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An Aid in Forecasting the Minimum Temperature at Medford, Oregon

ARTHUR W. FRITZ

Western Region

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A western Indian symbol for rain. It also symbolizes man's dependence on weather and environment in the West.

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

NOAA Technical Memorandum NWSTM WR-60

AN AID IN FORECASTING THE MINIMUM TEMPERATURE AT MEDFORD, OREGON

Arthur W. Fritz
Weather Service Office
Medford, Oregon

WESTERN REGION
TECHNICAL MEMORANDUM NO. 60

SALT LAKE CITY, UTAH
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AN AID IN FORECASTING THE MINIMUM TEMPERATURE AT MEDFORD, OREGON

I. INTRODUCTION

This study stems from an attempt to put forecasting of minimum temperature at Medford, Oregon on a more systematic and objective basis. The study uses the same or similar parameters of most temperature forecast studies of this type. Its uniqueness lies in the use of the same parameters throughout the year, and the particular combination of variables used. Measures of temperature and moisture content of the air near the surface during the afternoon or evening to make a "first estimate" of the minimum temperature reached during the ensuing night have been used by many investigators. The reader is referred to [1] and the numerous references listed in that publication, for detailed discussion of the various measures of these parameters and rationale for their use. Empirical corrections to the first estimate based upon expected cloud cover, wind speed, precipitation, and air mass changes during the night have also been used in many past studies. Many of these studies were reviewed by the author before initiating this one.

II. VARIABLES

Four primary variables were chosen as the basis for the first estimate of the minimum temperature:

1. Medford 1400 PST Dry Bulb Temperature

2. Medford 1400 PST Dew Point Temperature

3. Length of Ensuing Night.

4. Cloudiness and Precipitation During Night.

The time of 1400 PST was chosen for the dry bulb and dew-point temperatures because it is around this time that a dry adiabatic lapse rate is normally established through a layer in the lower atmosphere determined by the time of year and overall lapse rate below about 500 mb. A term coined at the Medford weather station for this phenomenon of establishing an adiabatic lapse rate from the surface to the maximum height attainable on a particular day is "air mass heat out." The 1400 PST temperature is, therefore, considered to be most representative of the air mass temperature at "heat-out" time. The dew point at this time is considered a measure of the dryness of the air mass and thus an indication of the amount of radiational cooling possible during the ensuing night.

To account roughly for differences in length of night throughout the year, the data were stratified by month. The state of the sky during the night was also used as a stratification variable, with the nights being designated as:

1. Clear - (including scattered low clouds and high thin broken or overcast cirrus. Fog cases were also included in the "clear" classification since it normally forms as the airmass approaches its lowest temperature.)

2. Cloudy - middle or low cloudiness and dense cirrus or cirrostratus averaging broken to overcast.

3. Precipitation - a trace or more of precipitation during night, except when precipitation was classified as drizzle.

For the purpose of this classification, nighttime hours were considered to be between 1800 and 0800 PST the following morning.

III. DATA AND DEVELOPMENT PROCEDURES

Observations from the years 1943 through February 1967 inclusive were used for developmental data, with some exceptions. Graphs and empirical rules developed from these data have been tested on 31 months, March 1967 - September 1969 inclusive.

For each month of the year and for each of the cloudiness and precipitation classifications, graphs were constructed using the 1400 PST dew point (Td) as ordinate and the difference between the 1400 PST temperature and dew point (T-Td) as abscissa. In the body of the graph, at the points determined by the coordinates, the difference between the 1400 PST temperature and the minimum temperature the following morning (T-Tm) was plotted for each case. Isolines of T-Tm were then drawn by eye for two-degree increments in such a manner that the value of each isoline is within $\pm$ 3 F degrees of the great majority of the plotted values in its immediate vicinity. Although three graphs for each month were constructed (one each for clear, cloudy, and precipitation classifications), only the set for April (Figures 1-3) is reproduced here. The general orientation of isolines is essentially the same for all months, the major differences being in range, magnitude and gradients, both with season and classification.

Although variables upon which graphs are based explain a goodly portion of the variance in the Medford minimum temperature, there are a number of factors affecting minimum readings from which empirical corrections to the first estimate from the graphs have been derived:

1. Strong wind throughout the night. Medford is located near the center of a large mountain valley; and due to high mountains surrounding the valley, wind conditions during morning hours are usually calm. However, during the colder portions of the year, there are occasions when strong winds will blow throughout the night. The valley is so oriented that a cold low aloft situated to the southwest, west or just north of the station will produce strong south to southeast winds through the valley. A strong southeast to northwest surface pressure gradient over southwestern Oregon will also produce strong south to southeast winds in the valley. A convenient measure of such a pressure gradient is the pressure difference between Red Bluff, California (RBL) and North Bend, Oregon (OTH). A pressure difference of 8 mb or greater will normally result in strong winds. Strong winds from directions other than south to southeast are rare and are usually of relatively short duration.

If strong winds are expected to persist throughout the night, a positive correction should be added to the first estimate. In operational use this correction can be left to the judgment of the forecaster; but for an objective evaluation of the system, a correction of +10 F degrees was used.

2. Cold air advection behind a front. There are frequent occasions during the colder portions of the year when a cold front or cold-type occlusion will pass Medford during the period between forecast time and time of occurrence of minimum temperature. Such nights will almost always be classified as cloudy or precipitation, and the observed minimum temperature will usually be lower than indicated by the "cloudy" or "precipitation" graphs. It was found through experimentation that such cases "fit" isolines of the clear chart much better, even though skies might remain cloudy after the frontal passage. Hence the empirical rule: If a cold front or cold-type occlusion is expected to pass the station before midnight, use the estimate obtained from the clear graph as the forecast of the minimum temperature.

3. "Overrunning" or strong warm air advection aloft. There were a number of cases, again generally during the colder portions of the year, in the cloudy and precipitation classifications in which the observed minimum temperatures were significantly higher than indicated by the graphs. These

"abnormally" high minima were generally associated with "warm overrunning" as indicated by 1000-500 mb thickness advection and/or relatively strong temperature advection on the 700-mb chart. When such situations are anticipated, a positive correction of 3-5 F degrees should be made to the first estimate from the appropriate graph. Here, again, in operational use the correction can be left to the judgment of the forecaster; but for an objective evaluation, a correction of +5 F degrees was used for such cases.

To use the graphs operationally, the forecaster must select the graph for the proper month and the nighttime conditions implied by the afternoon forecast, i.e., clear, cloudy, precipitation, windy, etc. Enter the graph with the 1400 PST dew point temperature and the difference between the 1400 PST temperature and dew point. At the point determined by these coordinates, interpolate a value of T-Tm from the family of curves. Subtract this value from the 1400 PST temperature to obtain the first estimate of the minimum temperature. When appropriate, apply corrections discussed above.

IV. RESULTS

This minimum temperature forecasting aid for Medford, Oregon, has been tested on 31 months from March 1967 to September 1969, inclusive. The character of the nighttime weather was determined by inspection of hourly observations between 1800 and 0800 PST the following morning. Surface and upper-air charts were examined to determine if any of the special conditions described above were present. Appropriate corrections to the first estimate from the graphs were made when they did exist; otherwise the temperature determined from the appropriate graph for the month and cloudiness classification was used as the forecast minimum.

This two-and-one-half year period was an excellent one for testing the aid since there were many extreme temperature changes, some of them very rapid. Best verification was obtained with clear sky conditions. Cloudy and precipitation cases showed larger errors due probably to greater variation in the depth of moisture aloft, and to air mass changes.

During the spring months a comparison was made with a fruit-frost type formula [2] which has been in use in the valley many years. The comparison showed the aid at least equal in accuracy to the fruit-frost formula with additional advantages from obtaining an objective low temperature forecast two hours earlier. In addition the system is applicable throughout the year.

In Table I are listed average absolute errors of "forecasts" made using the aid for each of the 31 months. Also listed are average errors of local forecasts of minimum temperature made at 1500 PST for the local verification program. The latter are verified by the 0400 PST minimum temperature. Note that average errors of the "aid" forecasts are smaller in 25 of the 31 months, and for many months are significantly smaller. The aid, of course, had the overwhelming advantage of "knowing" in advance what the character of the weather during the night would be.

V. SUMMARY

A semiobjective aid for forecasting nighttime minimum temperatures at Medford, Oregon, has been developed which is applicable the year around. The aid was based upon the 1400 PST observation of surface temperature and dew point and observed cloud and precipitation conditions during the ensuing night. Operational use of the aid in the afternoon forecast, therefore, requires a reasonably accurate estimate of cloudiness and/or precipitation conditions during the coming night. Empirical corrections for other factors affecting the minimum temperature, such as strong winds and cold front passages, are suggested. Obviously, the accuracy of the minimum temperature forecast is strongly dependent upon the accuracy of the general weather forecast, and large errors will be made when nighttime weather is wrongly classified. Systematic use of the aid, however, will assure a minimum temperature forecast consistent with the forecast of other weather elements. Having the estimate from the forecast aid as a base, the forecaster may be able to further improve upon it through other available guidance and consideration of factors not explicitly incorporated into the aid.

VI. ACKNOWLEDGMENTS

The helpful comments and suggestions offered by Mr. Joseph Lawrence, Meteorologist in Charge, Mr. Norman Peters, Fruit-Frost Forecaster, and all personnel of the Medford Weather Service Office are gratefully acknowledged and appreciated.

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[2] Smith, J. W. and others, 1920: Predicting of Minimum Temperatures from Hygrometric Data. Monthly Weather Review Supplement No. 16.

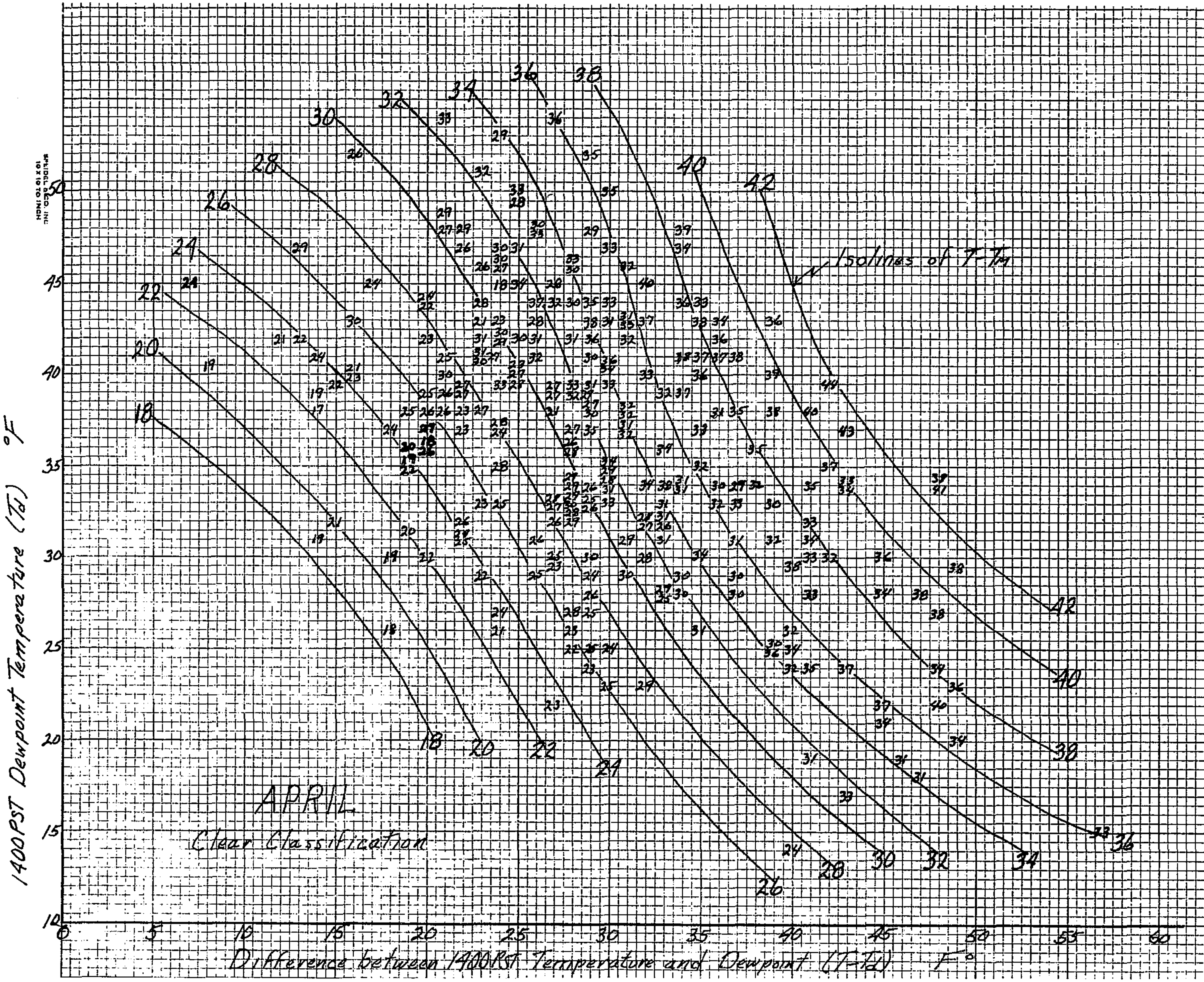

FIGURE 1. JOINT RELATIONSHIP OF 1400PST DEW POINT TEMPERATURE (T_D) AND DEW POINT SPREAD ($T-T_D$) WITH TEMPERATURE DROP FROM 1400PST TO MINIMUM ($T-T_M$) FOR MONTH OF APRIL AND CLEAR CLASSIFICATION.

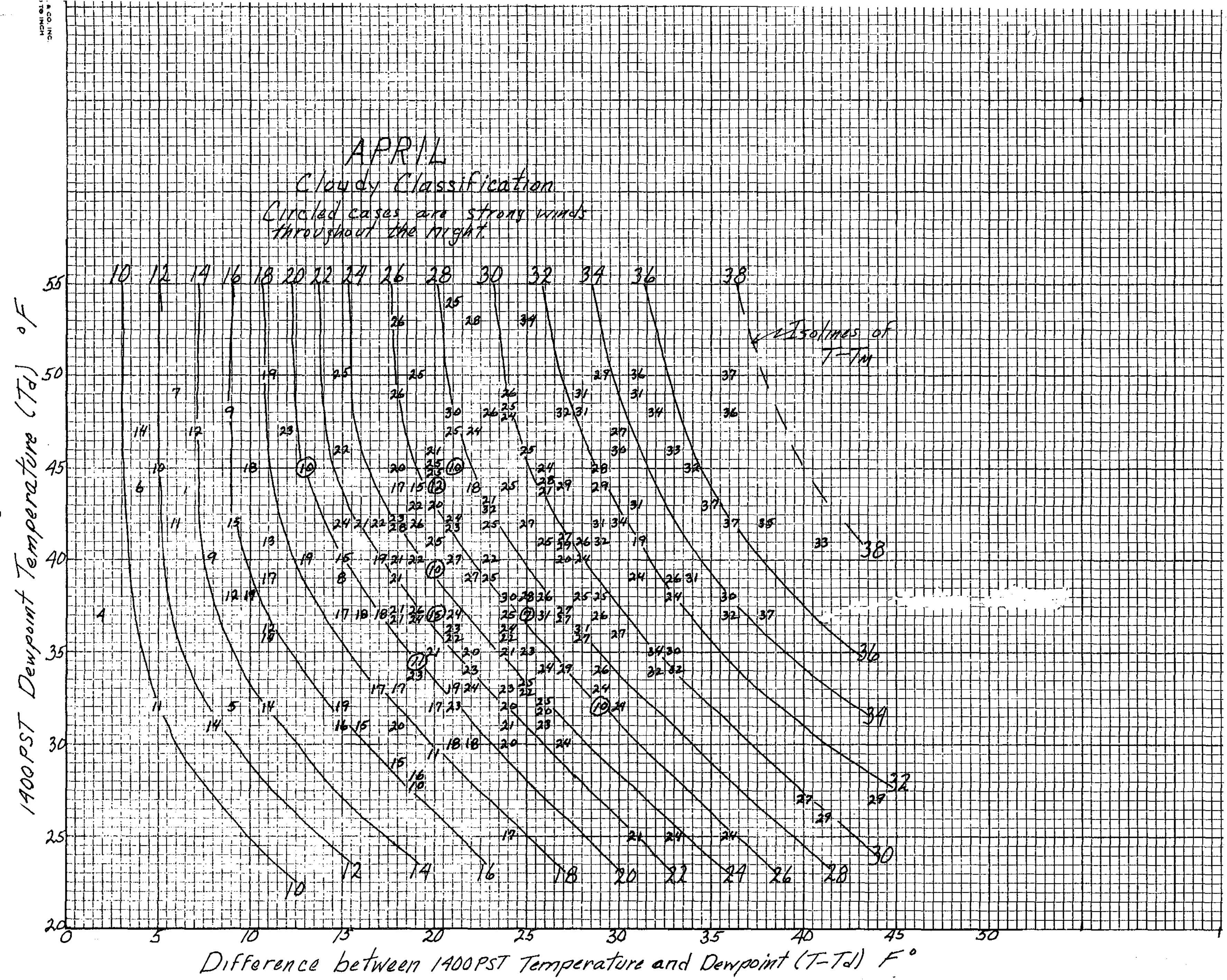

FIGURE 2. JOINT RELATIONSHIP OF 1400PST DEW POINT TEMPERATURE (T_D) AND DEW POINT SPREAD ($T-T_D$) WITH TEMPERATURE DROP FROM 1400PST TO MINIMUM ($T-T_M$) FOR MONTH OF APRIL AND CLOUDY CLASSIFICATION.

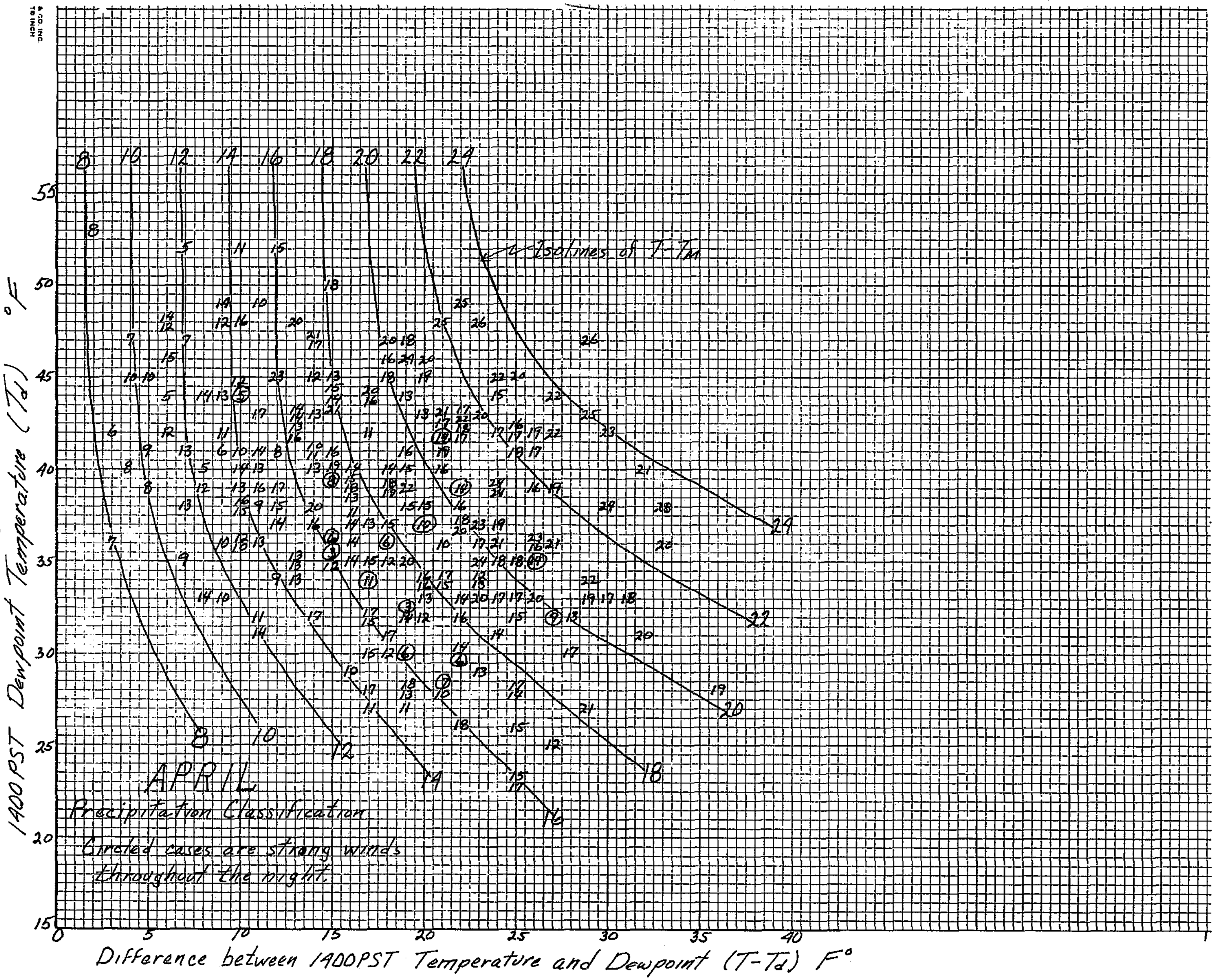

FIGURE 3. JOINT RELATIONSHIP OF 1400PST DEW POINT TEMPERATURE (T_D) AND DEW POINT SPREAD ($T-T_D$) WITH TEMPERATURE DROP FROM 1400PST TO MINIMUM ($T-T_M$) FOR MONTH OF APRIL AND PRECIPITATION CLASSIFICATION.

MONTH	1967 AID AVERAGE ERROR F°	1967 LOCAL FORECAST AVG.ERROR F°	1968 AID AVERAGE ERROR F°	1968 LOCAL FORECAST AVG.ERROR F°	1969 AID AVERAGE ERROR F°	1969 LOCAL FORECAST AVG. ERROR F°
JAN			2.6	3.0	3.6	2.6
FEB			2.4	3.8	3.1	3.8
MAR	2.0	3.2	2.4	3.7	2.0	3.8
APR	2.3	4.3	1.8	3.4	3.0	3.8
MAY	1.8	3.3	2.9	3.8	2.5	3.5
JUN	2.7	3.1	2.9	3.9	3.6	2.8
JUL	2.2	3.0	2.6	3.2	1.9	2.1
AUG	1.7	2.2	2.1	2.7	1.9	3.0
SEPT	2.0	2.7	3.4	3.1	3.0	3.1
OCT	2.5	3.4	3.1	3.3		
NOV	2.8	2.6	4.2*	3.8		
DEC	2.6	2.8	3.0	2.9		

*18 Precipitation Nights

Table I. Monthly average absolute errors of "forecasts" of minimum temperatures at Medford, Oregon, generated by application of the aid to daily observations, compared to monthly average errors of forecasts made by the Medford Weather Bureau Office.

Note: These two sets of forecasts are not strictly comparable since the aid forecasts were verified by the absolute minimum for the night, whereas the local forecasts were verified by the minimum occurring up to 1200Z (0400PST). The local forecasting skill for the 1200Z minimum is probably little different from the skill for the absolute minimum, however.

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