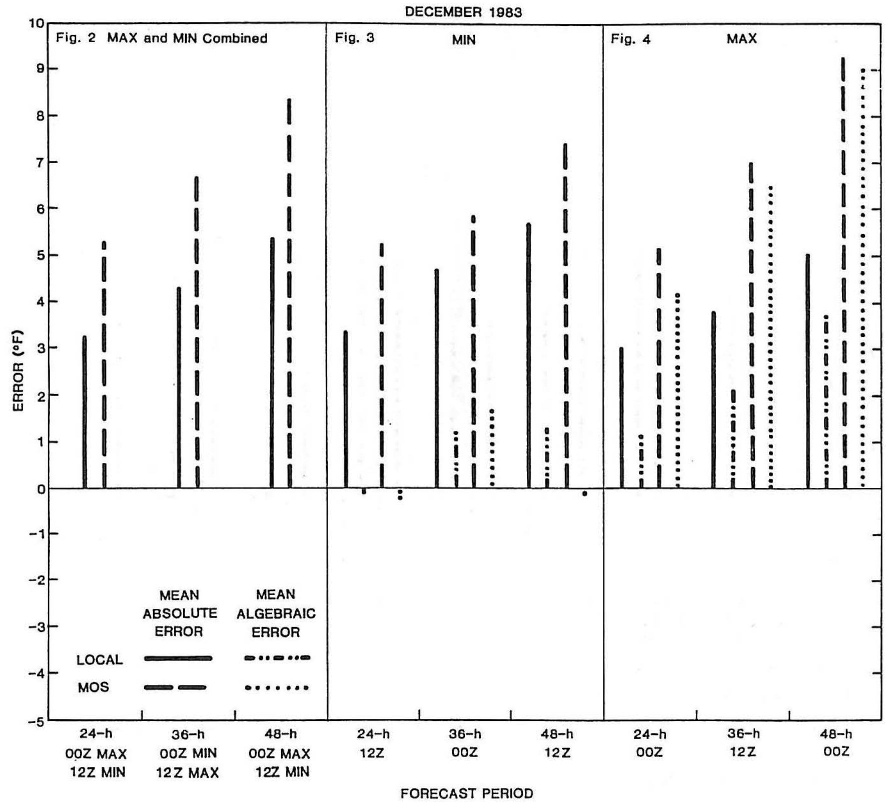
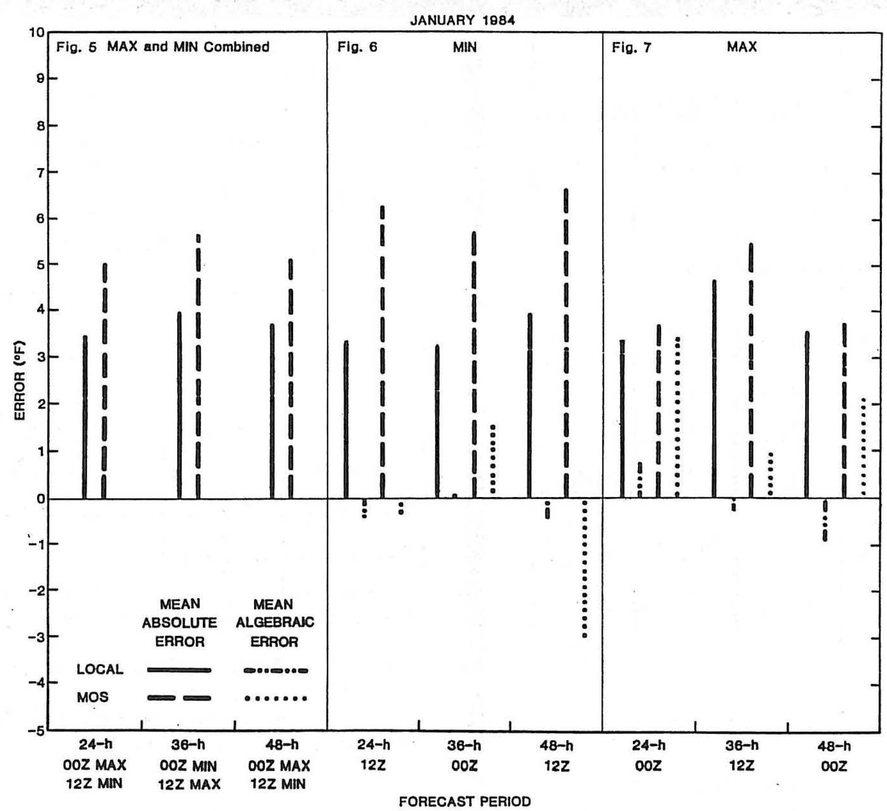


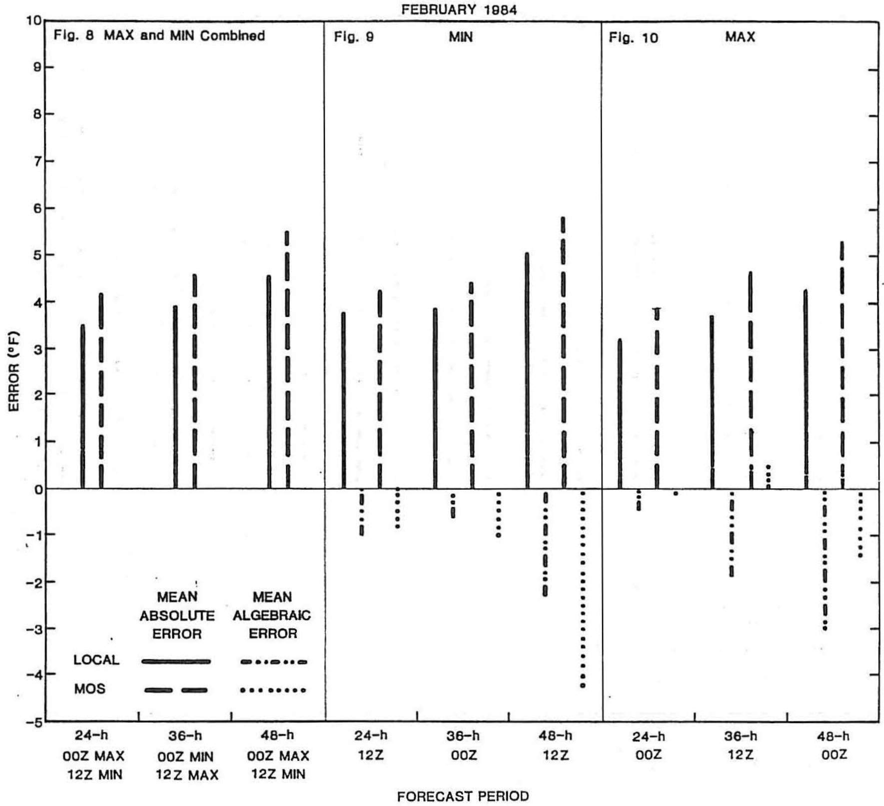
Figure 1. Maximum and Minimum temperature plot for Indianapolis winter 1983/84 and the observed 7am LST snow depth in inches at the Indianapolis International airport.



Figures 2, 3 & 4 MOS versus local forecast temperature error for December 1983, both absolute and algebraic (BIAS) errors. Note the large positive (too WARM) bias of MOS MAX temperatures.



Figures 5, 6 & 7 Same as 2, 3, 4 except for January 1984. Note MOS bias to be too cold on 48 hours MIN temperature.



Figures 8, 9 & 10 Same as 2, 3, 4 except for February 1984. See both MOS and local bias now generally too cold.

DECEMBER 83	1st Pd	2nd Pd	3rd Pd
Local Correct	41	36	41
MOS Correct	15	19	14
EVEN	6	7	7
JANUARY 84	1st Pd	2nd Pd	3rd Pd
Local Correct	36	[illegible]	33
MOS Correct	14*	16	19
EVEN	11	7	10
FEBRUARY 84	1st Pd	2nd Pd	3rd Pd
Local Correct	27	31	27
MOS Correct	23	18	18
EVEN	8	9	13

* One MOS 1st period Temperature Missing

Table I Winter Season Temperature verification 1983/84 for Indianapolis. Correct means closer to observed reading. EVEN means both MOS and local had the same absolute error.

	DEC 83		JAN 84		FEB 84	
MAXIMUM	LCL	MOS	LCL	MOS	LCL	MOS
TOO WARM	65	81	41	62	23	37
TOO COLD	20	6	43	21	56	46
HIT	8	4	9	10	8	4
MINIMUM	LCL	MOS	LCL	MOS	LCL	MOS
TOO WARM	44	37	42	39*	32	28
TOO COLD	42	48	44	48	46	53
HIT	7	8	7	5	9	6

*One MOS minimum temperature missing

Table II Winter Season temperature verification 1983/84 for Indianapolis showing monthly breakdown for MAX and MIN temperature bias. HIT means forecast was right on the mark.