# MAXIMUM TEMPERATURE BIASES AT WSFO WASHINGTON

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ABSTRACT

*The National Weather Service provides forecasters with numerical guidance through a process known as Model Output Statistics (MOS). Parameters such as temperature, precipitation probability, wind direction and speed are a few of the products derived from this system. The FO12 bulletin received twice daily contains much of the MOS information.*

*Numerical guidance, though accurate, is subject to systematic errors. Conditions not represented in the MOS equations such as snow and cloud cover, truncation errors, programming errors resulting in periodic biases, and differences in verification intervals all combine to lead MOS away from an accurate forecast.*

*Knowledge of systematic errors is essential for proper evaluation of guidance material. Forecasters must identify these errors, and make necessary adjustments before incorporating guidance products into their forecast.*

*This paper investigates maximum temperature, and attempts to locate systematic biases occurring on a seasonal basis. The conclusions and recommendations are somewhat subjective, and oriented primarily toward the forecaster. Six years of maximum temperature forecasts produced by MOS and WSFO forecasters were examined. Certain seasonal biases were discovered.*

## 1. PROCEDURE

WSFO Washington issues zone forecasts for Maryland, Virginia and Delaware. The WSFO also has the responsibility of preparing a more detailed forecast for the greater Washington metropolitan area, and because of this, it was decided to investigate temperatures at Washington National Airport (DCA). First period maximum temperatures were chosen because they were considered to be of most interest to the public.

WSFO forecasters issue the first DC and vicinity forecast about 5:00 AM EST. Before transmitting the local forecast, forecasters log on an office verification form the maximum temperature derived from MOS, and their own. The first period of the local forecast runs from 7:00 AM EST to 7:00 PM EST. Six years of temperature data was accumulated by filing through old WSFO verification forms.

To delineate temperature biases occurring on a seasonal basis, each of the six years was divided into thirty-five ten day intervals, one eight-day interval, and one five-day interval. Averaging six years of data within each interval, a bias was determined. (See Tables 3a-c). By arranging the intervals chronologically from January through December, it was possible to show graphically temperature bias as a function of season.

A total of 4200 cases were used. Failure of a MOS run, illegible handwriting, torn or lost forms accounted for any missing data.

Moisture has an important effect on maximum temperature. To detect any bias which might be produced by differences in atmospheric relative humidity, each ten-day interval was divided into those occurring in a 'wet' atmosphere, and those occurring in a 'dry' atmosphere.

A forecast of relative humidity was taken from the 0000 GMT FOUS 18-hour projection of mean relative humidity from the boundary layer to near 500 MBS. A wet atmosphere was defined as having a relative humidity equal to or greater than 60 percent; a dry atmosphere less than 60 percent. Sixty percent was chosen because a higher relative humidity might greatly limit the number of wet cases.

Figure 1 represents a graph showing intervals occurring with low relative humidity. Figure 2 represents those with high relative humidity. The number of cases comprising an interval is shown at the top or bottom of each point.

## 2. DISCUSSION

The first portion of this discussion deals with temperature biases occurring in an atmosphere forecast to have relative humidity less than 60 percent.

Beginning in early December and continuing through mid-February, maximum temperatures produced by MOS show a strong positive or warm bias. (See Figure 1.) WSFO forecasters continue the same warm trend, but with a lower bias. Several factors may contribute to this trend.

In December, the first of many arctic fronts pass through the Washington area. Cold advection associated with these is strong, and often overrides the normal diurnal temperature variation. Under these conditions, warmest temperatures occur within any verification period just before, or during, the onset of cold advection. This can lead to a bias.

For the Eastern Region, the National Weather Service defines the first period of the early morning forecast as beginning at 7:00 AM EST (1200 GMT), and ending at 7:00 PM EST (0000 GMT). A maximum temperature must be forecast within that time. MOS, however, selects a maximum from a longer time period (midnight to midnight). When strong cold air advection begins lowering temperatures at the start of the MOS verification period, by the time the forecaster's verification period begins, the actual temperature will be considerably lower. MOS 'sees' the earlier max, and makes a warmer forecast. Comparing the observed 12-hour maximum, the forecaster's max, and that produced by MOS, MOS is consistently warmer.

Warm biases which might occur during periods of little or no cold air advection, may be the result of MOS and forecasters overestimating the sun's ability to warm the lower layers of the atmosphere. Very cold air is not easily warmed, is often shallow, and is not adequately represented by MOS. Toward the end of the cold season, the sun's strength becomes an important factor.

The strong warm bias present during the coldest months ends abruptly in mid-February. MOS maximum temperatures shift to an equally strong cold bias. Except for one ten-day interval in mid-May, MOS continues a cold bias through mid-June, and to a lesser extent through mid-September. Compared with MOS, forecasters show a lesser cold bias from mid-February to mid-June, and no bias from mid-June to mid-September.

Probably the most important element contributing to the abrupt change in bias is the rapid increase in solar energy. Additionally, there is a decrease in the frequency and strength of cold air advection. The increasing strength of the sun and weaker cold air advection are apparently underestimated by MOS and the WSFO forecaster. The heat island effect also may be underestimated.

No long term biases were found during the fall season.

The remainder of this discussion deals with temperatures occurring in an atmosphere forecast to have relative humidity equal to or greater than 60 percent.

Beginning in mid-December and continuing through mid-April, MOS develops a widely variable but consistently warm bias. (See Figure 2.) WSFO forecasters continue the same warm trend, but with a smaller bias.

Earlier in this discussion, the effect of cold advection, differing verification periods, and how they combine to produce a bias were examined. A similar effect occurs during warm advection, causing temperatures at the beginning of any verification period to be colder than at the end. The verification period for MOS extends further in time than the forecaster's and comparing temperatures forecast by MOS against the forecaster, MOS would be consistently warmer.

Cold water may also contribute to a warm temperature bias. During the late winter and spring months, many moist patterns are accompanied by water cooled winds from the northeast through southeast. MOS may lower temperature statistically with respect to these wind directions, but apparently not enough.

Another important consideration is that, at this time of year, most, if not all, high relative humidity occurrences are accompanied by overcast skies. It has been shown by others that, when skies are overcast, MOS will often overforecast maximum temperature, i.e. forecast too warm.

The continuous warm bias shown by MOS ends abruptly in late April. Except for two periods in June, MOS consistently forecasts temperatures too cold from late April through late August. In contrast to MOS, WSFO forecasters, on the average, forecast temperatures too warm. Several factors may help explain the abrupt change in MOS bias.

Toward the end of April, a shift develops away from a more stratiform type of cloudiness and precipitation to a more convective type. The occurrence of days with 100 percent overcast is dramatically reduced. At this time of year, a short period of sunshine will allow temperatures to rise rapidly. MOS probably overestimates the effect of high relative humidity, underestimates the sun's strength, and lowers temperatures too much. Forecasters are aware of this, but overcorrect. Additionally, by late spring water temperatures become warm and are less important in reducing air temperatures.

In a dry atmosphere, no prolonged biases were discovered during the fall months. The same was true for a moist atmosphere. Short term biases varied widely, but on a seasonal basis averaged close to zero.

## 3. CONCLUSION

Examining six years of maximum temperature data revealed definite seasonal biases. Temperatures over large portions of any particular season varied from consistently warm to consistently cold. A few suggestions may help forecasters identify and reduce their biases.

In a dry atmosphere, and for a large portion of the winter, MOS and the WSFO forecast temperatures too warm. By identifying strong cold air advection, keeping in mind the differing verifying periods, and using the relatively new three-hourly MOS temperature guidance, this tendency can be reduced significantly. In situations with little or no cold air advection, keep in mind that a low sun angle will add little warmth to the lowest layers of the atmosphere. Cold air during the coldest months is often shallow, not easily warmed, and not adequately reflected by MOS.

As the season shifts from cold to warm, late February onward, MOS begins to underestimate the sun's ability to warm the lower atmosphere, and probably the heat island effect as well. Beginning in late February, if a sunny day is expected, adjust temperatures upward.

Seasonal biases also appear in a wet atmosphere. Most notable is the nearly continuous warm trend from mid-December through mid-spring. By remaining aware of the inability of MOS to adequately reduce temperatures with an overcast sky, forecasters can reduce their bias by lowering temperatures a few degrees. Keep in mind that, during strong warm air advection, the longer MOS verification interval will lead to a warmer forecast relative to our 12 hour period. As the season moves through early and mid-spring, place more emphasis on the cooling effect of ocean breezes.

Water temperatures begin to warm, cloudiness and precipitation become more convective, and by mid-spring MOS changes abruptly from a warm to a cold bias. Forecasters seem to be aware of this, but overcorrect, and continue a warm bias well into September. A more conservative forecast relative to MOS would reduce this bias to near zero.

This paper has attempted to identify and locate seasonal biases made by MOS and the WSFO forecaster. Certain biases were discovered, and it is hoped through their recognition that forecasters will be able to properly adjust guidance material and produce a more accurate forecast.

### *FOOTNOTE*

*1. Clifford Crowley is currently a forecaster with the NWS at Washington, D.C. A graduate of Florida State University, he has had a variety of work assignments in locations throughout the eastern U.S. He has had an article published in an earlier Digest.*

| | CASE TOTALS | | | | TEMPERATURE TOTALS | | | | AVERAGES | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ≥ 60% | | < 60% | | ≥ 60% | | < 60% | | ≥ 60% | | < 60% | |
| Periods | Fcstr | Guid | Fcstr | Guid | Fb | Gb | Fb | Gb | Fb | Gb | Fb | Gb |
| 1-10 | 22 | 22 | 35 | 35 | +17 | +39 | +39 | +79 | .77 | 1.77 | 1.11 | 2.26 |
| 11-20 | 24 | 24 | 33 | 33 | +18 | +29 | +37 | +77 | .75 | 1.21 | 1.12 | 2.33 |
| 21-30 | 29 | 29 | 29 | 29 | -15 | +28 | 0 | + 7 | - .52 | .96 | 0 | .24 |
| 31-9 | 23 | 23 | 34 | 34 | - 6 | + 2 | -23 | +12 | - .26 | .09 | - .68 | .35 |
| 10-19 | 22 | 22 | 36 | 36 | +18 | +28 | +33 | +46 | .82 | 1.27 | .92 | 1.28 |
| 20-28 | 14 | 14 | 38 | 38 | +26 | +34 | -62 | -36 | 1.86 | 2.43 | -1.63 | - .95 |
| 1-10 | 24 | 24 | 36 | 36 | +25 | +39 | - 6 | - 4 | 1.04 | 2.88 | - .17 | - .11 |
| 11-20 | 18 | 18 | 39 | 39 | - 5 | + 7 | -36 | -42 | - .28 | - .39 | - .92 | -1.08 |
| 21-30 | 25 | 25 | 30 | 30 | - 9 | +13 | - 5 | -30 | - .36 | .52 | - .17 | -1.00 |
| 31-9 | 16 | 16 | 40 | 40 | +57 | +60 | -43 | -67 | 3.56 | 4.13 | -1.08 | -1.68 |
| 10-19 | 13 | 13 | 47 | 47 | +27 | + 9 | -50 | -83 | 2.08 | .69 | -1.06 | -1.77 |
| 20-29 | 24 | 24 | 34 | 34 | +17 | -15 | -11 | -52 | .71 | - .63 | - .32 | -1.53 |
| 30-9 | 23 | 23 | 36 | 36 | +17 | -19 | -12 | -15 | .74 | - .83 | - .33 | - .42 |
| 10-19 | 28 | 28 | 30 | 32 | -26 | -62 | +19 | +29 | - .93 | -2.21 | .63 | .91 |
| 20-29 | 27 | 27 | 32 | 32 | +20 | - 2 | -38 | -32 | .74 | - .07 | -1.10 | -1.00 |
| 30-8 | 20 | 20 | 25 | 25 | +39 | -15 | + 3 | -46 | 1.39 | - .54 | .11 | -1.84 |
| 9-18 | 24 | 23 | 35 | 35 | +35 | + 8 | - 9 | -26 | 1.46 | .35 | - .26 | - .74 |
| 19-28 | 25 | 25 | 31 | 31 | +11 | +10 | - 3 | + 7 | .44 | .40 | - .07 | .23 |
| 29-8 | 20 | 19 | 36 | 36 | +13 | - 1 | +11 | -17 | .65 | - .05 | .31 | .47 |
| 9-18 | 19 | 19 | 33 | 37 | +12 | - 6 | - 5 | -27 | .63 | - .32 | - .15 | - .73 |
| 19-28 | 26 | 26 | 34 | 34 | +11 | -13 | +26 | -17 | .42 | - .50 | .76 | - .50 |
| 29-7 | 30 | 30 | 26 | 26 | -21 | -57 | -18 | -37 | - .70 | -1.90 | - .69 | -1.42 |
| 8-17 | 32 | 32 | 25 | 25 | +17 | -28 | - 2 | - 4 | .53 | - .88 | - .08 | - .16 |
| 18-27 | 23 | 23 | 35 | 35 | +14 | -13 | + 6 | - 4 | .61 | - .57 | .17 | - .11 |
| 28-6 | 32 | 31 | 26 | 25 | +26 | + 1 | + 7 | -15 | .81 | .03 | .27 | .60 |
| 7-16 | 20 | 20 | 37 | 37 | +31 | +27 | 0 | -19 | 1.55 | 1.35 | 0 | - .51 |
| 17-26 | 26 | 26 | 34 | 34 | +24 | +33 | +38 | +16 | .92 | 1.27 | 1.12 | .47 |
| 27-6 | 21 | 21 | 37 | 37 | +33 | +21 | +27 | +19 | 1.57 | 1.00 | .73 | .51 |
| 7-16 | 20 | 20 | 39 | 39 | +29 | +44 | +36 | +28 | 1.45 | 2.20 | .92 | .72 |
| 17-26 | 14 | 14 | 44 | 44 | - 3 | +13 | +17 | 0 | - .21 | .93 | .37 | 0 |
| 27-5 | 13 | 13 | 46 | 46 | -22 | -49 | -26 | -64 | -1.70 | -3.77 | - .57 | -1.39 |
| 6-15 | 22 | 22 | 36 | 36 | +15 | - 5 | -14 | -25 | .68 | - .23 | - .39 | - .69 |
| 16-25 | 14 | 14 | 43 | 43 | +28 | +19 | + 5 | -37 | 2.00 | 1.35 | .12 | .86 |
| 26-5 | 19 | 19 | 35 | 35 | -23 | + 5 | +10 | -11 | -1.21 | .26 | .29 | - .31 |
| 6-15 | 19 | 19 | 41 | 41 | -21 | -47 | +40 | +30 | -1.10 | -2.47 | .96 | .73 |
| 16-25 | 26 | 26 | 31 | 31 | - 6 | +12 | +53 | +67 | - .23 | .46 | 1.70 | 2.16 |
| 26-31 | 10 | 10 | 26 | 26 | +13 | +6 | +27 | +36 | 1.30 | .60 | 1.04 | 1.38 |

TABLE 3A

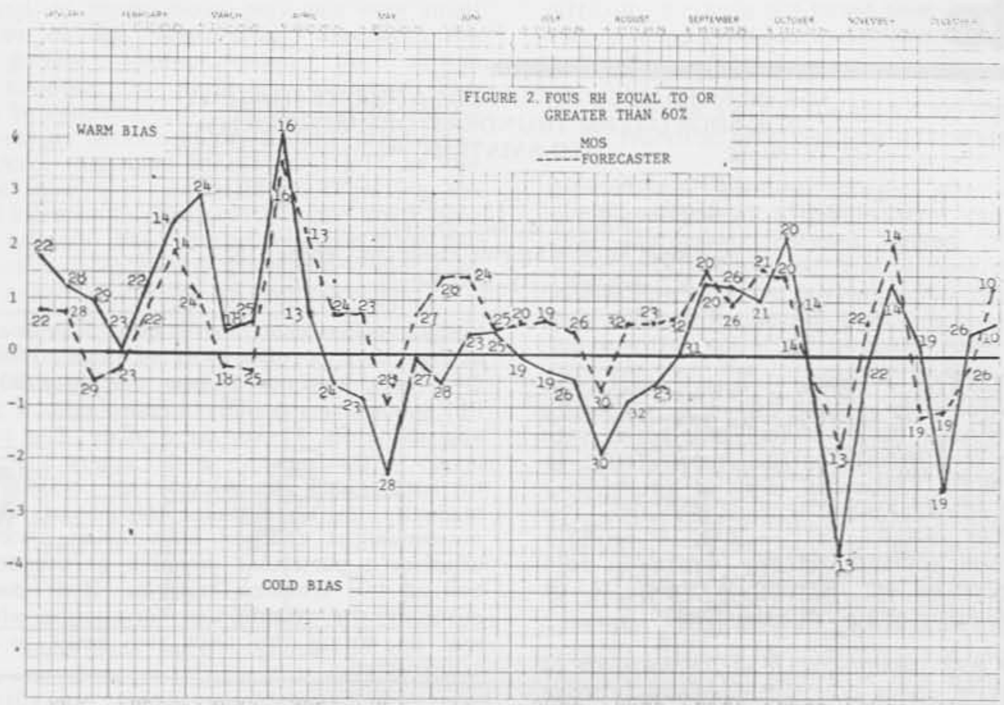
| | 1980 | | | | 1979 | | | | 1978 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ≥ 60% | | < 60% | | ≥ 60% | | < 60% | | ≥ 60% | | < 60% | |
| Periods | Fb | Gb | Fb | Gb | Fb | Gb | Fb | Gb | Fb | Gb | Fb | Gb |
| 1-10 | + 4 | 0 | + 1 | + 5 | + 1 | - 3 | + 7 | +22 | + 4 | +13 | + 7 | +15 |
| 11-20 | - 3 | -10 | +15 | +21 | +11 | +12 | + 6 | +15 | - 6 | + 4 | - 7 | - 4 |
| 21-30 | + 5 | + 3 | - 7 | -10 | -20 | - 9 | + 8 | + 9 | + 4 | + 7 | - 6 | - 1 |
| 31-9 | - 9 | -17 | - 9 | -21 | +12 | +13 | -13 | + 3 | -10 | + 1 | - 4 | - 7 |
| 10-19 | + 1 | + 3 | -13 | -14 | +14 | +12 | +16 | +27 | 0 | + 7 | + 2 | - 2 |
| 20-28 | +12 | +15 | -13 | -14 | +10 | +17 | - 5 | + 8 | + 4 | + 3 | - 6 | - 9 |
| 1-10 | - 3 | - 6 | -12 | - 6 | 0 | - 2 | - 1 | 0 | + 7 | +36 | + 7 | +10 |
| 11-26 | + 1 | + 2 | -12 | - 2 | + 5 | + 9 | -10 | -28 | - 6 | - 1 | - 5 | - 6 |
| 21-30 | - 9 | + 2 | - 6 | -12 | +1 | + 6 | - 4 | -20 | -17 | - 7 | -12 | -21 |
| 31-9 | 0 | - 2 | -19 | -15 | +35 | +47 | + 3 | + 5 | + 4 | + 9 | - 6 | -11 |
| 10-19 | - 2 | - 4 | -10 | - 9 | +17 | +20 | 0 | - 7 | - 2 | -17 | -26 | -32 |
| 20-29 | + 9 | +10 | 0 | - 6 | - 1 | + 5 | + 9 | + 4 | + 3 | 0 | -12 | -19 |
| 30-9 | + 3 | + 5 | - 1 | - 2 | + 1 | + 1 | - 7 | -10 | +12 | - 5 | -14 | -17 |
| 10-19 | - 3 | 0 | 0 | + 4 | 0 | - 1 | 0 | - 2 | -18 | -26 | + 8 | + 5 |
| 20-29 | + 6 | + 9 | + 2 | + 9 | - 1 | - 5 | - 3 | - 3 | - 6 | -18 | - 9 | -10 |
| | 1974 | | | | | | | | | | | |
| 30-8 | +23 | +21 | + 6 | - 4 | +10 | + 3 | -20 | - 3 | +11 | - 2 | + 5 | - 7 |
| 9-18 | + 5 | - 5 | - 2 | - 5 | + 7 | + 8 | +11 | +13 | - 3 | - 5 | 0 | - 6 |
| 19-28 | + 4 | + 3 | - 5 | - 8 | + 7 | + 6 | + 7 | +15 | - 7 | -17 | + 1 | - 7 |
| 29-8 | + 5 | + 5 | + 9 | + 6 | - 1 | - 4 | + 7 | + 9 | +21 | +23 | + 6 | + 4 |
| 9-18 | + 2 | + 2 | - 8 | - 5 | -11 | -13 | - 3 | - 8 | +15 | + 6 | + 3 | - 2 |
| 19-28 | + 1 | -21 | 0 | -15 | + 5 | -13 | 0 | 0 | - 3 | - 3 | - 9 | -10 |
| 29-7 | - 9 | - 9 | - 6 | -10 | - 5 | - 8 | - 3 | - 6 | - 6 | -21 | 0 | 0 |
| 8-17 | + 3 | - 2 | - 8 | - 7 | 0 | + 2 | - 1 | + 5 | - 5 | -20 | + 2 | + 3 |
| 18-27 | - 3 | - 9 | - 1 | - 4 | +14 | + 3 | - 5 | -12 | - 3 | - 7 | + 4 | + 6 |
| 28-6 | -10 | -15 | - 1 | - 1 | + 6 | - 6 | + 2 | - 4 | - 6 | - 9 | - 2 | - 5 |
| 7-16 | 0 | - 6 | - 3 | - 4 | 0 | - 6 | +10 | + 7 | + 3 | - 6 | 0 | - 3 |
| 17-26 | - 2 | -11 | + 1 | -15 | - 1 | + 6 | +10 | +11 | -10 | -12 | +12 | +10 |
| 27-6 | + 6 | - 3 | +14 | +18 | +13 | +10 | + 5 | + 5 | + 5 | + 6 | +15 | +17 |
| 7-16 | - 1 | - 1 | - 7 | 0 | +20 | +24 | + 3 | + 2 | + 4 | 0 | + 6 | + 4 |
| 17-26 | + 6 | + 6 | + 7 | + 1 | - 9 | - 9 | +13 | +13 | 0 | 0 | -20 | + 1 |
| 17-5 | -16 | -25 | -11 | -13 | - 2 | 0 | -10 | -10 | 0 | 0 | - 4 | -14 |
| 6-15 | - 2 | - 3 | + 5 | - 5 | + 6 | +12 | + 1 | + 1 | - 7 | - 8 | - 9 | - 5 |
| 16-25 | + 6 | + 3 | +24 | +23 | 0 | - 4 | -16 | -30 | + 3 | + 5 | - 1 | - 5 |
| 26-5 | - 9 | - 6 | - 4 | - 2 | - 2 | - 6 | - 4 | - 2 | - 3 | - 2 | - 3 | -11 |
| 6-15 | - 3 | - 8 | + 4 | + 7 | + 3 | 0 | + 1 | - 6 | -11 | -20 | - 3 | -11 |
| 16-25 | - 8 | - 8 | +11 | +18 | - 2 | +12 | +13 | +18 | + 3 | + 5 | + 2 | + 9 |
| 26-31 | - 3 | + 3 | - 1 | - 6 | 0 | 0 | + 3 | + 4 | + 5 | + 4 | +11 | + 6 |

TABLE 3B

| | 1977 | | | | 1976 | | | | 1975 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ≥ 60% | | < 60% | | ≥ 60% | | < 60% | | ≥ 60% | | < 60% | |
| Periods | Fb | Gb | Fb | Gb | Fb | Gb | Fb | Gb | Fb | Gb | Fb | Gb |
| 1-10 | + 2 | +26 | + 2 | + 8 | + 3 | + 3 | +18 | +24 | + 3 | 0 | + 4 | + 4 |
| 11-20 | +14 | +16 | +11 | +19 | +14 | +21 | + 7 | +20 | -12 | -14 | + 5 | + 6 |
| 21-30 | - 7 | +15 | -16 | + 3 | +22 | +31 | + 2 | - 1 | -11 | -19 | + 6 | + 7 |
| 31-9 | + 1 | + 2 | - 2 | + 1 | + 9 | +12 | + 3 | +34 | - 9 | - 9 | + 2 | + 2 |
| 10-19 | + 4 | +12 | +16 | +13 | -20 | -30 | - 1 | - 7 | +19 | +24 | +13 | +29 |
| 20-28 | - 4 | + 2 | -22 | -15 | - 2 | - 3 | -10 | - 1 | + 6 | 0 | - 6 | - 5 |
| 1-10 | - 6 | -11 | + 1 | - 1 | +16 | +41 | + 8 | + 5 | +11 | +11 | - 9 | - 6 |
| 11-26 | -13 | -15 | + 6 | + 7 | + 3 | + 2 | -17 | -16 | + 5 | +10 | + 2 | + 3 |
| 21-30 | - 1 | - 7 | + 7 | +10 | + 1 | + 4 | + 3 | + 7 | +16 | +15 | + 7 | + 6 |
| 30-9 | +13 | + 4 | 0 | - 2 | + 5 | + 8 | - 3 | -13 | 0 | 0 | -18 | -31 |
| 10-19 | 0 | 0 | - 3 | -20 | 0 | 0 | -13 | -18 | +14 | +10 | + 2 | + 2 |
| 20-29 | + 7 | -18 | - 1 | -11 | -10 | -18 | - 2 | -12 | + 9 | + 6 | - 5 | - 8 |
| 30-9 | + 7 | -11 | - 2 | - 4 | -11 | - 7 | +23 | +26 | - 5 | - 2 | -11 | - 8 |
| 10-19 | 0 | 0 | - 5 | + 3 | - 8 | -22 | +15 | +21 | - 3 | -13 | + 1 | - 2 |
| 20-29 | + 3 | - 3 | - 1 | 0 | +12 | + 8 | -23 | -25 | + 6 | + 7 | - 8 | - 3 |
| 30-8 | -12 | -13 | - 2 | - 7 | + 3 | -18 | + 1 | -18 | + 4 | - 6 | + 5 | - 7 |
| 9-18 | +16 | + 9 | - 8 | -13 | + 4 | - 1 | - 6 | -11 | + 6 | + 2 | - 4 | - 4 |
| 19-28 | + 4 | + 3 | +11 | + 3 | - 6 | -18 | -5 | - 6 | + 9 | +10 | + 1 | - 4 |
| 29-8 | + 3 | - 5 | - 1 | -22 | -14 | -18 | - 3 | - 3 | - 1 | - 2 | - 7 | -11 |
| 9-18 | + 4 | - 5 | +10 | - 2 | + 1 | + 1 | -10 | -11 | + 1 | + 3 | + 3 | + 1 |
| 19-28 | + 5 | + 6 | +16 | +11 | - 4 | - 5 | +10 | - 2 | + 7 | + 1 | + 9 | - 1 |
| 29-7 | + 3 | - 4 | + 2 | - 1 | + 3 | - 4 | -10 | -17 | - 7 | -11 | - 1 | - 3 |
| 8-17 | +10 | - 7 | 0 | 0 | + 5 | 0 | + 4 | - 4 | + 4 | - 1 | + 1 | - 1 |
| 18-27 | 0 | 0 | + 7 | + 7 | + 1 | - 2 | - 6 | -31 | + 5 | + 2 | + 7 | + 8 |
| 28-6 | + 4 | - 2 | - 3 | - 6 | + 9 | + 6 | - 2 | - 4 | +23 | +27 | +13 | + 5 |
| 7-16 | +17 | +23 | + 6 | + 1 | + 5 | +12 | -23 | -26 | + 6 | +14 | +10 | + 6 |
| 17-26 | - 4 | -10 | + 2 | 0 | - 5 | - 8 | +13 | +10 | +16 | +68 | 0 | 0 |
| 27-6 | + 7 | + 4 | - 3 | -11 | + 1 | + 3 | - 1 | - 3 | + 1 | + 1 | - 3 | - 2 |
| 7-16 | + 6 | +15 | + 6 | + 1 | - 7 | - 1 | +21 | +18 | + 7 | + 7 | + 7 | + 3 |
| 17-26 | -12 | - 2 | - 6 | -20 | +11 | +16 | +19 | +19 | + 1 | + 1 | + 4 | + 1 |
| 17-5 | - 5 | -18 | - 6 | -12 | + 1 | - 6 | +12 | + 9 | 0 | 0 | - 7 | -24 |
| 6-15 | +13 | - 1 | + 4 | + 4 | 0 | 0 | - 6 | - 5 | + 6 | - 8 | - 9 | -15 |
| 16-25 | +19 | +16 | +11 | + 7 | 0 | 0 | - 6 | - 8 | 0 | - 1 | - 7 | -24 |
| 26-5 | + 7 | +27 | + 6 | + 5 | -10 | - 5 | +11 | + 2 | - 6 | - 3 | + 4 | - 3 |
| 6-15 | - 1 | + 2 | - 4 | + 6 | + 4 | - 2 | +29 | +25 | -13 | -19 | +13 | + 9 |
| 16-25 | + 2 | + 6 | 0 | - 5 | + 7 | + 6 | +20 | +18 | - 8 | - 9 | + 7 | + 9 |
| 26-31 | - 4 | - 3 | + 1 | + 4 | + 2 | - 2 | + 8 | +24 | +13 | + 4 | + 5 | + 4 |

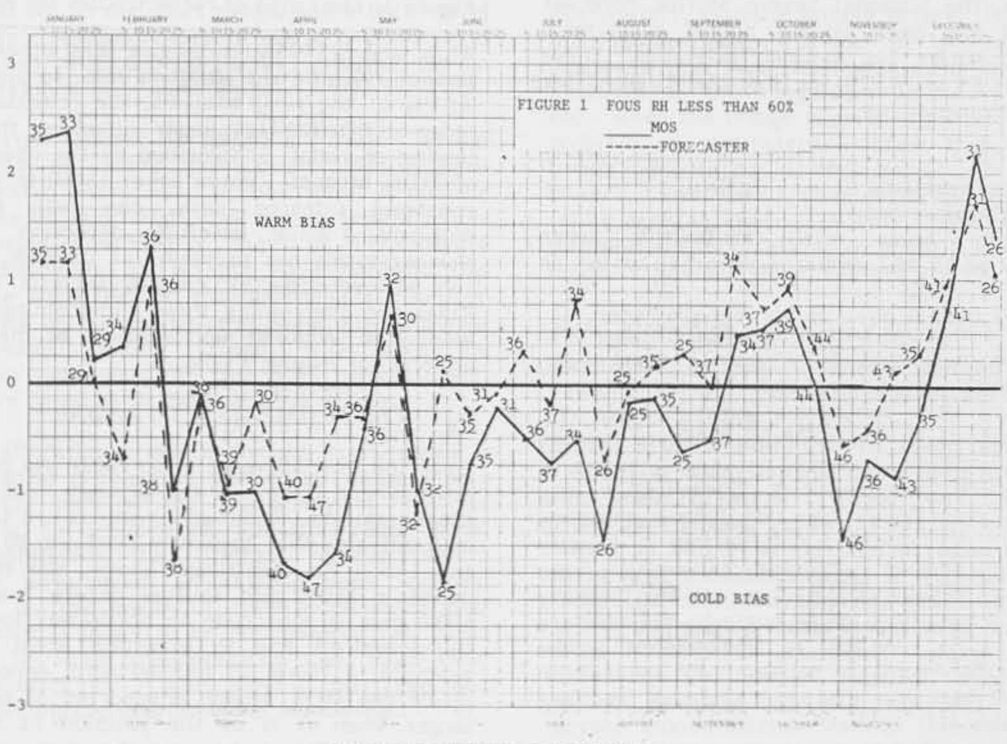
TABLE 3B CONTINUED

TEMPERATURE BIAS IN DEG F




EACH POINT REPRESENTS THE APPROXIMATE CENTER OF AN INTERVAL

TEMPERATURE BIAS IN DEG F




EACH POINT REPRESENTS THE APPROXIMATE CENTER OF AN INTERVAL