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

NOAA Technical Memorandum NWS SR-54

STATISTICAL FORECASTS OF DEW POINTS IN NORTHEAST TEXAS WITH ONSET OF SOUTHERLY FLOW

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FORT WORTH, TEXAS
February 1971

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1. Introduction

One of the more difficult forecast problems in the local fire weather program concerns the changes in the dew point temperatures during the time that an air mass is changing or modifying rapidly. Specifically, reference is made to the increase in dew point temperatures in Northeast Texas when the low level winds start blowing from the south following a period of north winds and low dew points. This is a report on a study that was conducted in search of forecast procedures that would provide consistently good dew point forecasts for Northeast Texas during periods favorable for the return of moisture from the Gulf of Mexico. During the course of the study, regression equations for forecasting dew point increase were developed for four weather observation stations. The stations are Lufkin (LFK), Tyler (TYR), Shreveport (SHV), and Texarkana (TXK).

2. Typical synoptic pattern

The typical synoptic pattern used in the study is one that usually occurs two or three days after a cold front passes through East Texas. Figs. 1 and 2 illustrate synoptic patterns associated with the influx of dry air. Fig. 3 illustrates a synoptic pattern typical of those that signify the return of moist air to East Texas.

FIG. 1. The passage of a cold front is the initial event leading up to the desired synoptic pattern. Dry air is being brought into East Texas by northerly winds.

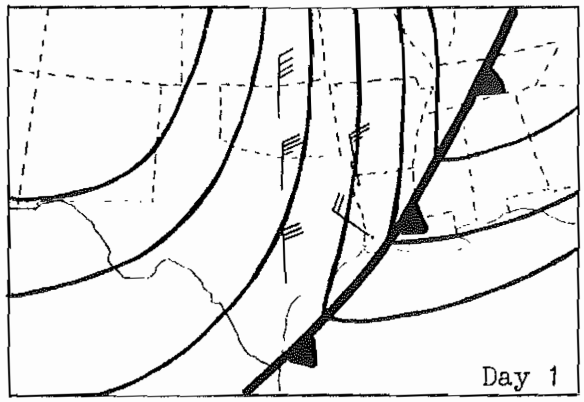


FIG. 2. On day number two, the center of the high pressure system is located to the north of the area in question. Low level winds continue to bring dry air into East Texas.

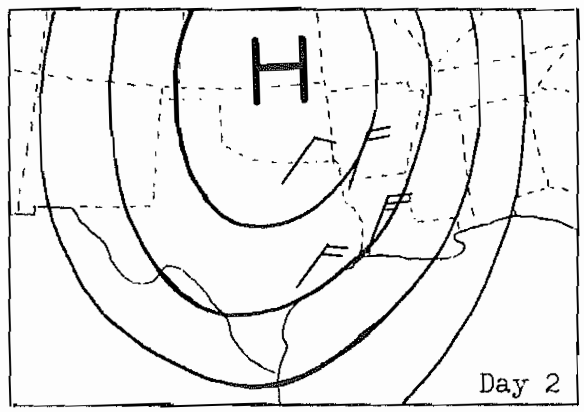
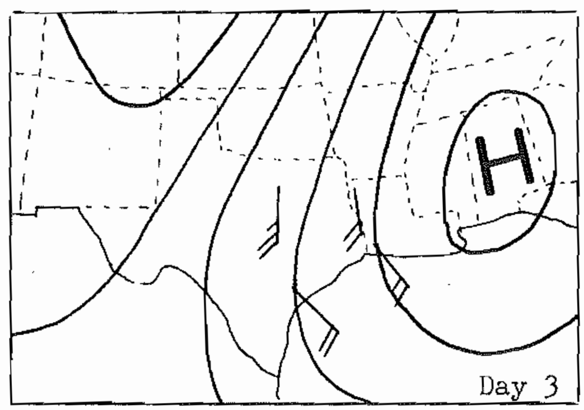


FIG. 3. At 0600 CST on day number three, the high pressure system has moved eastward. The flow of air at low levels is from the Gulf of Mexico. This is a typical pattern that exists on the day that dew point temperatures start to increase in East Texas.



3. Discussion and development

The first nine hour period of the fire weather forecast released at mid morning is based primarily on surface and upper air observations taken at 0600 CST. For this reason, 0600 CST data were used in this study concerning the increase in the dew point in Northeast Texas with onset of southerly flow.

A trial study was conducted for LFK. The regression equation developed in the trial study was based on a small amount of data, but the results justified an expanded study. For the primary study, data on selected dates were obtained for the ten year period from 1959 through 1968. There were 102 cases that met the requirements set up for the study. The requirements were as follows:

1. A synoptic pattern similar to that shown in Fig. 3.
2. A 1000-foot wind direction at Lake Charles (LCH) from 090 to 240 degrees after having been from 250 to 080 degrees at 0600 CST on the previous day.
3. An absence of Gulf moisture in Northeast Texas as evidenced by below normal dew points.

The data were separated into two types. The length of time that the 1000-foot wind at LCH had been blowing from the required direction was the criterion used in determining into which type each case fell. In Type I, the wind had shifted into the required direction during the 12 hour period prior to 0600 CST. In Type II, the wind had shifted into the required direction between 12 and 24 hours prior to 0600 CST. There were 51 cases in each type.

Data processing consisted of two main steps for each observation station for which forecast equations were developed. A map showing the location of each station from which data were used in the study is shown in Fig. 4.

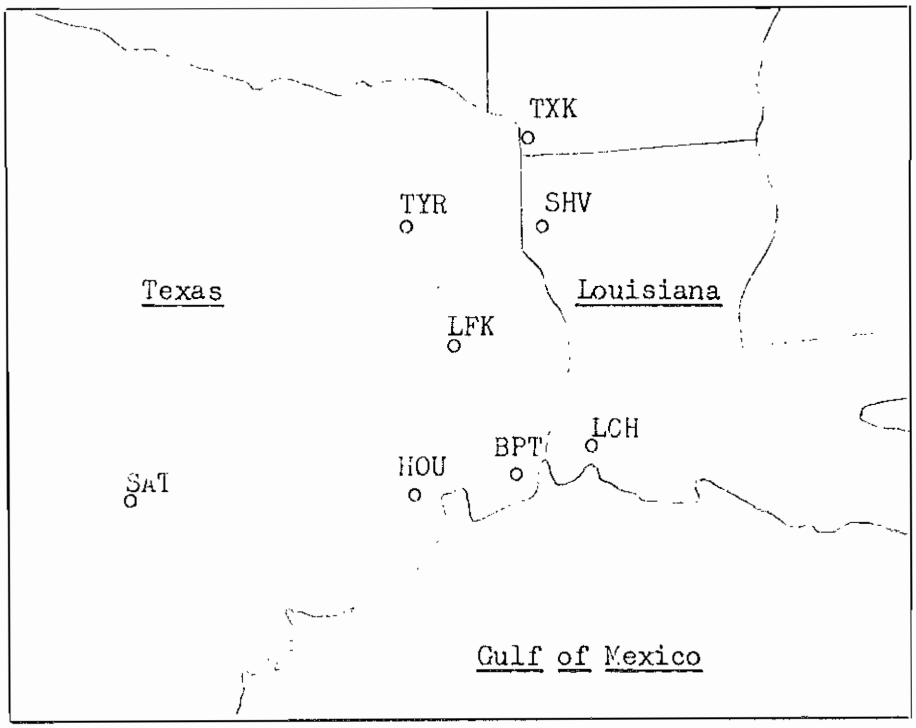


FIG. 4. Stations used in the forecast improvement study.

Data pertaining to LFK, Type I were processed first. In the first step, a method was developed for combining the 1000-foot wind direction and speed at LCH[1] into a single term to be used as one of

[1]Later statements in this report concerning wind refer to the 1000-foot LCH wind at 0600 CST.

the variables in the second step. This was accomplished by computing correlation coefficients between the wind velocity component along each direction being tested, and the dew point change at LFK[2]. These correlation coefficients are plotted in Fig. 5.

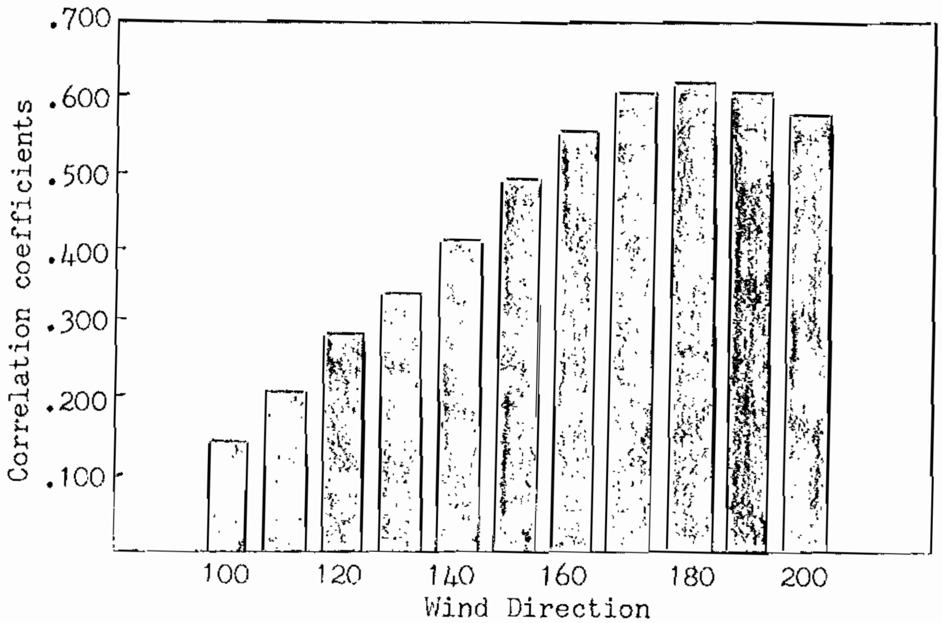


FIG. 5. Correlation coefficients between wind velocity components along each direction tested, and the dew point change at LFK, Type I.

As shown by Fig. 5, the wind velocity component along 180 degrees was most highly correlated with the dew point change at LFK. In step two, the wind velocity component along 180 degrees was used

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[2]When reference is made to the dew point change at a station, it refers to the change in the dew point from 0600 CST to that observed at the time of the lowest relative humidity during the afternoon.

as one of the independent variables along with the temperature at the coast[3], the dew point at the coast, the temperature difference between the coast and LFK, the dew point difference between the coast and LFK, the three hour pressure change at LFK, and the pressure difference between LCH and San Antonio (SAT). All of the independent variables were taken from 0600 CST data. The dependent variable was the change in the dew point at LFK from 0600 CST to that observed at the time of the lowest relative humidity during the afternoon.

A stepwise multiple regression program was used to process the data. The variables that explained most of the variance in the data were 1) the component of the 1000-foot LCH wind velocity along 180 degrees and 2) the temperature difference between the coast and LFK. The combination of these two variables resulted in a multiple correlation coefficient of 0.757, and a standard error of estimate of 2.78 F. The regression equation was terminated after two variables because the multiple correlation coefficient increased only 0.003 by the addition of the next most significant variable. Inclusion of all variables resulted in a multiple correlation coefficient of 0.761, an increase of only 0.004 over that obtained from the two best variables.

The same procedures were used in testing LFK Type II data. Fig. 6 shows the correlation coefficients between the wind velocity

[3]Variables at Houston (HOU) and Beaumont (BPT) were averaged to yield the value of a variable at the coast.

component along each direction tested, and the dew point change at LFK.

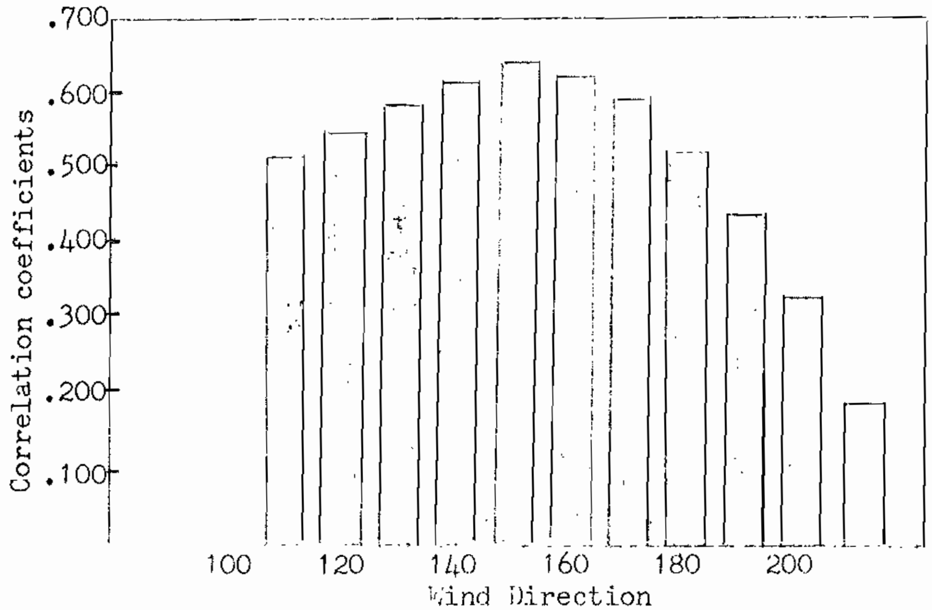

FIG. 6. Correlation coefficients between wind velocity component along each direction tested, and the dew point change at LFK, Type II.

From Fig. 6, we can see that the wind velocity component along 150 degrees was most highly correlated with the LFK dew point change in Type II data. With the exception of the wind velocity component, all other variables used in testing LFK, Type II data, were the same as those used in LFK, Type I testing. The variables that explained most of the variance in the data were 1) the component of the wind velocity along 150 degrees, 2) the temperature at the coast, 3) the dew point at the coast, and 4) the dew point difference between the coast and LFK. Using these four variables, the multiple correlation coefficient was 0.801, and the standard error of the estimate was 2.40 F. The use of all additional variables would only have increased the multiple correlation coefficient from 0.801 to 0.804.

Similar tests were run on both Type I and Type II data for TYR, SHV, and TXK. Temperature and dew point at each of these stations, plus the estimate of the dew point change for LFK, were used as additional variables in the testing. Forecast equations and variables used for each station are listed on pages 1 and 2 of the Appendix. Multiple correlation coefficients and standard errors of estimate are listed on page 3 of the Appendix.

4. Testing the equations

The equations were tested on independent data from November, 1969 through April, 1970. During this time, there were thirteen cases that met Type I requirements, and eleven cases that met Type II requirements. Table 1 shows the results of the tests.

Table 1. Average dew point change, and average error of the forecast equations.

Station	Type I		Type II	
	Avg. dew point change	Avg. equation error	Avg. dew point change	Avg. equation error
LFK	11.2 F	2.2 F	11.9 F	2.1 F
TYR	10.3 F	3.0 F	14.1 F	3.5 F
SHV	7.0 F	4.0 F	14.7 F	3.1 F
TXK	7.5 F	4.8 F	13.4 F	3.9 F

Fire weather forecasts were issued on ten of the thirteen Type I days, and on seven of the eleven Type II days. Dew point forecasts during that period were made subjectively. Fig. 7 shows the location of fire danger stations that are bounded by LFK, TYR, TXK and SHV. These fire danger stations are the verifying points for the fire weather forecast in that section of East Texas.

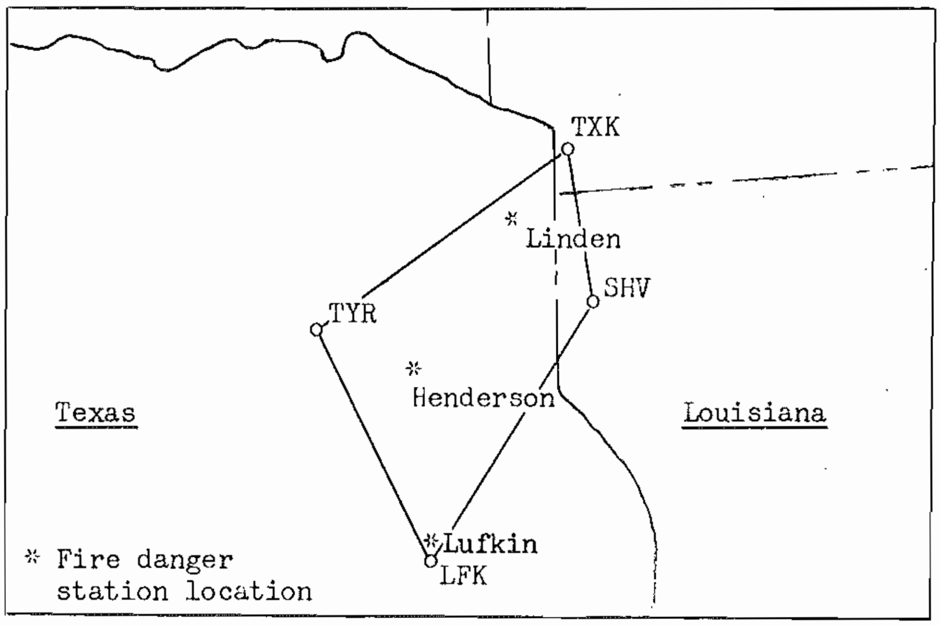

FIG. 7. Fire danger stations located in the area for which forecast equations were developed.

An attempt was made to compare the subjective dew point forecasts that were made for Lufkin, Henderson and Linden on the test case days, to objective dew point forecasts derived from the LFK, TYR, TXK and SHV equations. In order to do this, objective dew point forecasts for LFK, TYR, TXK and SHV were plotted on a map. Objective dew point forecasts for Henderson and Linden were obtained from this map by interpolation. Since the fire danger station at Lufkin is located within five miles of LFK, the two were considered as being the same location. Dew point observations for Linden and Henderson at 0600 CST, and at the time of the lowest relative humidity during the afternoon were obtained from hygrothermograph charts.

The results of the comparison between subjective and objective dew point forecasts are shown in Table 2. The average dew point change and the average objective forecast error for LFK are a little different than those shown in Table 1 because the number of days used in the average is different.

Table 2. Comparison of subjective and objective forecasts.

Station	Average dew point change	Avg. subjective fcst. error	Avg. objective fcst. error
	Type I		
LFK	11.3 F	4.3 F	2.3 F
Henderson	9.5 F	4.3 F	2.7 F
Linden	8.2 F	4.3 F	3.8 F
		Type II	
LFK	9.6 F	2.9 F	1.9 F
Henderson	13.3 F	5.7 F	1.7 F
Linden	14.0 F	4.6 F	2.7 F

5. Conclusion

Results of independent testing indicate that the objective forecast equations developed in this study will provide better dew point forecasts on the average than will subjective forecast techniques. However, since the amount of data used in developing the equations was rather small, and the number of test cases were few, the forecast equations will be used mainly as guidelines. Through the use of the forecast eouations, and through the subjective use of additional variables not considered in this study, such as the slope of the dew point trace in the boundary layer of area raobs, and the presence or absence of stratus along the coast, the accuracy of dew point forecasts in Northeast Texas during initial periods of moisture return should improve significantly.

Acknowledgements. The author wishes to thank J. A. Harman, National Weather Service Forecast Office, Fort Worth, and Dan Smith, Scientific Services Division, National Weather Service Regional Office, Fort Worth, for their work in computer programming, and for their advice and assistance throughout the study. Thanks are also due the members of the River Forecast Center, Fort Worth, for making computer time available for work on the study.

APPENDIX

Forecast equations and explanation of the variables in each equation.

LFK, Type I

$$Y = .78 + .51X_1 + .49X_2 \qquad (1)$$

where X_1 is the component of the 1000-foot wind velocity along 180 degrees at LCH (kts), and
X_2 is the temperature difference between the coast and LFK (F).

LFK, Type II

$$Y = 10.08 + .22X_3 - .43X_4 + .34X_5 + .52X_6 \qquad (2)$$

where X_3 is the component of the 1000-foot wind velocity along 150 degrees at LCH (kts),
X_4 is the temperature at the coast (F),
X_5 is the dew point at the coast (F), and
X_6 is the dew point difference between the coast and LFK (F).

TYR, Type I

$$Y = .27 + .13X_1 + .39X_7 + .57X_8 \qquad (3)$$

where X_1 is the component of the 1000-foot wind velocity along 180 degrees at LCH (kts),
X_7 is the dew point difference between LFK and TYR (F), and
X_8 is the predicted dew point change for LFK (F).

TYR, Type II

$$Y = 12.23 - .15X_3 - .64X_4 + .49X_5 + .58X_9 + .12X_{10} \qquad (4)$$

where X_3 is the component of the 1000-foot wind velocity along 150 degrees at LCH (kts),
X_4 is the temperature at the coast (F),
X_5 is the dew point at the coast (F),
X_9 is the dew point difference between the coast and TYR (F), and
X_{10} is the pressure difference between LCH and SAT (mb times 10).

APPENDIX

Forecast equations and explanation of the variables in each equation.

SHV, Type I

$$Y = -6.42 + .76X_5 - .12X_{10} + .45X_{11} + .45X_{12} - .62X_{13} \quad (5)$$

where X_5 is the dew point at the coast (F),
X_{10} is the pressure difference between LCH and SAT (mb times 10),
X_{11} is the component of the 1000-foot wind velocity along 200 degrees at LCH (kts),
X_{12} is the dew point difference between LFK and SHV (F), and
X_{13} is the temperature at SHV (F).

SHV, Type II

$$Y = 2.56 - 3.50X_2 + .39X_{14} - 3.11X_{15} + 3.73X_{16} \quad (6)$$

where X_2 is the temperature difference between the coast and LFK (F),
X_{14} is the component of the 1000-foot wind velocity along 190 degrees at LCH (kts),
X_{15} is the temperature difference between LFK and SHV (F), and
X_{16} is the temperature difference between the coast and SHV (F).

TXK, Type I

$$Y = -10.11 + .16X_5 + .64X_8 + .61X_{17} \quad (7)$$

where X_5 is the dew point at the coast (F),
X_8 is the predicted dew point change for LFK (F), and
X_{17} is the dew point difference between LFK and TXK (F).

TXK , Type II

$$Y = 8.94 - .26X_6 + .67X_{14} - .15X_{18} \quad (8)$$

where X_6 is the dew point difference between the coast and LFK (F),
X_{14} is the component of the 1000-foot wind velocity along 190 degrees at LCH (kts), and
X_{18} is the dew point at TXK (F).

APPENDIX

Multiple correlation coefficients and standard errors of estimate.

Station	Type	Multiple correlation coefficients	Standard errors of estimate (F)
LFK	I	0.757	2.78
	II	0.801	2.40
TYR	I	0.555	4.18
	II	0.707	3.97
SHV	I	0.746	4.69
	II	0.596	4.44
TXK	I	0.649	4.86
	II	0.581	5.00