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NOAA Technical Memorandum NWS WR-176

APPROXIMATIONS TO THE PEAK SURFACE WIND GUSTS FROM DESERT THUNDERSTORMS

Salt Lake City, Utah
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U.S. DEPARTMENT OF COMMERCE / National Oceanic and Atmospheric Administration / National Weather Service

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APPROXIMATIONS TO THE PEAK SURFACE WIND GUSTS FROM DESERT THUNDERSTORMS

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ABSTRACT. Simple procedures for estimating the peak surface wind gusts from desert thunderstorms are proposed. The fundamental assumption is that the peak surface wind gust is related to the difference (ΔT) between the maximum ambient air temperature attained prior to the thunderstorm and the minimum temperature of the cooler air generated by the thunderstorm downdraft. A total of 49 independent cases are analyzed statistically. Six different regression equations are developed. The simplest and perhaps the most useful expression suggests that the range of the peak gust can be calculated as $(15 + \Delta T) \pm 12$ mph with 90 percent confidence, provided ΔT is forecast perfectly.

I. INTRODUCTION

One of the important forecast problems associated with the prediction of thunderstorms is to ascertain the maximum speed of the surface wind gust accompanying the storm. Simple procedures for estimating this gust are addressed in this report. The proposed procedures are simple mathematical expressions derived from regression analysis of a rather homogeneous set of thunderstorm data.

Pioneering work on estimating the peak surface wind gust from thunderstorms was completed by Brancato (1942) and by Jordan (1945). Based on these works, Fawbush and Miller (1954) developed a forecasting scheme for predicting the peak surface wind gust. Their scheme was adopted and modified slightly by the Air Weather Service (1956). This procedure and another outlined by Miller (1972) are used by the Air Weather Service (Crisp, 1979) for predicting surface wind gusts accompanying severe thunderstorms in the eastern half of the United States. The basis for the Fawbush-Miller technique is that the peak surface wind gust is related to the difference between the ambient surface temperature observed just prior to the thunderstorm and the temperature associated with the thunderstorm downdraft. Specifically, the Fawbush-Miller technique relates the peak wind gust to the difference between the prethunderstorm surface temperature and the surface temperature of the saturation adiabat passing through the wet-bulb temperature at the freezing level. This technique has not functioned satisfactorily with desert thunderstorms. Observed minimum temperatures accompanying thunderstorm downdrafts are usually 10 to 15° F warmer than those predicted by the Fawbush-Miller scheme. In addition, the bases of desert thunderstorms tend to be higher than those associated with midwestern thunderstorms (MacDonald, 1976). Higher cloud bases generally result from the small mixing ratios occurring over the desert southwest. In fact, for many desert thunderstorms, moist adiabatic descent to the ground may be terminated with complete evaporation of the precipitation before the downdraft reaches the ground. Dry adiabatic descent will then ensue, as the downdraft continues to accelerate downward. Upon reaching the ground, the downdraft air spreads out under the thunderstorm, creating the often observed haboob (Idso et al., 1972) over the desert regions of the world.

Analyses of atmospheric soundings taken during desert thunderstorm situations in southern Nevada tend to show that when precipitation reaches the ground the maximum surface wind gust is part of a moist adiabatic downdraft that descends to the ground and spreads out under the thunderstorm. The saturation adiabat followed during this process is the one passing through the convective condensation level (Saucier, 1959, p. 71) and intersecting the ground at the observed surface pressure. The temperature difference between the observed surface temperature theoretically identified by this adiabat and the observed maximum ambient air temperature just prior to the thunderstorm is highly correlated with the observed peak surface wind gust (V_m).

II. PROCEDURE

A survey of the MF1-10A and 10B forms for Yucca Flat (UCC), Desert Rock (DRA), and Las Vegas, Nevada (LAS) revealed that local thunderstorms form during a variety of weather conditions and at almost any time of day (Quiring, 1972). Moreover, the data show great variability in the measured peak surface wind gust for individual thunderstorms. Such variety is common in meteorology. One approach to simplifying such a complex physical situation is to attempt to homogenize the data set. Homogenization is justified on the basis of finding physical phenomena with uniform dynamics and constant forcing functions. The following set of criteria were used to select a homogeneous set of thunderstorm events for this study:

1. To help restrict the thunderstorm activity to that modulated by summertime surface heating, consider only those thunderstorms that occurred in the period June through September between the hours of 1000 LST and 2200 LST daily.

2. To obtain similar amounts of surface heating for each case, no ceilings were permitted below 20,000 feet AGL although high broken to overcast conditions were acceptable.

3. No precipitation was permitted before 1000 LST.

4. To help assure that the observed surface wind gusts were associated with moist adiabatic descent, the thunderstorms must have been observed to occur at a weather station and have been recorded in column 5 of MF1-10A (formerly WBAN-10A).

5. To help assure that descending air followed the moist adiabatic process to the ground, at least 0.01" of precipitation had to be measured during the thunderstorm.

6. The peak wind gust must have been observed to occur during the thunderstorm.

7. Estimated values of the peak wind gust (e.g. July 19, 1969, at UCC) were not allowed; the peak wind gust must have been read from a recorder by an observer on duty at a weather station.

8. For days with more than one thunderstorm occurrence, only the peak surface wind gust from the first storm was used.

All the above criteria had to be met for a peak surface wind gust to be entered into the developmental data base.

III. DATA

All the data used were collected from three stations located in southern Nevada. Data from UCC, DRA, and LAS were used because they were easily accessible. Both UCC and DRA are located on the Nevada Test Site (NTS). UCC is near the center of the NTS on the western edge of a normally dry lake bed at an elevation of nearly 1,200 m above mean sea level (MSL). This station is surrounded by mountains with the highest terrain to the northwest rising nearly 1,000 m above the valley floor. DRA, located 40 km south of UCC, is situated in the southern part of the NTS at an elevation of nearly 1,000 m above MSL. The terrain slopes gradually upward to the north. The northern end of the Spring Mountains is to the south of DRA. Located approximately 120 km southeast of the NTS and 10 km south of downtown Las Vegas, at McCarran International Airport, LAS is nearly 660 m above MSL. This WSO station is in a broad valley surrounded by mountains ranging from near 600 m to 3,000 m above the valley floor (near 550 m above MSL). The tallest mountains are west and north of the city.

The developmental data set consists of 49 thunderstorm-generated, peak surface wind gusts during the period June through September for 1963 through 1980. Included in this data sample are 28 cases from UCC for 1963 through 1977, 18 cases from LAS for 1971 through 1980, and 3 cases from DRA from 1978 through 1980. All the data used are tabulated in Table 1 and categorized in Table 2.

Peak surface wind gust data were extracted from columns 71, 72, and 73 of Form MF1-10B (formerly WBAN 10B). To confirm that the peak wind gust was from the observed thunderstorm, the MF-10B data were compared with the hourly (and special) observations entered on Form MF1-10A (formerly WBAN 10A). On Form MF1-10A, special attention was given to present weather conditions, to reported surface winds, and to the remarks column where "PK WND" reports are listed.

Observations of the maximum temperature prior to the thunderstorm and of the minimum temperature during the storm were obtained from columns 47 and 48 of Form MF1-10B, respectively. These observations were compared with the hourly observations and with columns 82, 83, and 84 of MF1-10B to confirm that

Table 1. Tabulation of data used to develop Figures 1, 2, and 3. Stations (STN) used are Yucca Flat (UCC), Las Vegas (LAS), and Desert Rock (DRA). Observed maximum temperatures (T_m) and observed thunderstorm-associated minimum temperatures (T_{min}) are in °F and come from MF1-10B forms. Observed minimum temperatures are assumed to be those occurring with the thunderstorm downdraft and are not the minimums observed near sunrise. The observed temperature difference (ΔT) is in °F. The peak wind gust (V_m) is in mph and comes from MF1-10B forms. Total precipitation for the day (R) is in inches. The minimum downdraft temperature derived from the sounding data from UCC (and DRA) are listed under the T_e column in °F. Calculated values of ΔT are listed under the ΔT_c column and represent $T_m - T_e$.

				Observed			Calculated	
DATE	STN	T_m	T_{min}	ΔT	V_m	R(in)	T_e	ΔT_c
081563	UCC	97	76	21	38	.05	65	32
081265	UCC	92	71	21	30	.18	66	26
081365	UCC	94	68	26	37	.12	64	30
072366	UCC	97	78	19	42	.56	66	31
072966	UCC	100	64	36	48	.36	60	40
081866	UCC	97	79	18	37	.13	61	36
080967	UCC	94	76	18	35	.05	65	29
081467	UCC	98	85	13	25	.01	63	35
081967	UCC	98	72	26	35	.16	68	30
090667	UCC	87	66	21	22	.39	59	28
070668	UCC	97	65	32	41	.05	61	36
070768	UCC	93	65	28	44	.21	M	M
080668	UCC	95	64	31	47	.25	65	30
071369	UCC	96	72	24	36	.10	64	32
071869	UCC	97	62	33	54	.77	66	31
091669	UCC	83	69	14	31	2.13	57	26
081670	UCC	94	74	20	30	.03	66	28
073071	LAS	110	93	17	40	.05	65	45
080871	LAS	104	73	31	58	.35	65	39
060472	UCC	90	63	27	51	.01	57	33
060472	LAS	96	84	12	28	.01	57	39
071672	LAS	107	72	35	54	.13	67	40
081472	LAS	89	81	8	21	.12	62	27
073074	UCC	102	72	30	31	.57	62	40
080174	LAS	102	93	9	26	.01	63	39
080274	UCC	95	67	28	41	.03	64	31
090574	LAS	103	85	18	28	.16	64	39
070475	LAS	95	86	9	31	.01	63	32
072675	UCC	104	90	14	34	.01	62	42
072775	UCC	100	70	30	37	.02	61	39
091675	LAS	94	71	23	24	.92	59	35
091875	UCC	90	86	4	19	.08	64	26
072476	LAS	100	75	25	43	.20	64	36

		Observed					Calculated	
DATE	STN	T_m	T_{min}	ΔT	V_m	R(in)	T_e	ΔT_c
072576	LAS	97	73	24	38	1.25	65	32
072676	UCC	93	63	30	40	1.10	65	28
072876	LAS	103	88	15	44	.04	66	37
072976	UCC	94	76	18	39	.08	64	30
072976	LAS	102	69	33	70	.35	64	38
090476	LAS	104	95	9	20	.16	61	43
090776	UCC	83	69	14	29	.28	60	23
092576	UCC	74	61	13	22	.05	60	14
092576	LAS	82	78	4	12	.15	60	22
081277	UCC	99	75	24	39	.05	64	35
072878	LAS	102	78	24	45	.19	65	37
080378	LAS	112	75	37	58	.04	68	44
080678	LAS	114	80	34	55	.46	65	49
090478	DRA	96	74	22	35	.06	64	32
072380	DRA	107	74	33	63	.29	67	40
073080	DRA	102	75	27	37	.01	67	35
Mean	-	97.0	74.9	22.1	37.6	0.26	63.3	33.4
S.D.	-	7.6	8.6	8.8	12.1	0.39	2.8	6.6

Table 2. Data listing of maximum surface wind gust (V_m) by wind-gust temperature (ΔT) category. The median V_m value in each ΔT category is underlined in the V_m column. The average maximum surface wind gust ($\overline{V}_m$) is calculated for each ΔT category.

ΔT(°F) Category	$\overline{\Delta T}$(°F)	N	V_m(mph)	$\overline{V}_m$
8	5	2	12,19	15.5
8-12	10	5	20,21,$\underline{26}$,28,31	25.2
13-17	15	7	22,25,29,$\underline{31}$,34,40,44	32.1
18-22	20	10	22,28,30,30,$\underline{35}$,35,37,38,39,42	33.6
23-27	25	10	24,35,36,37,$\underline{37}$,38,39,43,45,51	38.5
28-32	30	8	31,37,40,$\underline{41}$,41,44,47,58	42.4
33-37	35	7	48,54,54,$\underline{55}$,58,63,70	57.4
37	40	0		

they occurred before and during the thunderstorm event, respectively. The moist adiabatic downdraft temperature is assumed to produce the minimum temperature (T_{min}) observed during the thunderstorm. The maximum temperature prior to the thunderstorm was assumed to represent the maximum possible temperature (T_m) achieved before the arrival of the downdraft. The difference between these two temperatures ($T_m - T_{min}$) is referred to as the wind-gust temperature, ΔT.

In Table 2, the V_m data are classified according to ΔT categories. This table shows that V_m values are spread across a wide range of ΔT's. The mean V_m is 37.6 mph (16.8 m/s), the median V_m is 37 mph (16.5 m/s), and the mode is 37 mph. In addition, the $\bar{V}_m$ for each ΔT class increases as ΔT gets larger. Tables 1 and 2 also help establish the bounds on ΔT. In general, we can expect ΔT to range between 0° and 40° F (or 0° to 22°C).

IV. ANALYSIS

To determine if V_m is related to ΔT, the data tabulated in Table 1 were plotted on linear graph paper. The independent variable ΔT was plotted along the abscissa and the dependent variable V_m along the ordinate as in Figure 1. The resulting scatter diagram (Figure 1) shows that a relationship does exist between V_m and ΔT.

Also plotted in Figure 1 are the threshold wind speeds for severe thunderstorms and for special weather advisories for the NTS. The plotted data show that 8 percent of the wind gusts were in the severe thunderstorm category and that 22 percent were equal to or greater than the threshold for an NTS wind advisory.

A linear relationship appears to exist for the data plotted in Figure 1. Consequently, the data were analyzed using a simple linear regression program. A Hewlett-Packard (HP) statistical package for use with an HP-65 calculator contains such a program (STAT 1-22A). This program was used to determine the line of best fit to the data. This line is plotted in Figure 1 according to the derived expression,

$$V_m = 13.24 + 1.1\Delta T \qquad (1)$$

where V_m is in mph and ΔT is in °F. In Eq. 1, 64 percent of the variance of V_m is accounted for by ΔT. The residual mean square or the standard error of the estimate of V_m on ΔT is 7.3 mph, the standard error of the V_m intercept (13.24 mph) is 2.85 mph, and the standard error of the slope of the line (1.1 mph/°F) is 0.12 mph/°F. Without much loss in precision, Eq. 1 can be simplified to

$$V_m = 15 + \Delta T \qquad (2)$$

where the 13.24 has been rounded up to compensate for the 10 percent loss in the coefficient for ΔT. Equation 2 provides a very simple method for estimating the average maximum surface wind gust as a function of ΔT. Equation 2 is suggested as the first approximation to the peak surface wind gust (in mph)

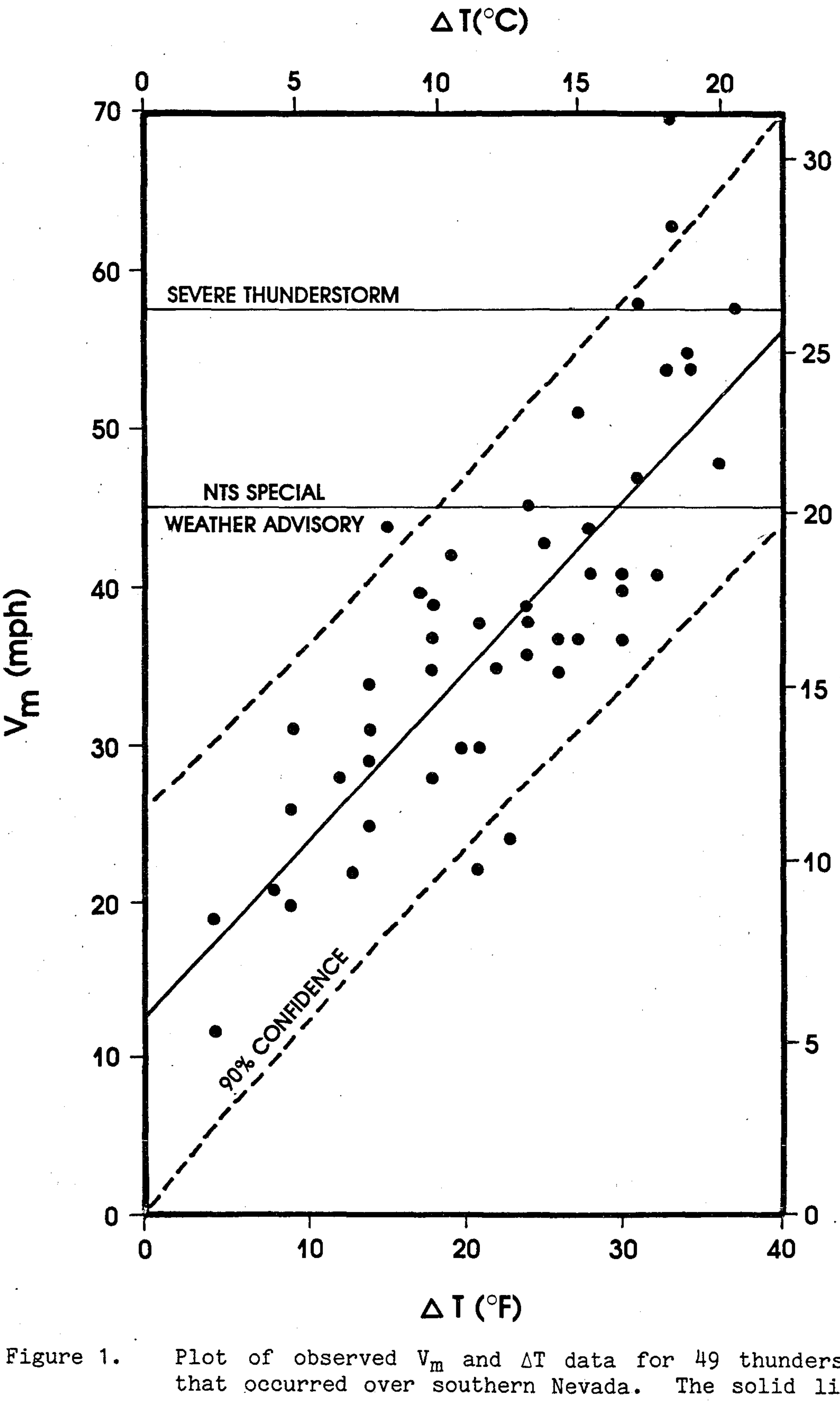

Figure 1. Plot of observed V_m and ΔT data for 49 thunderstorms that occurred over southern Nevada. The solid line is the line of best fit to these data and is given by Eq. 1. The 90 percent confidence limits are plotted as dashed lines.

from thunderstorms occurring over southern Nevada. To be valid, all the criteria in Section II must be satisfied and ΔT must be forecast perfectly. In other words, the proposed model is a "perfect prog" model.

Point estimates of V_m are not very meaningful unless some measure of the possible error in the estimate is given. An estimate of the peak surface wind gust should be accompanied by some sort of number interval together with a measure of assurance that the true V_m lies within the interval. Confidence or prediction intervals are a useful means of providing the necessary limits on estimates of V_m. Ostle (1963, pp. 170-174) differentiates between confidence intervals and prediction intervals. Ostle adopts the concept of a confidence interval to specify limits of acceptability when predictions by the dependent variable are used to estimate the mean of a population. A prediction interval is calculated when the dependent variable is used to predict an individual value rather than the mean. Both schemes can be included under the generic concept of confidence intervals and this terminology is used here only in the generic sense because the prediction interval is actually calculated and plotted in Figure 1.

A procedure for calculating the prediction interval is described by Ostle. In general, this interval is a function of the estimated variance of predicted individual V_m values for given ΔT values. Use is also made of the t-distribution to account for different levels of confidence. Based on the procedure outlined by Ostle, the 90 percent confidence interval is bounded by the dashed lines drawn in Figure 1. This interval tells us that we can be 90 percent confident that the observed value of an individual V_m will lie within the plotted interval. For example, if $\Delta T = 30^{\circ}F$, we can be 90 percent confident that the observed V_m will lie between 33 and 59 mph. In other words, $V_m = 46 \pm 13$ mph with 90 percent confidence. Or, in a practical sense, we could advise that the peak surface wind gusts expected with thunderstorms would range from 35 to 60 mph.

Near the mean wind-gust temperature ($\overline{\Delta T} = 22^{\circ}F$ for the data in Table 1) the prediction interval narrows. For $\Delta T = 22^{\circ}F$, the prediction interval for V_m is $\pm$ 12 mph. This result means that any prediction of an individual V_m associated with a given ΔT will be more meaningful for those values of ΔT near $\overline{\Delta T}$.

Errors in the application of Eq. 2 (and 1) can enter through imprecise estimates of the maximum temperature and from inaccurate determination of the mean mixing ratio near the ground. Equations 1 and 2 show that a $1^{\circ}F$ error in ΔT will result in an error rate of 1 mph/$^{\circ}F$ in estimates of V_m.

Other regression fits to the V_m and ΔT data were applied to determine if the unexplained variance could be reduced further. An exponential curve fit to the data yields an r^2 of 0.66 for

$$V_m = 17.68e^{0.032\,\Delta T} \tag{3}$$

where V_m is in mph and ΔT is in $^{\circ}F$. This regression line is plotted in Figure 2. The main difference between Eq. 3 and Eq. 1 (or 2) is that Eq. 3

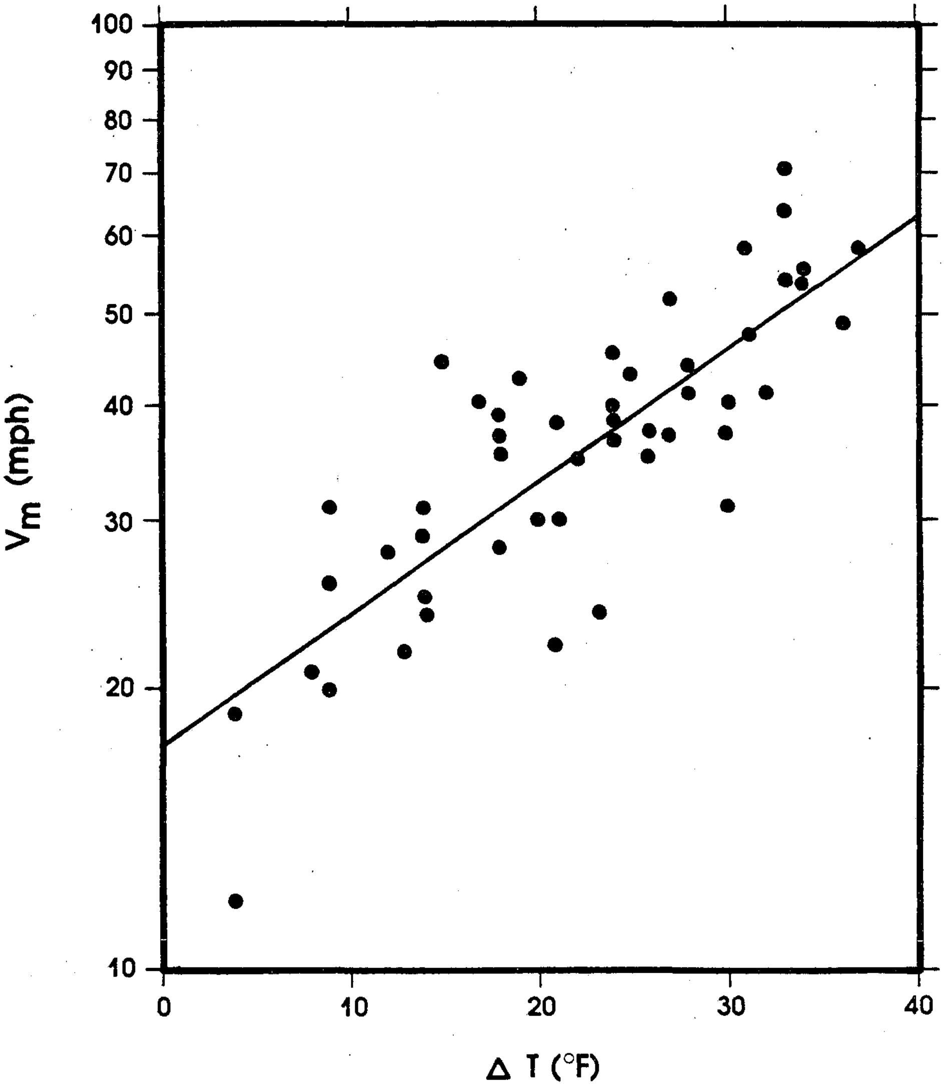

Figure 2. Exponential plot of the 49 cases on log-linear paper. The solution to Eq. 3 is plotted as the solid line.

gives larger estimates of V_m for $\Delta T > 30^oF$ (see Table 3). This difference increases to 6 mph for $\Delta T = 40^oF$. Without much loss in precision, Eq. 3 can be estimated by

$$V_m = 18e^{0.032\,\Delta T} \qquad (4)$$

This equation is proposed as an alternative approximation to V_m.

The same sources of error are found in Eqs. 3 and 4 as in Eqs. 1 and 2; however, the error rate, ε, varies exponentially in Eqs. 3 and 4. For Eq. 3, $\varepsilon = 0.56e^a$ where $a = 0.032\Delta T$. Consequently, for $\Delta T < 20^oF$, $\varepsilon < 1$ mph/^oF. As ΔT approaches 40^oF, ε approaches 2 mph/^oF.

A power-curve was also fit to the V_m and ΔT data. The resulting expression is

$$V_m = 7.1\,\Delta T^{0.54} \qquad (5)$$

where V_m is in mph and ΔT is in ^oF. Equation 5 has an r^2 of 0.67 so that 67 percent of the variance of V_m is accounted for by ΔT. This equation yields values of V_m smaller than those of Eqs. 1 through 4 for $\Delta T > 25^oF$ (see Table 3).

A special analysis was conducted to help confirm the theory that the maximum surface wind gust from desert thunderstorms can be closely approximated from the difference T_m-T_{min}. Consequently, the only cases considered were those in which the calculated difference (T_m-$T_e = \Delta T_c$) was within $\pm 5^oF$ of the observed ΔT. In addition, only those cases close to the upper-air sounding site (UCC) were used. Ten cases in Table 1 satisfy these conditions. An exponential curve fit to these 10 points explains slightly more variance ($r^2 = 0.92$) than linear regression ($r^2 = 0.86$).* The derived exponential expression is,

$$V_m = 13.8e^{0.037\,\Delta T} \qquad (6)$$

where V_m is in mph and ΔT is in ^oF.** The estimates of V_m from this equation are similar to those from Eqs. 1 and 3 (see Table 3). Equation 6 and the related data are plotted in Figure 3. These 10 cases are probably as close to an ideal sample as possible. This exercise confirms that there is a strong connection between observed ΔT and V_m and suggests it is possible to derive an estimate of T_e from the vertical temperature/humidity profile. Furthermore, the analysis emphasizes that the reliability of the prediction of V_m is closely tied to the accuracy with which ΔT can be estimated.

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*Linear regression equation for N = 10 is $V_m = 4.0 + 1.3\,\Delta T$.

**There are two other cases that satisfy the temperature criteria ($\leq 5^oF$). These two cases are for LAS. If added to the data base, N = 12, $V_m = 12.6e^{0.042\,\Delta T}$ and $r^2 = 0.81$.

Insight into the behavior of derived T_e values relative to observed T_{min} and to "observed" ΔT values can be obtained from Table 1. In general, the tabulated data demonstrate that values of T_e derived from the UCC (or DRA) soundings are usually colder than the observed thunderstorm-related minimum temperatures (T_{min}). Consequently, for a fixed T_m, the calculated ΔT (listed in Table 1 under ΔT_c) normally will be larger than the observed ΔT. In fact, Table 1 shows that $\Delta T_c < \Delta T$ (or $T_e > T_{min}$) for only three cases. Therefore, the proposed models (Eqs. 1, 3, and 6) may tend to predict wind speeds that are too fast. Or from a different perspective, the models may be considered to yield conservative estimates of the peak surface wind gusts from desert thunderstorms.

Table 3 summarizes values of V_m as functions of ΔT according to the equations developed in this report. The table demonstrates that the greatest difference in the V_m predictions is 11 mph for $\Delta T = 40^{\circ}F$. In general, the V_m values differ only by 5 to 7 mph for a given ΔT so that the prediction from one equation is probably as valid as that from any of the others.

Table 3. Tabulation of the estimates of V_m according to the regression equations developed in this report.*

	V_m(mph)					
ΔT(°F)	Eq. 1	Eq. 2	Eq. 3	Eq. 4	Eq. 5	Eq. 6
5	19	20	21	21	17	17
10	24	25	24	25	25	20
15	30	30	28	30	31	24
20	35	35	33	34	36	29
25	41	40	39	40	40	35
30	46	45	46	47	45	42
35	52	50	54	55	48	50
40	57	55	63	65	52	61

*To convert from mph to m/s, multiply mph by 0.447.
To convert from mph to kt, multiply mph by 0.868.
To convert from mph to km/h, multiply mph by 1.61.

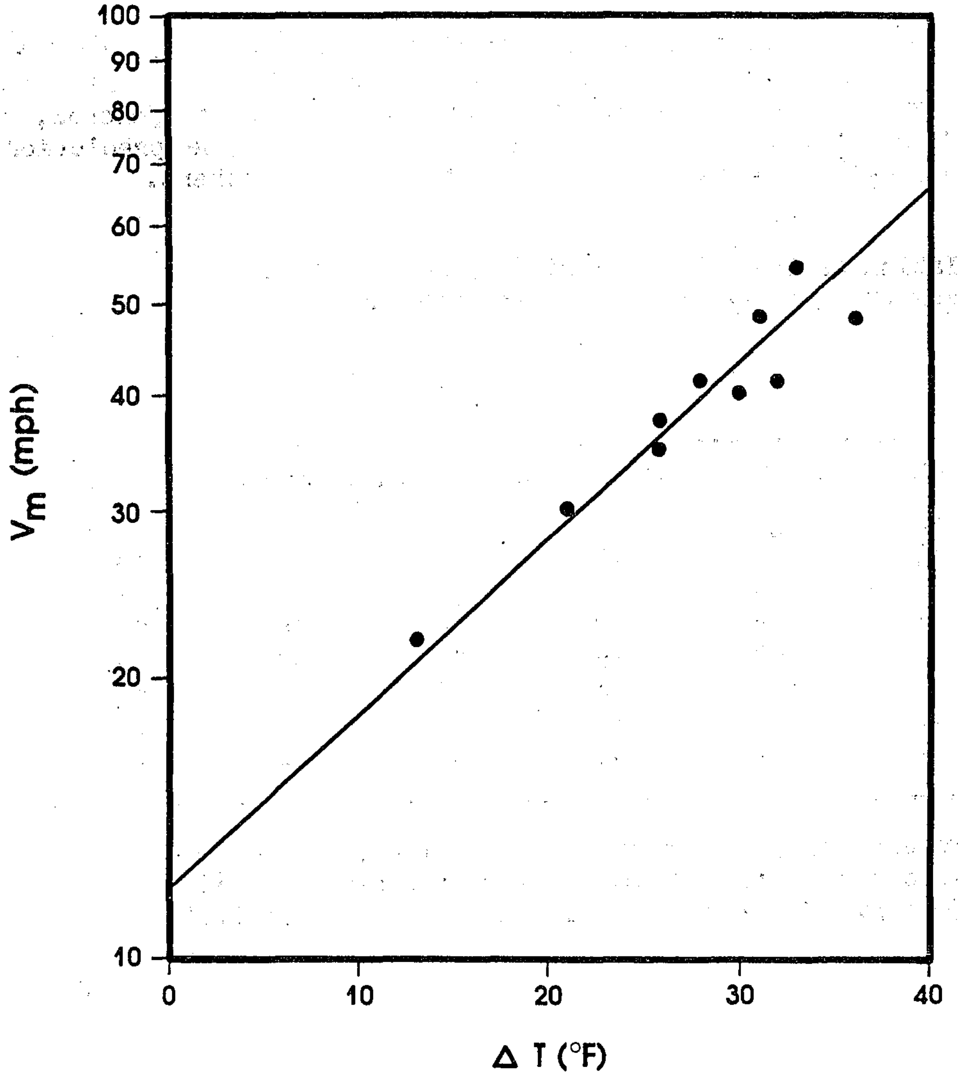

Figure 3. Exponential plot for 10 cases where the difference between observed and predicted ΔT is $\leq 5^{o}F$. Solid line is the line of best fit as given by Eq. 6.

V. APPLICATION

To use the equations and diagrams in this report, the wind-gust temperature (ΔT) must be calculated. This temperature is found by subtracting the moist adiabatic downdraft temperature (T_e) from the predicted maximum temperature (T_m) occurring before the thunderstorm. There are numerous methods for predicting T_m and they will not be described here except to mention that persistence is a powerful predictor in the summertime. In fact, for those days when the selected thunderstorms occurred only on the NTS,

$$T_m \text{ (today)} = 6.7 + 0.92\ T_m \text{ (yesterday)}$$

with $r^2 = 0.90$, $N = 31$ cases.

To find T_e on a thermodynamic chart, the following steps are suggested for southern Nevada with the use of the 1200 GMT sounding for DRA.

1. Estimate T_m in °F.
2. Determine the mean mixing ratio from the surface to the 850-mb level (approximately a depth of 50 mb).
3. For use in adiabatic ascent, reduce the predicted T_m by 3°C to account for super-adiabatic conditions near the ground. Using the parcel method, lift the parcel with temperature ($T = T_m - 3^\circ$) dry adiabatically to the CCL.
4. Read the moist-adiabatic temperature at the CCL and follow this process line to the ground. Read T_e in °F.
5. Calculate $T_m - T_e = \Delta T$ in °F. Here T_e is assumed to be an accurate estimate of T_{min}.
6. Enter the abscissa in, say, Figure 1 with ΔT and find V_m or calculate V_m using the desired equation.

As an example, predict T_m to be 92°F (33°C, $P_{sfc} = 900$ mb) and let the mean mixing ratio be 10 g/kg giving a dew-point temperature of 54°F. Subtract 3°C from T_m and find the CCL to be near 700 mb so that the CCL lies on the 22°C saturation adiabat. Follow this saturation adiabat to the ground ($P_{sfc} =$ 900 mb) and find $T_e = 65$°F. The value for T_m is predicted to be 92°F so that $\Delta T = 27$°F. For this temperature difference, Figure 1 yields a maximum gust of approximately 43 mph. Within the confidence interval we could say the peak gusts will range from approximately 30 to 55 mph. We would be 90 percent confident that the observed V_m would lie within this speed range <u>when ΔT is forecast perfectly</u>.

VI. SUMMARY

In using the proposed schemes it is important to emphasize that Figure 1 (and 2 and 3) will only estimate the peak surface wind gust to be expected from a desert thunderstorm in the summertime. In using all three figures, the thunderstorm must pass over the forecast site, measurable precipitation must occur, and the other criterion listed in Section II must take place to attain the estimated peak speeds. If all these conditions are not met, the proposed scheme may tend to overestimate the peak surface wind gusts. It is not known if this scheme is applicable to other sites in the desert southwest or for desert sites elsewhere in the world. Perhaps the most useful aspect of the derived expressions is that they give the user an objective basis for providing forecast guidance on expected peak surface wind gusts from desert thunderstorms. The schemes may be especially useful in alerting forecasters to the potential for locally severe thunderstorms.

The reader should understand that the strength of surface outflow winds generated by thunderstorm downdrafts varies greatly. For example, Fritsch and Rodgers (1981) note that it depends upon such physical parameters as the vertical shear of the horizontal wind, midlevel intrusions of dry air, and cloud microphysical processes. This report has endeavored to draw together a physically homogeneous set of thunderstorm-generated, wind-gust data. Differences in cloud microphysics, macroscale dynamics, distance from the initial ground contact by the downdraft, and other factors will all contribute to the variable strength of observed outflow surface wind gusts. Such variability is portrayed by the scatter of the data plotted in Figures 1, 2, and 3.

A plot of only the ΔT and V_m data used in this study is presented in Figure 4. This figure is made available for individuals who might want to test and compare the proposed schemes for their areas of concern.

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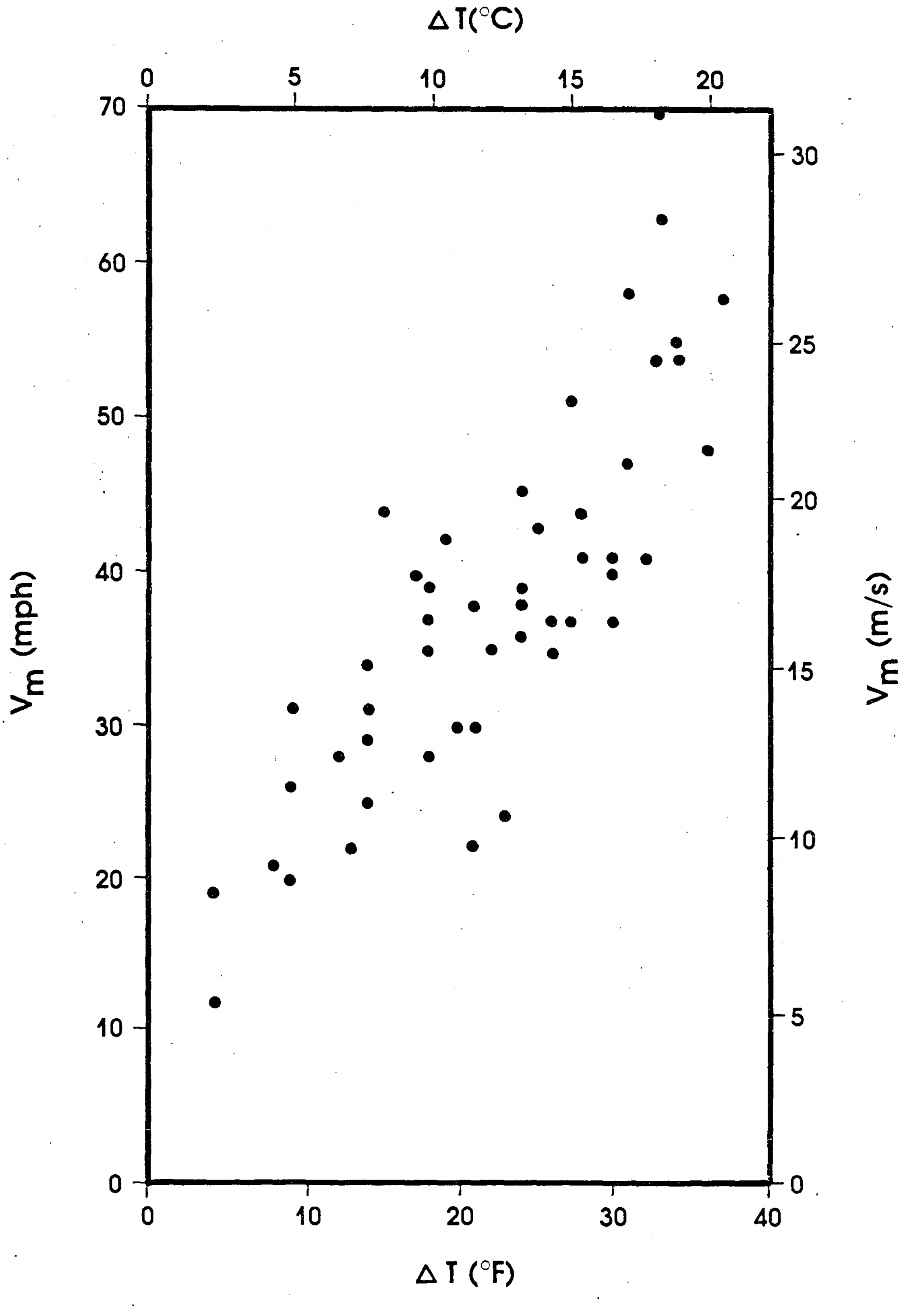

Figure 4. Reproduction of Fig. 1 with only the plotted data.

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