U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL WEATHER SERVICE
SYSTEMS DEVELOPMENT OFFICE
TECHNIQUES DEVELOPMENT LABORATORY

TDL OFFICE NOTE 78-7

COMPARATIVE VERIFICATION OF THE OPERATIONAL 24-H CONVECTIVE OUTLOOKS WITH THE OBJECTIVE SEVERE LOCAL STORM GUIDANCE BASED ON MODEL OUTPUT STATISTICS

Donald S. Foster and Ronald M. Reap

June 1978

Comparative Verification of the Operational 24-h Convective Outlooks with the Objective Severe Local Storm Guidance Based on Model Output Statistics

Donald S. Foster and Ronald M. Reap

1. INTRODUCTION

The National Severe Storms Forecast Center (NSSFC) routinely prepares and distributes a daily severe local storm outlook (AC) between February 1 and August 31. The latest description of this operational product may be found in Technical Procedures Bulletin No. 154 (National Weather Service, 1976). The National Meteorological Center also routinely prepares and distributes for forecaster guidance a daily objective conditional probability forecast of severe local storms between April 1 and September 30. This guidance product was developed in the Techniques Development Laboratory (TDL) by Reap and Foster (1977) using model output statistics (MOS). A description of this product can be found in Technical Procedures Bulletin No. 199 (National Weather Service, 1977a). NSSFC and TDL verify their products independently to determine the reliability of their respective forecasts and to measure improvement from year to year. However, because of differences in the verification methods, scores derived from the forecasts cannot be compared. In response to a request by the Office of Meteorology and Oceanography, we have developed a compatible verification method that permits comparison of the two sets of forecasts. This office note describes the ground rules, the scores computed, and verification results for the spring and summer of 1976 and 1977.

2. GROUND RULES

As a first step in the verification procedure, ground rules were established so that one forecast product did not have an unfair advantage over the other. Ground rules were as follows:

(1) Verification was done on the 761 overland blocks of the manually digitized radar (MDR) grid shown in Fig. 1. TDL probability forecasts are routinely made for blocks in this grid. NSSFC forecast areas were translated to this grid, omitting areas or portions that fall outside the grid. The size of a forecast area was measured by the number of MDR blocks within the area. The approximation was made that if the center point of an MDR block falls inside an area the whole block does, and vice versa.

(2) Only the 0600-0600 CST NSSFC outlook was verified. This period coincides with the TDL guidance period of 1200-1200 GMT.

(3) The same days were verified. If data were missing for a TDL forecast, that day was also eliminated from NSSFC data.

(4) The TDL product is transmitted on FOFAX (slot FO40C) at 0649 GMT, while the NSSFC product is transmitted on NAFAX (slot N49) at 0927 GMT. This schedule gives the NSSFC forecaster an opportunity to see the TDL guidance product before he prepares his own. However, no attempt was made to take this into consideration in the verification.

(5) NSSFC forecast areas labeled "approaching" were not verified. Only forecast areas labeled "isolated," "few," "scattered," and "numerous" were considered.

(6) Reports of tornadoes, surface hail $\geq$ 3/4 in ($\sim$2 cm) and wind gusts $\geq$ 50 kts ($\sim$93 km/h) and/or wind damage were used to verify the forecasts. In the tabulation of severe local storm events, only one event per MDR block was counted. In other words, severe local storm blocks were counted rather than the individual storms.

3. PROBABILISTIC TO CATEGORICAL FORECASTS

The NSSFC forecaster outlines his forecast area(s) on a map of the United States and makes a categorical forecast that all of the severe local storms that occur within the forecast valid time will fall inside the forecast area(s). In reality, some fall inside (hits) and some outside (misses). The TDL system draws contours on the map shown in Fig. 1 and labels each with the conditional probability of a severe local storm falling in one of the enclosed MDR blocks. The condition consists of the occurrence of a thunderstorm in the same MDR block. In other words, the conditional probability applies only to MDR blocks where thunderstorms are expected. In order to make a "hit/miss" or categorical forecast similar to NSSFC's, we first defined a thunderstorm forecast area and then outlined within the thunderstorm area a severe local storm forecast area. This was accomplished in two steps:

(1) First, using 1977 spring and summer data and a trial and error procedure, we found the thunderstorm probability value, when used in a categorical sense, that gave a maximum "threat score." (See Appendix A for the definition of all scores.) A maximum "threat score" of 0.45 occurred with a thunderstorm probability of 35% (see Fig. 2). This means that 35% is the best probability value for dividing thunderstorm from no-thunderstorm forecast blocks. Fig. 2 also shows that MDR blocks with forecast probability values of 35% or greater included 76% of the thunderstorm blocks that occurred in the MDR grid.

(2) In the second step, we used the 35% thunderstorm probability value to provide the thunderstorm "condition" for the severe local storm conditional probability. With a thunderstorm area so defined, we found the severe local storm probability value that produced a maximum "threat score" for the 1977 spring data. A maximum "threat score" of 0.074 was found with a severe local storm conditional probability of 10% (see Fig. 3). However, Fig. 3 shows that the area enclosed by the 35% thunderstorm probability and the 10% severe local storm conditional probability contours contains only 30% of the severe local storm blocks that occurred in the MDR grid. We thought this percentage to be too low for most users and decided, after further testing, to sacrifice some "threat score" in order to capture more severe local storm blocks. We finally chose the 6% severe local storm conditional probability contour along with the 35% thunderstorm probability contour to outline the TDL severe local storm forecast area. Fig. 3 shows that these values produced a threat score of 0.066 and enclosed 46% of the severe local storm blocks, based on 1977 spring data.

4. VERIFICATION SCORES

We computed scores from data gathered in a contingency table; the data in the table and most of the scores are described in Appendix A. In addition, we verified the forecaster's or the forecast equation's ability to forecast the coverage of severe local storm blocks within the forecast area. Coverage in NSSFC's forecast is implied by the use of the words, isolated, few, scattered, and numerous. In order to use these terms in a quantitative sense they must be assigned numerical values. The following values were taken from the National Weather Service (1977b) Operations Manual:

Isolated - an extremely small number
Few - up to 15% coverage
Scattered - 16-45% coverage
Numerous - more than 45% coverage

Coverage in this verification scheme is defined as the number of severe local storm blocks in the forecast area divided by the total number of blocks in the area. We used the observed coverage for the spring of 1977 to select a reasonable value for isolated coverage, which is not numerically defined in the Operations Manual. The average observed coverage in the NSSFC isolated areas was 6.3%. Therefore, we chose 6% for the isolated coverage category. We chose 15% for the few category, which was the upper limit of the Operations Manual definition, and 30% for the scattered category, which was near the average of the limits given in the Operations Manual.

Coverage for the TDL areas was defined as the average conditional probability of severe local storms for blocks within the forecast area. This definition is based on the fact that the higher the probability for a given area the greater the expected coverage. The minimum conditional probability for defining a TDL forecast area is 6%, which would probably result in a minimum average probability slightly higher than 6%. Therefore, the coverage for a minimum NSSFC forecast area and a minimum TDL area are practically the same, which is as it should be for compatibility. Considering the above, we chose the following coverage values for each category:

Isolated - 6% coverage
Few - 15% coverage
Scattered - 30% coverage
Numerous - 50% coverage

In order to verify the coverage forecast, we computed a coverage bias (CBIAS) for the forecast area.

$$\text{CBIAS} = \frac{\text{number of expected severe local storm blocks}}{\text{number of observed severe local storm blocks}}$$

The number of expected severe local storm blocks is defined as the product of the coverage forecast and the number of blocks in the forecast area. The number of observed severe local storm blocks is the value of x from the contingency table described in Appendix A. We believe the coverage bias measures a forecast skill not detected by the other scores and adds significantly to the overall verification.

5. VERIFICATION RESULTS

We initially verified the TDL and NSSFC severe local storm forecasts for the spring of 1977. Since we used 1977 data to help us define the optimum TDL forecast area and the coverage bias, we shall also show scores computed from other forecast data; namely, the spring and summer of 1976.

Table 1 shows comparative scores for the spring and summer of 1977 and 1976. The compatible verification period for the spring of 1977 extended from April 8 through June 15 with four missing days. The critical success index was the same for both sets of forecasts, with the NSSFC outlooks holding a slight edge in all the other scores. Columns labeled x, y, z, and w give the totals from the contingency tables for each set of forecasts.

The day-to-day scores for the spring of 1977 are shown in Appendix B. Daily scores for the other seasons are available at TDL but are omitted here for the sake of brevity. The daily scores show considerable fluctuation, with NSSFC doing better on some days and TDL on others. High bias (BIAS) scores indicate the number of forecast blocks for severe local storms is too large compared with the number of storm blocks observed. A high coverage bias (CBIAS) indicates the coverage forecast was too high compared with the number of storm blocks observed

within the forecast area. The false alarm ratio (FAR) is unusually high for both products. This is due to the rarity of severe local storm blocks which results in many non-severe storm blocks among the severe blocks in a comparatively large forecast area.

As was noted earlier, the 1977 spring and summer data made up the dependent sample used to define the TDL forecast area and the coverage bias. To see how well these definitions held up on other forecast data we also verified the spring and summer months of 1976 (see Table 1). The comparative verification period for the spring months extended from April 17 through June 30 with one missing day. Except for the probability of detection, most of TDL's scores appear slightly worse for the spring of 1976. However, we had substantially changed and improved our thunderstorm and severe local storm forecast equations for 1977, so it is difficult to say if the difference in the scores was due to a different sample, the new forecast equations or a combination of the two. Most of NSSFC's scores for the 1976 and 1977 spring seasons show relatively little change. NSSFC's improvement in the coverage bias from the spring of 1976 to the spring of 1977 may have resulted from fewer forecasts of "scattered" coverage, a coverage rarely observed. Perhaps NSSFC's scores reflect the stability of the verification method better than TDL's scores.

Table 1 also shows the comparative verification scores for the summer months of 1977 and 1976. The comparative verification period for the summer of 1977 extended from June 16 through September 15 with one missing day. For the summer of 1976 the period extended from July 1 through September 30 with three missing days. As expected, scores are lower in summer than in spring reflecting the increased difficulty of forecasting severe local storms in summer. The critical success index was nearly the same for both sets of forecasts. NSSFC's outlook areas (x + z) were smaller and/or fewer in number compared with TDL's. As a result NSSFC enjoyed a better bias but suffered a lower probability of detection. NSSFC's coverage bias of 1.06 for the summer of 1976 was almost perfect.

6. SUMMARY AND CONCLUSIONS

We have shown how the MOS thunderstorm and severe local storm probability guidance forecasts transmitted on facsimile can be used to make a categorical or yes/no forecast of severe local storms. As a result of this study, we anticipate an increase in the value of these forecasts as guidance to NSSFC and field forecasters in preparing their convective outlooks.

Although the TDL and NSSFC forecast products are different in design and are prepared by contrasting systems, we believe the verification method proposed here produces a fair evaluation. The scores used are well defined in the literature and generally understood by the meteorological community. They should provide an

excellent "yardstick" for measuring the effects of forecasting changes that may be made from year to year. Also, we believe the verification method is compatible for both forecast products and that the scores obtained may be compared.

REFERENCES

Donaldson, R. J., Jr., R. M. Dyer, and M. J. Kraus, 1975: An objective evaluation of techniques for predicting severe weather events. Proc. Ninth Conference on Severe Local Storms, October 1975, Norman, Okla., Amer. Meteor. Soc., 321-326.

National Weather Service, 1976: SELS severe weather outlook - AC. NWS Technical Procedures Bulletin No. 154, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, 4 pp.

National Weather Service, 1977a: Thunderstorm and severe local storm probabilities based on model output statistics--No. 5. NWS Technical Procedures Bulletin No. 199, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, 12 pp.

National Weather Service, 1977b: Operations Manual, Chapter C-40, Severe Local Storm Warnings, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, 26 pp.

Palmer, W. C., and R. A. Allen, 1949: Note on accuracy of forecasts concerning the rain problem. Unpublished manuscript, U.S. Weather Bureau, Washington, D.C., 4 pp.

Panofsky, H. A., and G. W. Brier, 1958: Some applications of statistics to meteorology. The Pennsylvania State University, Universtiy Park, Pa., 224 pp.

Reap, R. M., and D. S. Foster, 1977: Operational thunderstorm and severe local storm probability forecasts based on model output statistics. Proc. Tenth Conference on Severe Local Storms, October 1977, Omaha, Neb., Amer. Meteor. Soc., 376-381.

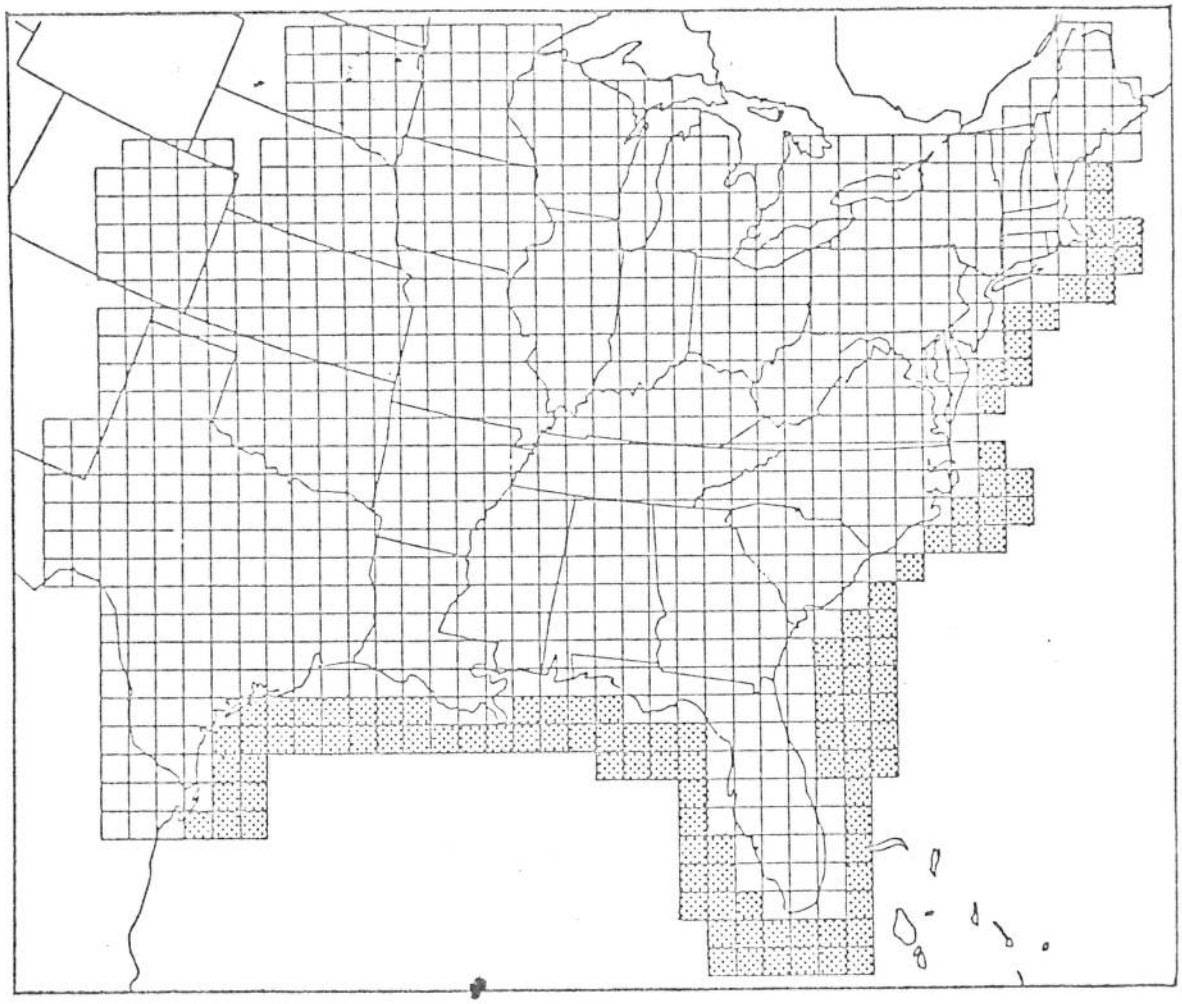

Figure 1. MDR grid region. Data from clear blocks are used to verify the NSSFC operational 24-h convective outlooks and the TDL 24-h guidance forecasts of severe local storms.

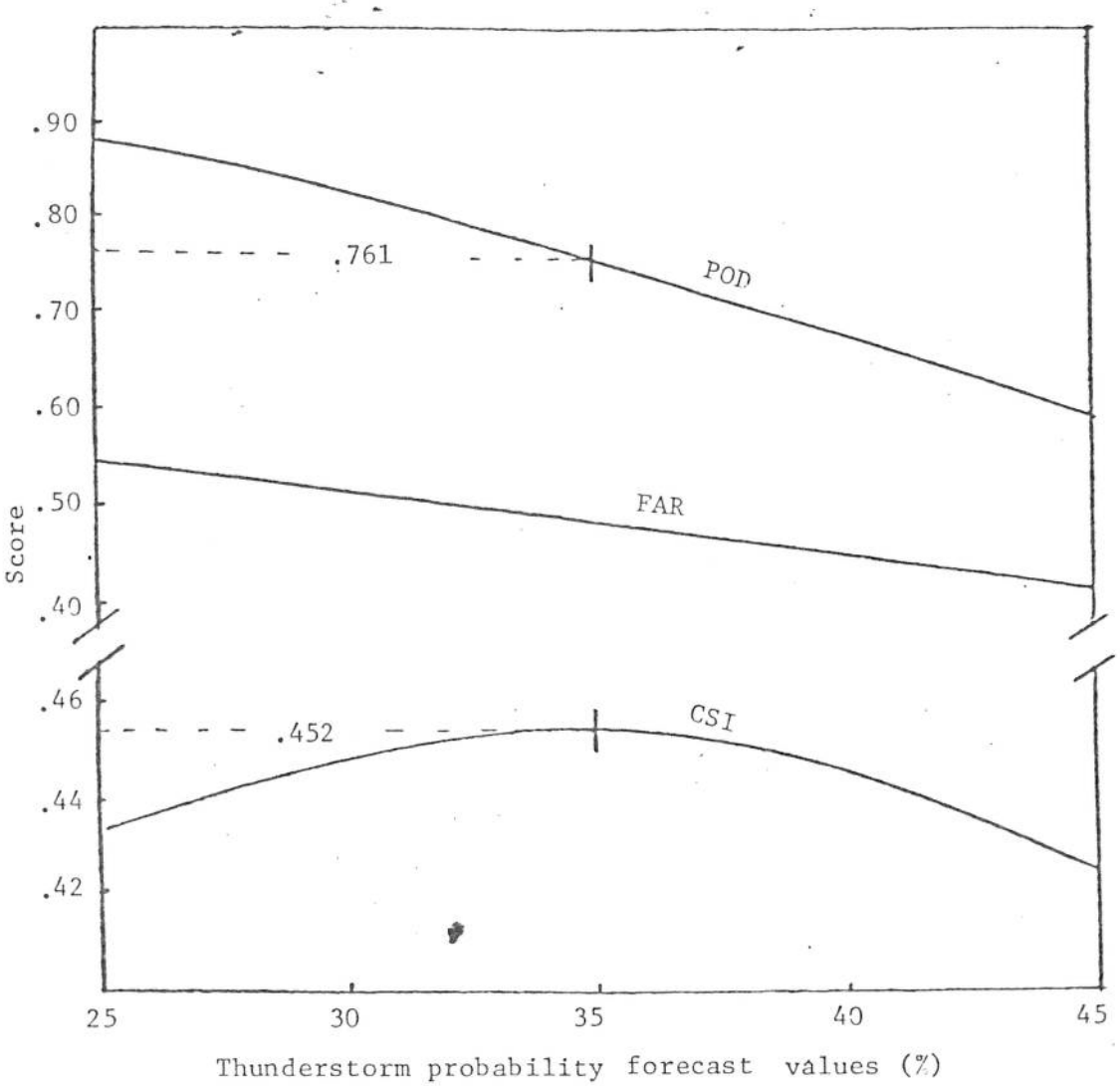

Figure 2. The relationship among the critical success index (CSI) or threat score, false alarm ratio (FAR) and probability of detection (POD) for a range of thunderstorm probability forecast values. The threat score maximizes at 35% where the POD shows 76.1% of the thunderstorms occurring within this contour. Data were for 761 overland MDR blocks shown in Fig. 1 for the period March 16 through September 15, 1977.

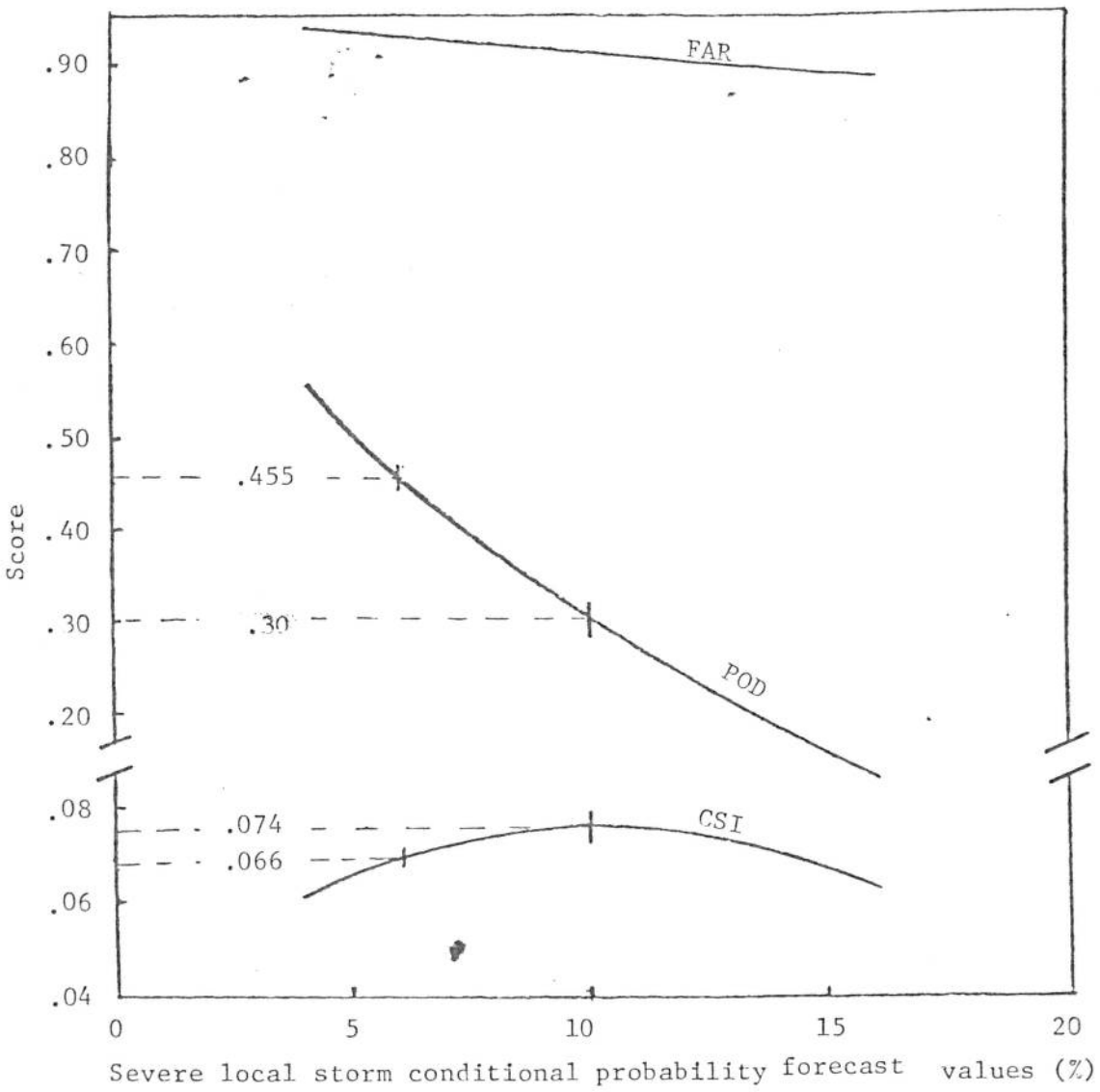

Figure 3. The relationship among the critical success index (CSI) or threat score, false alarm ratio (FAR) and probability of detection (POD) for a range of severe local storm conditional probability forecast values. The condition was a 35% probability forecast for thunderstorms (see Fig. 2). The threat score maximizes at 10% where the POD shows 30% of the severe local storms occurring within this contour and the 35% thunderstorm contour. Data were for 761 overland MDR blocks shown in Fig. 1 for the period March 16 through June 15, 1977.

Table 1. Comparative verification scores for the TDL and NSSFC 24-h severe local storm forecasts. Scores and column headings x, y, z, and w are defined in Appendix A.

	Unit	CSI	POD	FAR	BIAS	SS	CBIAS	x	y	z	w
Spring 1977	TDL	0.07	0.46	0.93	6.31	0.10	1.66	346	415	4455	44249
	NSSFC	0.07	0.49	0.92	6.13	0.11	1.27	372	389	4289	44415
Spring 1976	TDL	0.05	0.52	0.95	10.12	0.07	2.16	445	413	8239	47217
	NSSFC	0.07	0.46	0.92	5.98	0.11	1.62	396	462	4737	50719
Summer 1977	TDL	0.05	0.41	0.95	8.34	0.06	1.93	418	596	8036	60201
	NSSFC	0.05	0.32	0.95	5.82	0.07	1.55	321	693	5579	62658
Summer 1976	TDL	0.04	0.35	0.95	7.53	0.07	1.75	200	365	4055	63109
	NSSFC	0.05	0.18	0.93	2.68	0.09	1.06	100	465	1416	65748

APPENDIX A

CONTINGENCY TABLE AND VERIFICATION SCORES DEFINED

Contingency table:

		Forecast		
		severe	non-severe	total
Observed	severe	x	y	x + y
	non-severe	z	w	z + w
	total	x + z	y + w	x + y + z + w

x = number of observed severe local storm blocks inside the forecast area (hits).

y = number of observed severe local storm blocks outside the forecast area (misses).

z = number of observed non-severe local storm blocks inside the forecast area.

w = number of observed non-severe local storm blocks outside the forecast area and inside the MDR grid.

x+y = number of observed severe local storm blocks in the MDR grid.

x+z = number of MDR blocks inside the forecast area.

x+y+z+w = number of MDR blocks verified in the forecast period (761 times number of days).

x+w = number of correct severe and non-severe forecasts in the MDR grid.

y+w = number of non-severe local storm blocks forecast in the MDR grid.

z+w = number of non-severe local storm blocks observed in the MDR grid.

The following scores are computed from this contingency table.

Probability of detection (POD) as defined by Donaldson (1975):

$$POD = \frac{x}{x + y}$$

False alarm ratio (FAR) (Donaldson, 1975):

$$FAR = \frac{z}{x + z}$$

Critical success index (CSI) (Donaldson, 1975) or threat score (Palmer and Allen, 1949):

$$CSI = \frac{x}{x + y + z}$$

Bias (BIAS):

$$BIAS = \frac{x + z}{x + y}$$

Skill score (SS) (Panofsky and Brier, 1958):

$$SS = \frac{(x + w) - (A + B)}{(x + y + z + w) - (A + B)}$$

where:

$$A = \frac{(x + z)(x + y)}{x + y + z + w}$$ = severe forecast blocks expected to verify by chance.

$$B = \frac{(y + w)(z + w)}{x + y + z + w}$$ = non-severe forecast blocks expected to verify by chance.

APPENDIX B

DAILY COMPARATIVE VERIFICATION SCORES

Appendix B contains the daily comparative verification scores for spring 1977. Daily scores for the spring and summer of 1976 and the summer of 1977 are available at TDL. They are omitted here for the sake of brevity.

Daily comparative verification scores for spring 1977.

Date	Unit	CSI	POD	FAR	BIAS	SS	CBIAS	x	y	z	w
4/8/77	TDL	.00	.00	1.00	.00	.00	.00	0	0	1	760
	NSSFC	.00	.00	.00	.00	.00	.00	0	0	0	761
4/9/77	TDL	.00	.00	.00	.00	.00	.00	0	0	0	761
	NSSFC	.00	.00	.00	.00	.00	.00	0	0	0	761
4/10/77	TDL	.00	.00	.00	.00	.00	.00	0	0	0	761
	NSSFC	.00	.00	.00	.00	.00	.00	0	0	0	761
4/11/77	TDL	.00	.00	.00	.00	.00	.00	0	1	0	760
	NSSFC	.00	.00	.00	.00	.00	.00	0	1	0	760
4/12/77	TDL	.00	.00	1.00	5.00	-.00	.00	0	1	5	755
	NSSFC	.02	1.00	.98	41.00	.05	2.46	1	0	40	720
4/13/77	TDL	.13	.67	.87	5.00	.21	.61	4	2	26	729
	NSSFC	.06	.33	.93	4.83	.10	.87	2	4	27	728
4/14/77	TDL	.03	.25	.97	8.75	.04	3.16	1	3	34	723
	NSSFC	.05	.50	.95	10.00	.08	1.20	2	2	38	719
4/15/77	TDL	.09	.90	.91	9.60	.15	1.28	9	1	87	664
	NSSFC	.09	.90	.91	10.50	.14	.70	9	1	96	655
4/17/77	TDL	.07	.67	.93	9.50	.11	1.23	4	2	53	702
	NSSFC	.00	.00	.00	.00	.00	.00	0	6	0	755
4/18/77	TDL	.00	.00	1.00	2.00	-.00	.00	0	2	4	755
	NSSFC	.00	.00	.00	.00	.00	.00	0	2	0	759
4/19/77	TDL	.00	.00	1.00	.22	-.00	.00	0	9	2	750
	NSSFC	.00	.00	.00	.00	.00	.00	0	9	0	752
4/20/77	TDL	.08	.40	.92	4.73	.11	1.15	6	9	65	681
	NSSFC	.12	.73	.88	5.87	.19	.48	11	4	77	669
4/21/77	TDL	.04	.40	.96	9.00	.05	2.42	6	9	129	617
	NSSFC	.04	.53	.96	14.67	.03	3.43	8	7	212	534
4/22/77	TDL	.00	.00	1.00	2.00	-.00	.00	0	1	2	758
	NSSFC	.00	.00	.00	.00	.00	.00	0	1	132	628
4/23/77	TDL	.00	.00	.00	.00	.00	.00	0	1	0	760
	NSSFC	.00	.00	.00	.00	.00	.00	0	1	0	760
4/24/77	TDL	.07	.27	.92	3.36	.11	.94	3	8	34	716
	NSSFC	.00	.00	.00	.00	.00	.00	0	11	0	750

Date	Unit	CSI	POD	FAR	BIAS	SS	CBIAS	x	y	z	w
4/25/77	TDL	.00	.00	1.00	19.50	-.01	.00	0	2	39	720
	NSSFC	.02	.50	.98	30.50	.03	9.15	1	1	60	699
4/26/77	TDL	.00	.00	.00	.00	.00	.00	0	0	0	761
	NSSFC	.00	.00	.00	.00	.00	.00	0	0	0	761
4/27/77	TDL	.00	.00	.00	.00	.00	.00	0	1	0	760
	NSSFC	.00	.00	.00	.00	.00	.00	0	1	0	760
4/28/77	TDL	.00	.00	1.00	.00	.00	.00	0	0	20	741
	NSSFC	.00	.00	.00	.00	.00	.00	0	0	0	761
4/29/77	TDL	.02	.33	.98	21.33	.02	4.72	1	2	63	695
	NSSFC	.00	.00	.00	.00	.00	.00	0	3	0	758
5/1/77	TDL	.00	.00	1.00	10.00	-.01	.00	0	3	30	728
	NSSFC	.02	.33	.98	21.33	.02	3.84	1	2	63	695
5/2/77	TDL	.02	.06	.97	2.06	.01	3.54	1	15	32	713
	NSSFC	.12	.69	.88	5.56	.18	0.49	11	5	78	667
5/3/77	TDL	.02	.13	.98	7.00	.01	5.38	1	7	55	698
	NSSFC	.04	.25	.95	5.25	.06	1.26	2	6	40	713
5/4/77	TDL	.08	.27	.90	2.67	.12	1.06	4	11	36	710
	NSSFC	.05	.27	.94	4.40	.07	.99	4	11	62	684
5/5/77	TDL	.14	.86	.86	6.19	.16	1.31	37	6	229	489
	NSSFC	.14	.61	.85	3.93	.17	.62	26	17	143	575
5/6/77	TDL	.06	.52	.94	7.94	.05	2.35	16	15	230	500
	NSSFC	.06	.26	.93	3.77	.05	1.68	8	23	109	621
5/8/77	TDL	.03	.08	.96	1.92	.03	1.97	1	12	24	724
	NSSFC	.00	.00	.00	.00	.00	.00	0	13	0	748
5/9/77	TDL	.06	.37	.93	5.48	.06	1.30	10	17	138	596
	NSSFC	.03	.07	.95	1.41	.02	1.14	2	25	36	698
5/11/77	TDL	.00	.00	1.00	8.50	-.01	.00	0	4	34	723
	NSSFC	.03	.50	.97	14.50	.06	1.74	2	2	56	701
5/12/77	TDL	.00	.00	1.00	.50	-.00	.00	0	2	1	758
	NSSFC	.00	.00	.00	.00	.00	.00	0	2	0	759
5/13/77	TDL	.00	.00	.00	.00	.00	.00	0	1	0	760
	NSSFC	.00	.00	.00	.00	.00	.00	0	1	0	760

Date	Unit	CSI	POD	FAR	BIAS	SS	CBIAS	x	y	z	w
5/14/77	TDL	.01	.50	.99	35.00	.02	7.05	1	1	69	690
	NSSFC	.04	1.00	.96	27.50	.07	4.13	2	0	53	706
5/15/77	TDL	.05	.42	.95	8.08	.07	3.70	5	7	92	657
	NSSFC	.07	.92	.93	13.83	.10	1.66	11	1	155	594
5/16/77	TDL	.06	.37	.93	5.58	.07	2.15	7	12	99	643
	NSSFC	.13	.84	.87	6.42	.19	.46	16	3	106	636
5/17/77	TDL	.14	.62	.85	4.03	.18	.96	23	14	126	598
	NSSFC	.16	.76	.83	4.43	.22	.88	28	9	136	588
5/18/77	TDL	.05	.58	.95	11.50	.07	2.75	7	5	131	618
	NSSFC	.07	.83	.93	12.08	.10	.87	10	2	135	614
5/19/77	TDL	.11	.87	.89	8.17	.14	1.49	20	3	168	570
	NSSFC	.13	.83	.87	6.26	.19	1.14	19	4	125	613
5/20/77	TDL	.06	.63	.94	9.94	.08	2.09	10	6	149	596
	NSSFC	.07	.81	.93	12.19	.09	2.25	13	3	182	563
5/21/77	TDL	.12	.68	.87	5.19	.16	.89	21	10	140	590
	NSSFC	.24	.71	.73	2.65	.35	.56	22	9	60	670
5/22/77	TDL	.07	.58	.93	8.32	.08	1.67	11	8	147	595
	NSSFC	.09	.63	.91	6.90	.12	1.64	12	7	119	623
5/23/77	TDL	.04	.22	.95	4.17	.04	1.59	5	18	91	647
	NSSFC	.04	.17	.95	3.35	.04	1.16	4	19	73	665
5/24/77	TDL	.02	.29	.99	18.86	.01	9.32	2	5	130	624
	NSSFC	.01	.14	.99	9.29	.01	3.90	1	6	64	690
5/25/77	TDL	.00	.00	1.00	22.00	-.01	.00	0	2	44	715
	NSSFC	.02	.50	.98	24.00	.04	2.88	1	1	47	712
5/26/77	TDL	.05	.46	.95	9.00	.07	2.86	5	6	94	656
	NSSFC	.07	.55	.93	7.36	.11	2.03	6	5	75	675
5/27/77	TDL	.07	.73	.93	9.93	.10	2.11	11	4	138	608
	NSSFC	.09	.73	.91	8.33	.13	1.71	11	4	114	632
5/28/77	TDL	.04	.36	.96	8.93	.04	3.39	5	9	120	627
	NSSFC	.05	.64	.94	11.57	.07	2.27	9	5	153	594
5/29/77	TDL	.03	.25	.97	8.33	.03	3.55	3	9	97	652
	NSSFC	.15	.33	.78	1.50	.25	.27	4	8	14	735

Date	Unit	CSI	POD	FAR	BIAS	SS	CBIAS	x	y	z	w
5/30/77	TDL	.05	.45	.95	8.60	.05	1.80	9	11	163	578
	NSSFC	.07	.65	.93	9.15	.09	.85	13	7	170	571
5/31/77	TDL	.10	.26	.87	2.00	.11	.64	11	31	73	646
	NSSFC	.10	.31	.87	2.38	.11	1.15	13	29	87	632
6/1/77	TDL	.05	.57	.95	10.79	.07	1.80	8	6	143	604
	NSSFC	.04	.43	.96	10.21	.04	3.58	6	8	137	610
6/2/77	TDL	.02	.07	.98	3.13	.00	4.39	1	14	46	700
	NSSFC	.02	.07	.97	2.27	.01	2.04	1	14	33	713
6/3/77	TDL	.03	.25	.97	7.50	.05	2.16	1	3	29	728
	NSSFC	.00	.00	.00	.00	.00	.00	0	4	0	757
6/4/77	TDL	.03	.67	.97	25.33	.04	3.64	2	1	74	684
	NSSFC	.00	.00	1.00	16.00	-.01	.00	0	3	48	710
6/5/77	TDL	.10	.69	.90	7.00	.15	.94	9	4	82	666
	NSSFC	.10	.62	.89	5.62	.16	.55	8	5	65	683
6/6/77	TDL	.08	.50	.91	5.55	.11	1.26	10	10	101	640
	NSSFC	.07	.35	.92	4.55	.09	1.95	7	13	84	657
6/7/77	TDL	.20	.67	.78	3.06	.29	.39	24	11	83	643
	NSSFC	.19	.86	.80	4.37	.26	.77	30	5	123	603
6/8/77	TDL	.00	.00	1.00	1.17	-.01	.00	0	6	7	748
	NSSFC	.00	.00	1.00	3.00	-.01	.00	0	6	18	737
6/9/77	TDL	.04	.83	.96	20.17	.07	2.27	5	1	116	639
	NSSFC	.06	.50	.94	8.33	.09	1.00	3	3	47	708
6/10/77	TDL	.05	.75	.95	15.25	.08	2.28	3	1	58	699
	NSSFC	.03	.50	.97	18.25	.04	2.19	2	2	71	686
6/11/77	TDL	.07	.67	.93	9.22	.11	1.83	6	3	77	675
	NSSFC	.13	.89	.87	7.00	.21	.47	8	1	55	697
6/12/77	TDL	.03	.20	.97	5.93	.03	2.66	3	12	86	660
	NSSFC	.04	.40	.96	10.60	.03	3.11	6	9	153	593
6/13/77	TDL	.06	.22	.92	2.78	.07	1.14	5	18	59	679
	NSSFC	.06	.48	.94	7.61	.06	.96	11	12	164	574
6/14/77	TDL	.16	.37	.79	.79	.25	.39	7	12	26	716
	NSSFC	.05	.16	.94	2.58	.05	.98	3	16	46	696
6/15/77	TDL	.07	.29	.92	3.71	.11	1.44	2	5	24	730
	NSSFC	.02	.29	.98	15.71	.02	3.30	2	5	108	646