NOAA Technical Memorandum NWS WR-117

THE RELATIVE FREQUENCY OF CUMULONIMBUS CLOUDS AT THE NEVADA TEST SITE AS A FUNCTION OF K-VALUE

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Salt Lake City, Utah
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I. INTRODUCTION

The K-value is a familiar index used as a guide for predicting the occurrence of thunderstorms in the conterminous United States and has become established as an initial state and predicted parameter in the teletype and facsimile products of the National Meteorological Center. Daily K-values were generated from the Yucca RAOBs as a cumulonimbus predictor for the Nevada Test Site (NTS). The K-values from this developmental data set were used to derive a probabilistic prediction curve in order to have a forecast suitable for comparison with another routinely used index (i.e., Randerson Z-index [1]) forecast. The purpose of this report is to share this adaptation of the K-value to the NTS with Western Region meteorologists.

II. DEVELOPMENTAL DATA

The developmental data set consists of 1079 cases during June through September for the years 1962 through 1971. Each case was established as a day with or without cumulonimbus, without regard for duration or time of day, on the basis of the hourly surface observations at the Yucca Weather Station. The K-value was computed from the Yucca 12Z RAOBs. The 141 missing cases were due almost entirely to missing RAOBs in the Meteorological Data Storage and Retrieval (MDSAR) file.

A few minor irregularities in the hourly observations were resolved to provide 328 cases with cumulonimbus of which 168 qualified as thunderstorm days. A thunderstorm day is defined here as a day on which either thunder or lightning (not qualified as distant) were observed at some time during the day at the Yucca Weather Station. Please note that this departs from the official definition of a thunderstorm day.

Observations of cumulonimbus and of thunderstorm phenomena cover a circular area with the observation point at the center. The radius of this circle is rather poorly defined because it depends on so many variables (weather, terrain, observer, activity, etc.) but is probably on the order of about 25 miles so that the Yucca surface observations--with some reservations--can be construed as encompassing the NTS.

III. THE PREDICTION CURVE

The distribution of K-values is given in Table I. The distribution for all cases is rather irregular but distinctly bimodal. The primary mode at K-values of 28 to 31 corresponds to the mode for cumulonimbus cases while the secondary mode at K-values of 12 to 15 corresponds to the mode for non-cumulonimbus cases. The substantial difference between the central tendencies of two distinct, approximately normal distributions comprising the overall distribution of K-values suggests that the K-value provides a fair degree of discrimination with regard to the occurrence or non-occurrence of cumulonimbus.

The prediction curve presented in Figure I is a subjective smoothing of points representing the relative frequency of cumulonimbus cases for overlapping intervals of 6 K-values. The dashed lines provide a smoothed envelope encompassing the relative frequencies of cumulonimbus cases for individual K-values and represent a crude attempt to provide confidence limits for the prediction curve.

The ability of the K-value to discriminate between the occurrence or non-occurrence of thunderstorms on a day with cumulonimbus is very limited. The distribution of K-values for non-thunderstorm and thunderstorm cases is given in Table I. There is very little difference in the range of K-values and the central tendencies of the distributions are rather close together. There is a distinct tendency for non-thunderstorm cases to predominate at low K-values and for thunderstorm cases to predominate at high K-values; however, the pattern of relative frequencies of thunderstorm cases based on cumulonimbus cases is very erratic. Careful consideration of all factors strongly suggests that it is pretty much of a fifty-fifty proposition whether or not the observer at Yucca will hear thunder or see lightning when cumulonimbus are present.

The dotted line in Figure I is based on the probability of thunderstorm assigned to ranges of K-values by Hambidge (1967). According to Hambidge these probabilities are applicable to the western United States, and as can be seen, agree reasonably well with the cumulonimbus prediction curve. The suggestion is that a prediction of the probability that cumulonimbus will be observed at Yucca is essentially a prediction that a thunderstorm will occur somewhere within the surrounding area--that is, over the NTS.

IV. COMPARISON WITH THE Z-INDEX

The reason for calibrating the K-value to the NTS as a probability predictor was to have an independent forecast to compare with the Z-index forecast. Both forecasts give the probability that cumulonimbus will be observed at the Yucca Weather Station. A comparison of the two methods, along with climatology, is given in Table 2 in terms of the Brier Score (see Compendium of Meteorology, page 845). The Z-index achieves the best score (smallest value) in both seasons tested and in 5 of the individual months. Both systems do better than climatology.

V. CONCLUSIONS

The K-factor prediction curve is a useful guide for predicting the probability of occurrence or non-occurrence of cumulonimbus clouds at the Yucca Weather Station. The prediction is, for practical purposes, the probability of a thunderstorm occurring somewhere on the NTS. In comparison with the Randerson Z-index and climatology, the K-factor comes out as runner-up to the Z-index.

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TABLE 1. DISTRIBUTION OF K-VALUES AT YUCCA DURING JUNE-SEPTEMBER (1079 CASES 1962-1971)

K-Value	All Cases	Non-CB Cases	CB Cases	Relative Frequency of CB Cases (%)	Non-☈/☇ Cases	☈/☇ Cases	Relative Frequency of ☈/☇ Cases for CB Cases (%)
-22/-21	1	1					
-20/-19	0	0					
-18/-17	1	1					
-16/-15	2	2					
-14/-13	3	3					
-12/-11	3	3					
-10/-9	10	10					
-8/-7	19	19					
-6/-5	26	26					
-4/-3	24	24					
-2/-1	32	32					
0/1	32	31	1	3.1		1	100.0
2/3	33	32	1	3.0		1	100.0
4/5	33	32	1	3.0		1	100.0
6/7	45	41	4	8.9	4	0	0
8/9	42	36	6	14.3	4	2	33.3
10/11	43	40	3	7.0	3	0	0
12/13	59	55	4	6.8	2	2	50.0
14/15	59	53	6	10.2	3	3	50.0
16/17	53	48	5	9.4	4	1	20.0
18/19	51	44	7	13.7	5	2	28.6
20/21	48	39	9	18.8	7	2	22.2
22/23	57	41	16	28.1	11	5	31.3
24/25	56	40	16	28.6	8	8	50.0
26/27	60	26	34	56.7	22	12	35.3
28/29	71	25	46	64.8	18	28	60.9
30/31	67	20	47	70.1	24	23	48.9
32/33	57	15	42	73.7	19	23	54.8
34/35	45	7	38	84.4	14	24	63.2
36/37	25	5	20	80.0	6	14	70.0
38/39	16		16	100.0	4	12	75.0
40/41	6		6	100.0	2	4	66.7
Total	1079	751	328	30.4	160	168	51.2
Mean	17.2	12.3	28.4		26.8	29.9	
Median	18	13	30		29	31	
Lowest	-21	-21	0		6	0	
Highest	41	37	41		40	41	

TABLE 2. COMPARISON OF THE K-VALUE AND Z-INDEX PROBABILITY OF CUMULONIMBUS FORECASTS IN TERMS OF THE BRIER SCORE

		1972 (120 forecasts)					1973 (122 forecasts)				
		Jun	Jul	Aug	Sep*	Season	Jun	Jul	Aug	Sep	Season
K-value		.24	<u>.24</u>	.39	.31	.30	<u>.08</u>	.38	.32	<u>.07</u>	.22
Z-index		<u>.19</u>	.27	<u>.31</u>	<u>.22</u>	.24	.11	<u>.23</u>	<u>.16</u>	.11	.15
Climatology		.30	.44	.50	.26	.41	.30	.44	.50	.26	.41
No. of	Expected	6	10	14	4	34	6	10	14	5	35
CB Days	Observed	11	8	17	6	42	3	9	12	2	26

*2 days missing

Best score is underlined

Climatological Probability of CB:

Jun	.187
Jul	.329
Aug	.468
Sept	.153
Season	.286

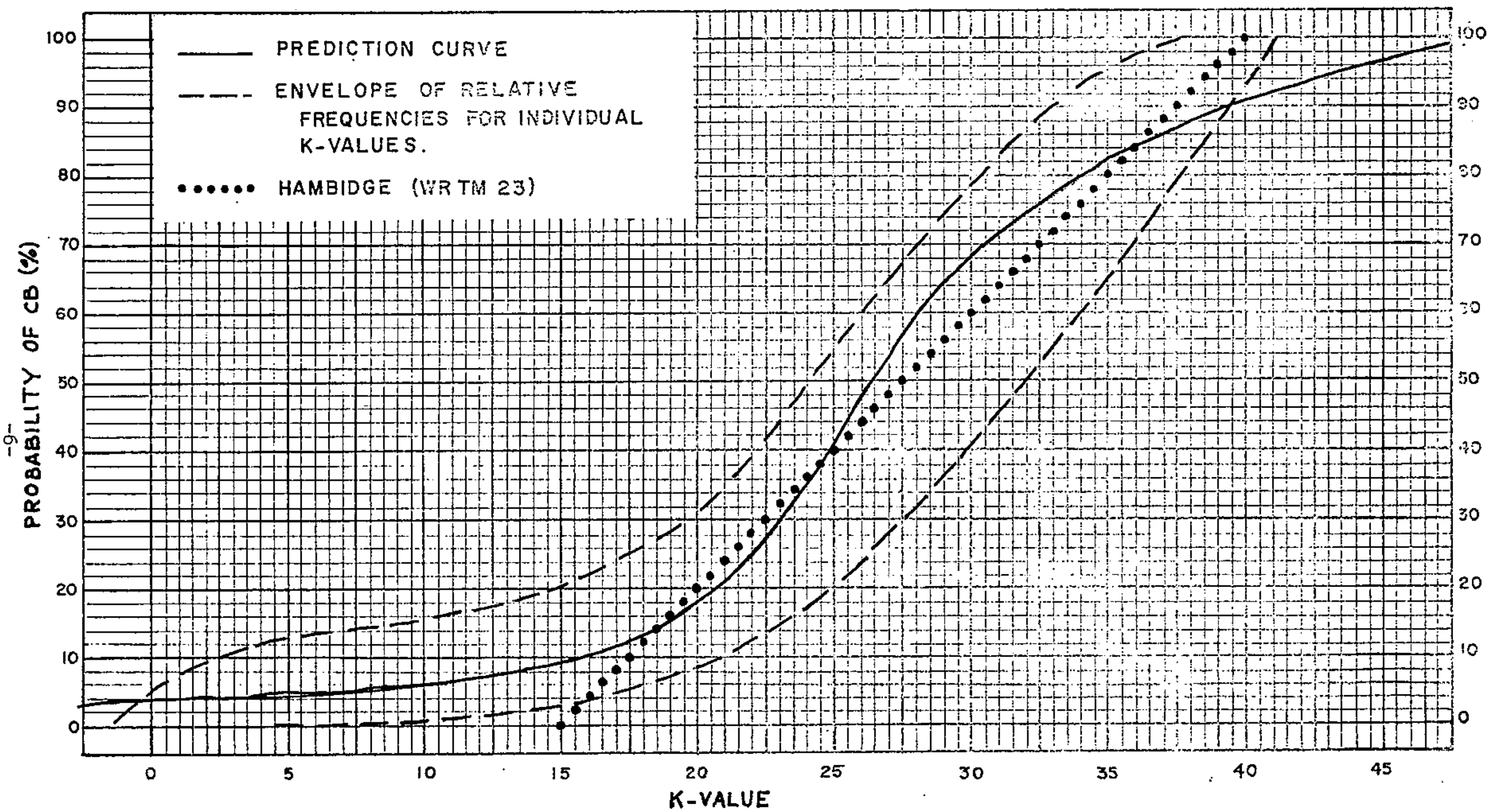

Fig. 1. Cumulonimbus prediction curve for the NTS - June through September.

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