NOAA Technical Memorandum NWS ER-58

AN ANALYSIS OF FORECASTERS' PROPENSITIES IN MAXIMUM/MINIMUM TEMPERATURE FORECASTS

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Eastern Region Headquarters
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UNITED STATES DEPARTMENT OF COMMERCE
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Robert M. White, Administrator
/ National Weather Service
George P. Cressman, Director

INTRODUCTION

Since objective forecast techniques do not exactly describe the real world, a forecaster must apply subjectivity or propensity to produce the final forecast. One can measure this propensity in terms of numerical indicators derived solely from forecast and observed data. When these indicators are plotted against time, various patterns may emerge. These patterns can be interpreted as optimism or pessimism, over-reaction or under-reaction of a forecaster, or even a lack of any propensity when it is compared to an objective forecasting model.

In the following we will investigate an objective model used in measuring a forecaster's subjectiveness as indicators derived from forecast and observed maximum/minimum temperatures based on the FP/NMC Verification Data Tabulation. For the sake of better reader visualization, three common verification statistics have been renamed:

1. Mean algebraic error - "direction"

2. Root mean square error - "deviation"

3. Mean interdiurnal temperature variability - "difficulty"

We will plot and discuss the direction and deviation versus time for a few series of forecasts and superimpose these on a plot of the difficulty.

I. THE MODEL

The equation for the direction (mean algebraic error) is:

$$D_1 = \frac{\sum_{i=1}^{N} (F_i - O_i)}{N}$$

This is simply the mean of the differences of the forecast and observed maximum or minimum temperatures for a given sample, N. If, for a given sample, the sum of the F_i's is greater than the sum of the O_i's, the number derived will have a positive sign. The higher D_1 is, the larger the direction tendency, suggesting that the forecast temperatures were too high or too low, depending on the sign.

The equation of the deviation (root mean square error) is:

$$D_2 = \sqrt{\frac{\sum_{i=1}^{N} (F_i - O_i)^2}{N}}$$

This is the root mean of the sum of the differences of the forecast and observed maximum or minimum temperatures, squared, for a given sample, N, and measures the accuracy of the forecast temperature. The smaller that D_2 is, the more accurate the forecast temperature. Note that one can forecast equally above and below the observed temperature for a given period, have no directional tendency, but show a large deviation.

The equation for difficulty (mean interdiurnal temperature variability) is:

$$D_3 = \frac{\sum_{i=1}^{N} \left| O_i - O_{i-1} \right|}{N}$$

This is the mean of the absolute differences between the observed maximum or minimum temperature and the observed maximum or minium temperature 24 hours ago for a given sample, N. This indicator will be reflected in the other two indicators and describes, to a large extent, the temperature regime of the sample. This will become more obvious when the indicators are plotted.

II. DATA TABULATION AND EXAMPLES

Figure 1 is an example of the FP/NMC Verification Data Tabulation issued to WSFO's at regular intervals.

With these tabulations in hand one can calculate indicators for any forecaster, for any series of forecasts issued on his assigned dates, times, or stations, by reading the F-O or M-O and OB columns for any one of the forecast periods. For N>1, N must be consecutive and determined for the same period. The pattern recognition may be enhanced for N>2, by calculating overlapping or discrete smaller N's instead of one N for the entire period. Figures 2 a) - d) demonstrate that additional information can be gained by examining a time series of smaller samples. In Figure 2 a), the forecaster demonstrates a negative bias (D_1), but he does show more skill than a persistence forecast (D_2 is much less than D_3). As the sample size (N) becomes smaller (Figures 2 b), c), d), several aspects of the forecaster's performance appear:

1. His bias or direction (D_1) is not always negative.

2. His deviation error (D_2) increases as the difficulty (D_3) increases -- but not in a direct one-to-one manner.

3. The dramatic reversal of D_1, on day 6, may indicate that he was premature in the timing of a synoptic event.

Figure 1

FP/NMC VERIFICATION DATA TABULATIONS

FP/M FORECAST BY WSFO 414 FOR STATION 72414 CHARLESTON, W. VA. NOVEMBER 1972

0600Z FORECASTS AND OBSERVATIONS

DAILY TEMPERATURE FORECASTS

FCSTR NO.		12 - 00Z 1ST PERIOD					00 - 12Z 2ND PERIOD					12Z - 00Z 3RD PERIOD				
FP	DAY	F	M	OB	F-O	M-O	F	M	OB	F-O	M-O	F	M	OB	F-O	M-O
16	1	68	66	55	13	11	53	42	43	10	-1	62	62	43	19	19
16	2	57	58	43	14	15	38	38	42	-4	-4	56	57	46	10	11
16	3	56	56	46	10	10	41	40	49	-8	-9	62	63	62	0	1
15	4	60	61	62	-2	-1	42	41	48	-6	-7	55	58	53	2	5
15	5	61	58	53	8	5	37	39	41	-4	-2	63	58	53	10	5
15	6	56	56	53	3	3	38	40	30	8	10	60	61	58	2	3
15	7	58	62	58	0	4	45	41	52	-7	-11	53	60	60	-7	0
15	8	52	60	60	-8	0	38	36	45	-7	-9	42	43	37	5	6
18	9	40	42	37	3	5	25	29	28	-3	1	46	45	41	5	4
18	10	46	45	41	5	4	34	33	34	0	-1	40	49	43	-3	6
18	11	47	43	43	4	0	30	30	36	-6	-6	46	46	45	1	1
16	12	47	44	45	2	-1	36	31	37	-1	-6	50	48	43	7	5
16	13	42	47	39	3	8	28	27	34	-6	-7	41	41	40	1	1
16	14	41	40	40	1	0	31	24	31	0	-7	41	38	37	4	1
17	15	35	37	37	-2	0	28	25	31	-3	-6	36	35	37	-1	-2

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.
.
ETC.

Figure 2

D_1, D_2, D_3 FOR DISCRETE AND VARIOUS OVERLAPPING N'S
(REF: FIG. 1, FORECASTER #15, DAYS 4-8, PERIOD #2(00Z-12Z))

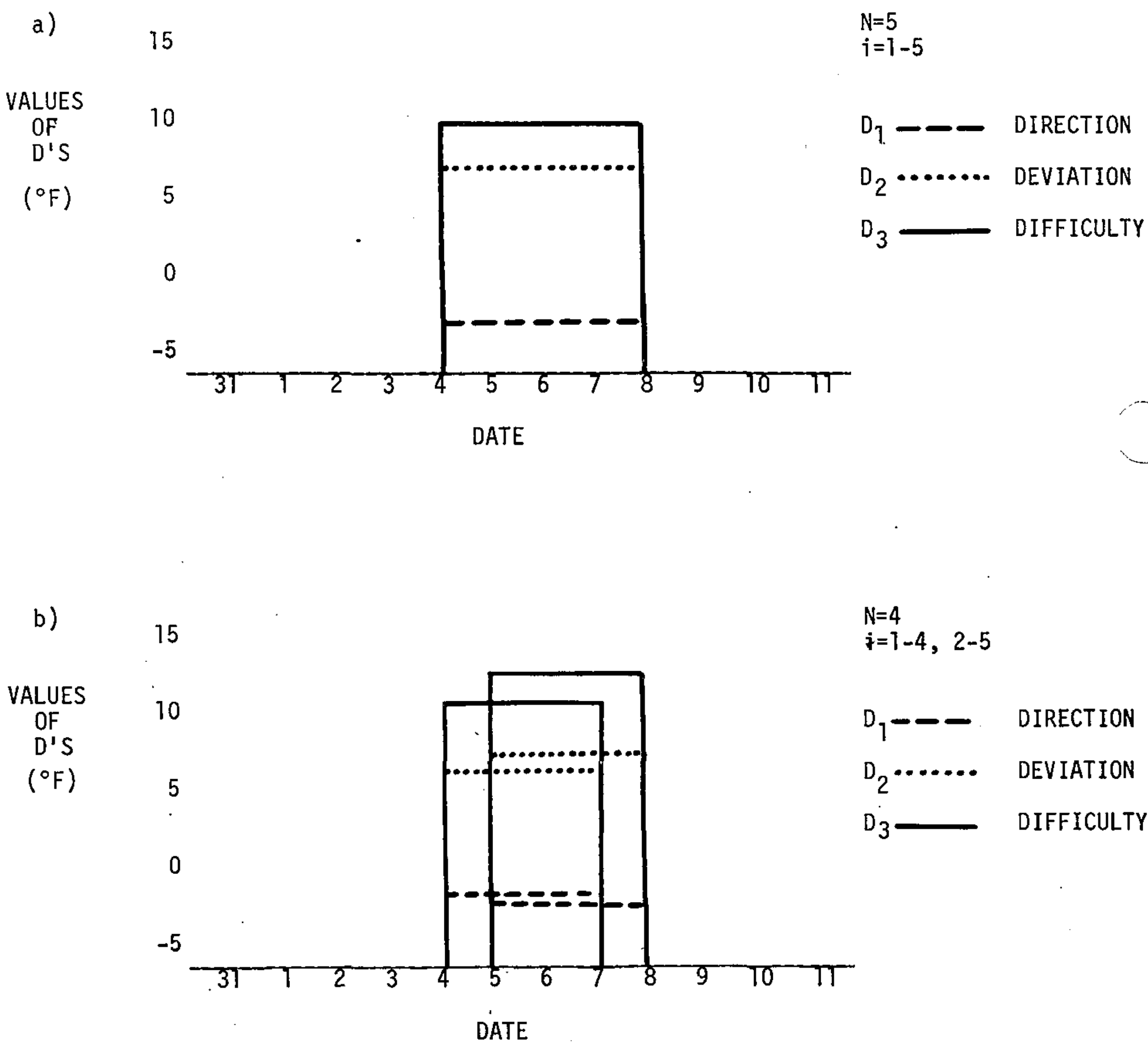
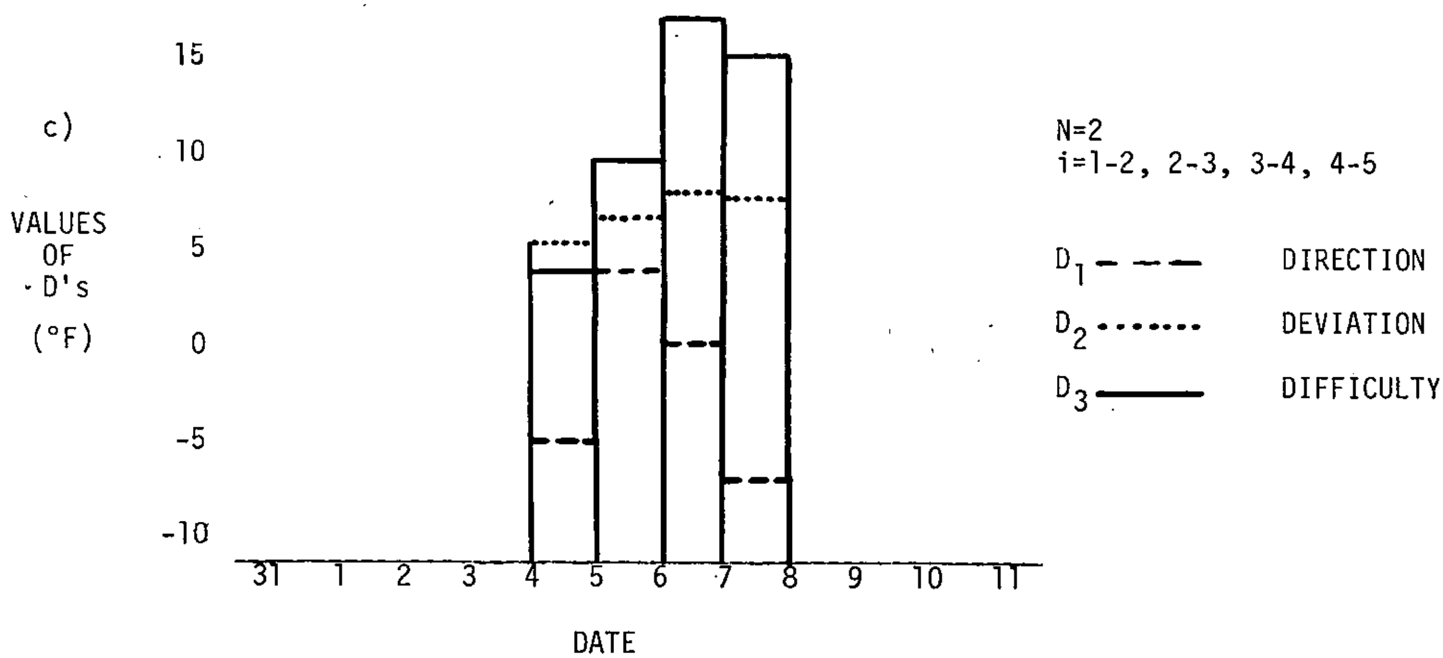
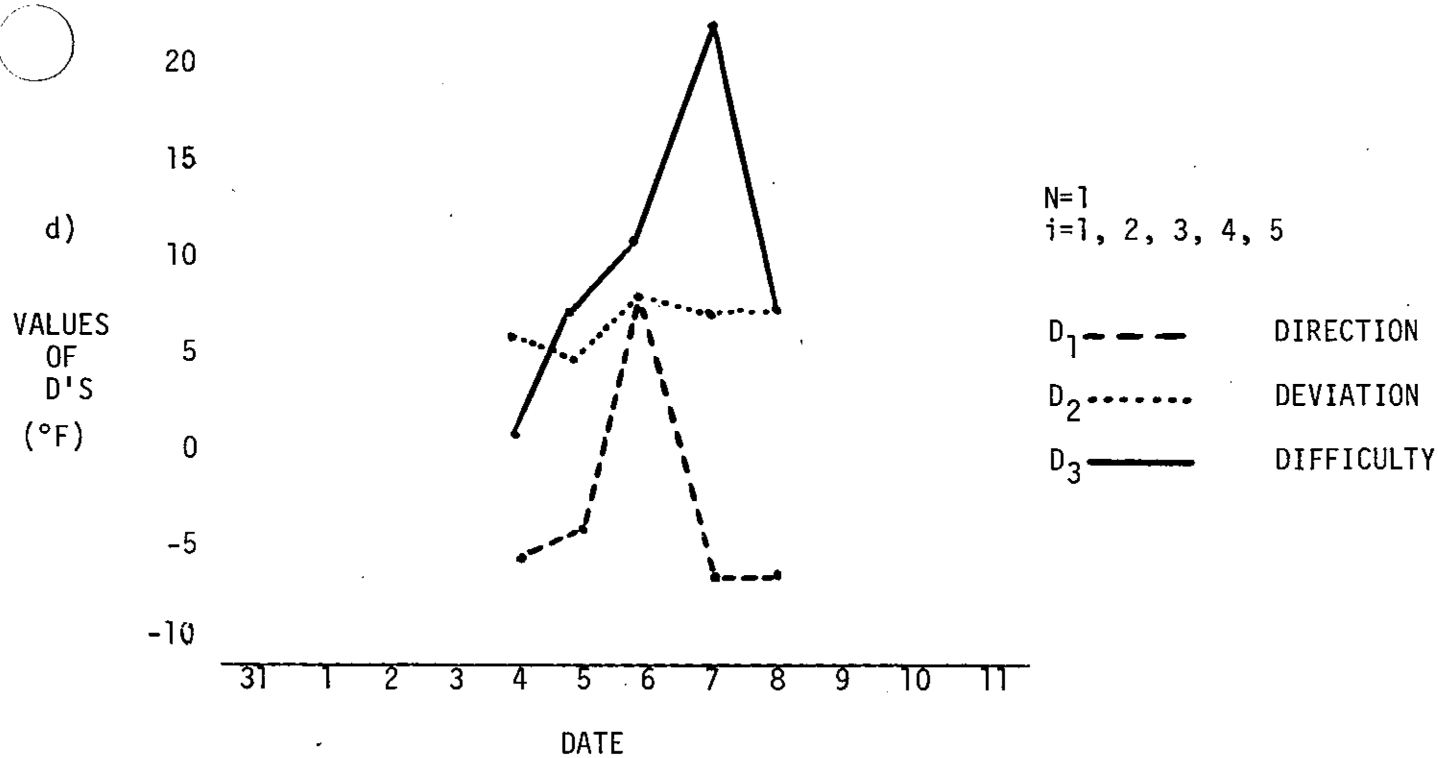


Figure 2 (cont'd.)

c)



d)



PATTERN RECOGNITION AND ANALYSES

Over a generous period of time one can differentiate patterns when calculations are plotted into a graphic display. The following are samples of some patterns with associated analyses.

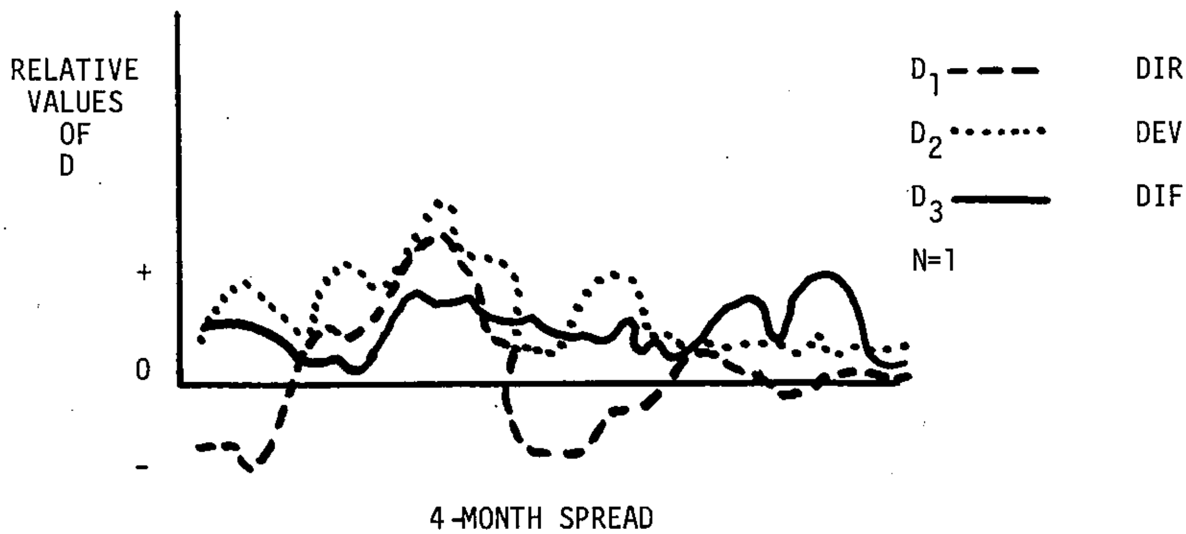
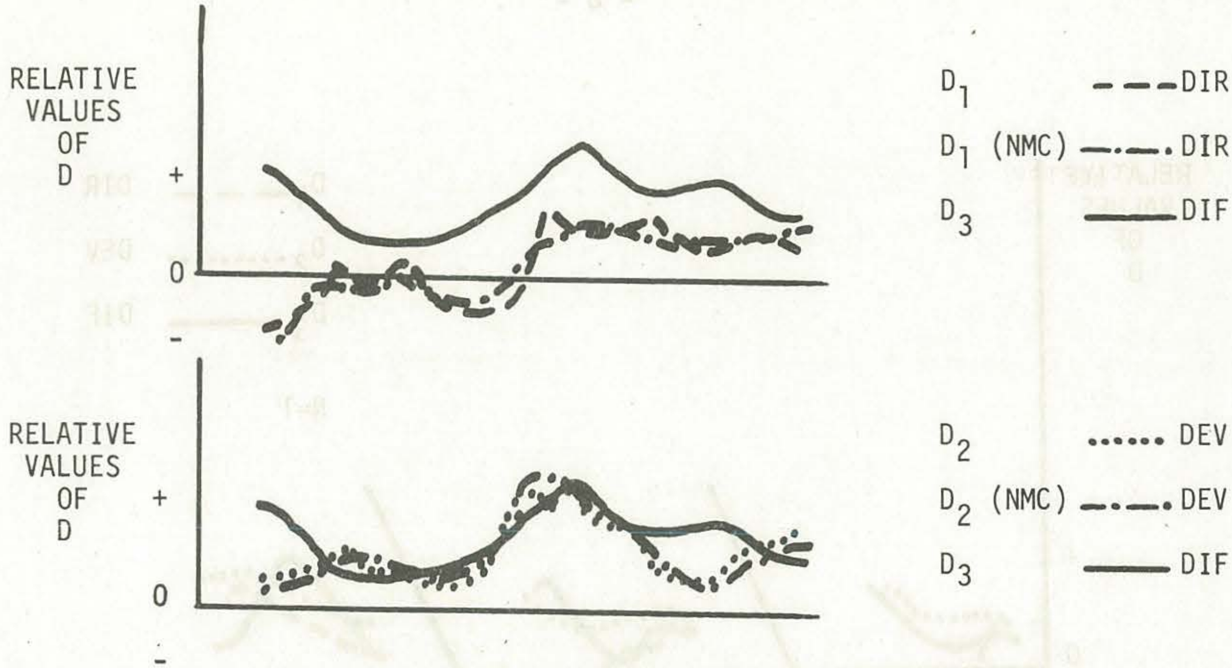


Figure 3

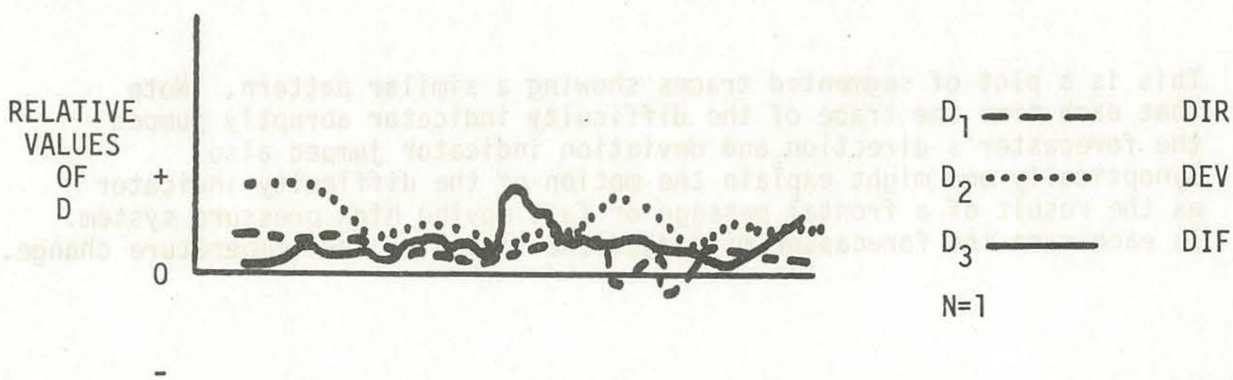
This is a plot of a novice GS-11 Forecaster during his first few months at forecasting. The trace of the difficulty indicator has a normal variability, but the variability of the direction and deviation indicator trace diminishes with time. This might be equated to a learning curve showing improvement with experience. (In Figures 3, 4, and 5, the time series have been depicted as continuous for the sake of visual clarity. In reality, the traces should be discontinuous with data available only when the forecaster is on duty).



2-MONTH SPREAD

Figure 4

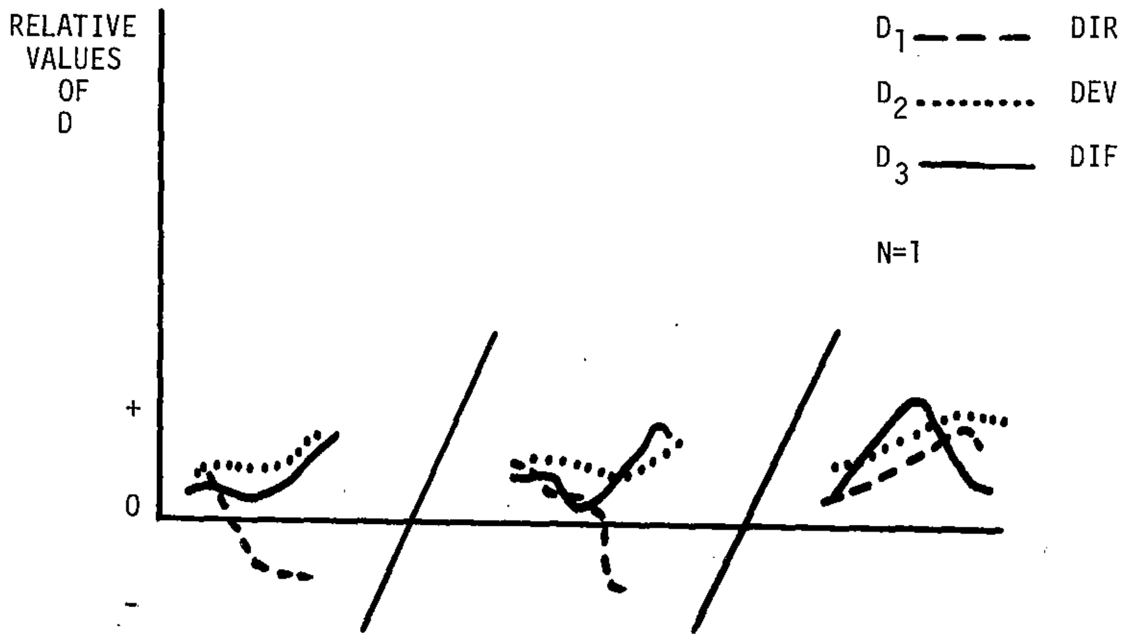
This is a plot of a forecaster with D values of NMC superimposed. Note the similarity of the traces indicating an almost complete concurrence of the forecaster with the NMC product under the same difficulty regime. The concurrence may be due to a lack of interest or confidence on the forecaster's part.



2-MONTH SPREAD

Figure 5

This is a forecaster with a general positive tendency in his direction. He would improve both his direction and deviation scores if he would lower his forecast temperatures.



SEGMENTED SAMPLES OF 2 TO 3 DAYS

Figure 6

This is a plot of segmented traces showing a similar pattern. Note that each time the trace of the difficulty indicator abruptly jumped the forecaster's direction and deviation indicator jumped also. Synoptically one might explain the motion of the difficulty indicator as the result of a frontal passage or fast moving high pressure system. In each case the forecaster misjudged the timing of the temperature change.

CONCLUSION

The methods demonstrated in this paper can be utilized by supervisors and forecasters alike. For the supervisor it can be a technique for monitoring the progress of a newly arrived journeyman forecaster. For the forecasters in the senior grade it can be a method of monitoring the rate of his acclimation into a new assignment or location, or just a technique for improving his current verification score.

The equations for the indicators are simple and easy to calculate from the FP/NMC Verification Data Tabulations. When computed and plotted over a substantial period of time, subjective forecasting patterns become more obvious and heuristic in nature.

ACKNOWLEDGMENT

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BIBLIOGRAPHY

Thierauf, Robert J. and Richard H. Grosse, "Decision Making Through Operations Research," John Wiley & Sons, Inc., New York, 1970.