METEOROLOGICAL OFFICE

FORECASTING TECHNIQUES MEMORANDUM

N° 14

FURTHER TESTS OF THUNDERSTORM FORECASTING METHODS

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Further tests of thunderstorm forecasting methods

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Introduction

A number of thunderstorm forecasting techniques were tested at forecasting offices under the author's control in 1965 (1). This note describes further similar tests carried out during the summer of 1966.

Methods tested

The methods tested in 1966 were those of Hanssen (2), Rackliff (3), modified Jefferson (4) and Boyden (5).

The usefulness of the Hanssen method in the 1965 Manby tests was limited by the fact that no diagram was included for dealing with troughs or ridges to east of the area. This diagram was received in time for testing in 1966.

In the case of the modified Jefferson method, it was desired to test a time-saving suggestion by Mr. G.J. Jefferson that the wet-bulb potential temperature for 850 mb should be used in place of the 900 mb value, using tables of the dry-bulb and dew point readings. It had also been noted that for some areas, for north-westerly air streams, Lowndes (6)(7)(8) had found lower values of the modified Jefferson critical number than originally recommended by the author (27/28). Values quoted by Lowndes were as follows:-

Area	Critical value	Skill score
S.E. England	24/25	0.61
S.W. England & S. Wales	24/25	0.43
N.W. England	27/28	0.66

Similarly, with the Boyden method, some doubt had arisen concerning the critical value, following the work of Lowndes, and an unpublished report describing tests carried out at Uxbridge during 1965.

The Uxbridge tests gave the following results:-

Area	Critical value	Skill score
London F.I.R.	93/94	0.09
	94/95	0.28

Lowndes found critical values as below:-

Area	Critical value	Skill score
S.E. England	93/94	0.67
S.W. England & S. Wales	94/95	0.50
N.W. England	94/95	0.46

It was clear, therefore, that it would be worth while testing lower values of the modified Jefferson index than the 27/28 originally recommended, and that Boyden 94/95 should be tested for the Manby Group Area.

As in 1965, the results obtained by the Manby forecasters in their normal day-to-day work were included under the heading "General Practice".

/ Testing arrangements

Testing arrangements

Arrangements for testing for the Manby Group Area were identical with those for 1965, so that the results are fully comparable.

Tests were carried out on Mondays to Fridays in the period 1st April to 30th September, 1966.

Forecasters were asked to use 0000 GMT upper air data with the chosen technique, to allow for effects of advection and surface heating as seemed appropriate, and record a simple "yes" or "no" forecast for thunderstorms for the Manby Group Area for the period 1200-2359 GMT. The Hanssen method is purely objective, and in this case no allowance could be made for advection or heating. Results were marked against records kept at Manby.

As an additional feature, forecasts whether or not thunderstorms would occur in small areas were included in the tests. The small areas were taken as individual aerodromes, Leeming and Manby being used for this purpose. These results were marked against the records of the stations concerned.

In all the tests, SFLOC reports were counted as positive.

Discussion of results

The results of the 1966 tests are set out in Tables I to IX. Where a method was also included in the 1965 tests, those results (skill score* or percentage, as appropriate) are included under a column headed "1965", for ease of comparison.

Table I gives the overall accuracy of forecasts for the Manby Group Area, taking all types of occasion together. The outstanding features appear to be as follows:-

(i) The improvement over 1965, shown by comparison of skill scores, in all those methods which require the skill and judgement of the forecaster. Only in the completely objective Hanssen method was there a slight decline in skill score.

(ii) With the Boyden method, 94/95 is seen to be the most useful critical value, for this area.

(iii) Using the modified Jefferson method, 27/28 is only marginally better than 26/27. The improvement over 1965 suggests that use of the 850 mb instead of the 900 mb wet-bulb potential temperature had no adverse effect. However, one station commented that there were often inversions below 850 mb and would prefer to return to 900 mb.

In Table II, the results for frontal and trough occasions are analysed separately. The improvement over 1965, noted in Table I, was maintained with the "General Practice" and Rackliff methods. Other methods tested in both years showed some decline. Boyden 94/95 appeared the most useful aid, as in Table I.

/ In

* Skill score defined as:

$$S = \frac{\text{number of forecasts correct} - \text{number correct by chance}}{\text{total number of forecasts} - \text{number correct by chance}}$$

In Tables III, IV and V, the results have been analysed according to air mass. It was found practicable to divide the test days into three groups for this purpose - (i) polar maritime, (ii) returning polar maritime, and (iii) warm and miscellaneous air masses. The tables show that the great majority of occasions were in the first two groups, with most of the actual thunderstorms occurring in returning polar maritime air. The relative usefulness of the methods can be seen from Tables III and IV. In Table III, the Rackliff method is shown to be the best aid in polar maritime air. This might be expected, since the method was designed for use in convection conditions, and this point received comment in our 1965 report (1). Table IV shows that for some reason almost all the skill scores are higher in dealing with returning polar maritime air than with polar air. Boyden 94/95 is here the most useful aid. If modified Jefferson is used, critical value 26/27 is rather better than 27/28. Only one thunderstorm occurred on the occasions grouped in Table V.

As in 1965, it was thought worth while dealing separately with the question of how well actual thunderstorms were included in the forecasts. This has been done for all occasions taken together, and for occasions separated into frontal or trough days and convection days, in Table VI, and separated according to air mass in Table VII.

The "all occasions" column in Table VI continues the tendency to show improved results in 1966 compared with 1965. In the "frontal and trough days" column, the Hanssen method is shown to be the best aid, as in 1965. On the "convection days", 100% accuracy was achieved with Boyden 94/95.

In Table VII, the modified Jefferson method is shown to be a useful aid, using one of the lower critical values, 25/26 in polar maritime and 26/27 in returning polar maritime, if the object is to include as many as possible of actual thunderstorms.

Tables VIII and IX give the results of tests for Leeming and Manby aerodromes. A striking feature is that although the numbers of actual thunderstorms at the two places were almost identical (9 at Leeming, 8 at Manby), all methods produced much better results for Leeming. Assuming both teams of forecasters to be equally skilled, the only possible interpretation of this appears to be that it is intrinsically more difficult to forecast thunderstorms for a small area near the coast than it is for an area well inland. For Leeming, the most useful aid was modified Jefferson 27/28. For Manby, it was Boyden 94/95 or Rackliff.

It is of interest to compare the results in Tables VIII and IX with results of tests of forecasts for thunderstorms occurring on the same day at Russian stations, reported by Ponomarenko (9). These tests were carried out at 18 stations during the summer of 1964. They followed up earlier tests, in which the results were rather less satisfactory, and certain amended procedures were introduced. The final product seems to have been a forecast rather comparable with "general practice" in the Manby tests. Ponomarenko's results were given in percentages, and are set out below side by side with the "general practice" results for Leeming, taken from Table VIII of this paper.

/ No. of forecasts

	18 Russian stations	Moscow	Leeming
No. of forecasts	1,656	- *	122
General correctness	84%	90%	94%
Forecast that thunderstorms would occur	41%	50%	58%
Forecast that thunderstorms would not occur	91%	97%	98%

(* Moscow was apparently one of the 18 stations, and the Moscow percentages were separated out because they were higher than those of the other stations)

This table shows that the Leeming "general practice" results obtained by Linton forecasters were better than those for the general run of Russian stations, and very similar indeed to those for Moscow. The above comparison does not allow for probable variations in the difficulty of forecasting thunder in UK and in Russia.

General practice forecasts

One feature of the 1966 tests is the major improvement in results obtained in "general practice" at Manby. In these tests, these forecasts have obtained the best results, however the occasions were analysed, which was not always the case in the 1965 tests. Furthermore, in the tests for small areas, the "general practice" forecasts for Leeming, prepared quite independently at Linton-on-Ouse, proved superior to forecasts restricted to a particular method. It is therefore worth considering the methods applied in "general practice".

All the forecasters concerned had before them twice daily charts of the Boyden index, broadcast on National Facsimile, and a "95 isopleth" was included on these charts from the beginning of the tests, at the author's request. It is difficult to assess just how much use was made of these charts. What is certain, from the brief day-to-day notes made by forecasters, is that a detailed study was made of all relevant tephigrams on each occasion, making due allowances for advective changes of temperature and humidity, taking into account the wind field at various levels, and matters such as subsidence, and arriving at the likely depth of convection cloud. Many other matters of background knowledge no doubt entered into the final decision in each case, but their relative importance is difficult to assess.

Time occupied in applying the techniques

The times taken were given in the 1965 report (1). In the case of the modified Jefferson method, it was found that if the 850 mb wet-bulb potential temperature replaces the 900 mb value, and tables of dry-bulb and dew point readings are used, the time taken is about 30 sec per ascent.

Where forecasts are being made for small areas, some economy in time is obviously possible. For instance, with the Rackliff method times of 5-8 min were reported, as against 10 min in 1965 tests for the larger area.

Conclusions

The overall improvement over 1965 could in some part be accounted for by the fact that the number of actual thunderstorm days was a little smaller in 1966 (40 days, as against 46 in 1965). In these tests, the percentage of

/ correct

correct "no" forecast always exceeds that for "yes" forecasts, so that as the number of thunderstorms decreases the overall accuracy of forecasts increases. However, this seems unlikely to have accounted for all the improvement noted, and comparisons leave the impression that the repeated testing of forecasts has its own intrinsic value in improving forecasts by making forecasters more aware of the problems involved and raising the general level of experience in dealing with them.

On these results, it appears rather unlikely that any known single technique could be expected to supersede "general practice". For the Manby Group Area, the Boyden index appears to be the most useful aid for general purposes, and for this area 94/95 seems the best critical value. However, in some circumstances one of the other techniques gives rather better results, as shown in the Tables. For localised forecasting, there is little to choose between modified Jefferson and Rackliff for Leeming, and between Boyden and Rackliff for Manby.

Acknowledgements

As in 1965, some forty forecasters shared in the work involved in these tests, and all have contributed to the useful results obtained. They now have the satisfaction of knowing that these efforts have contributed to an improved service being given in the matter of thunderstorm forecasting.

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Method	Testing Station	Accuracy of "Yes/No" forecasts			Accuracy of "Yes" forecasts			Accuracy of "No" forecasts			Skill Score	
		Number of forecasts	Number correct	% correct	Number of forecasts	Number correct	% correct	Number of forecasts	Number correct	% correct	1966	1965
General Practice	Manby	126	111	88	45	35	78	81	76	94	0.73	0.54
Boyden 94/95	Leeming	122	101	83	41	30	73	81	71	88	0.61	-
Rackliff 29/30	Syerston	122	100	82	35	26	74	87	74	85	0.57	0.46
Jefferson 27/28	Oakington	124	98	79	38	26	68	86	72	84	0.51	0.36
Jefferson 26/27	Oakington	124	95	77	49	30	61	75	65	87	0.49	-
Boyden 93/94	Topcliffe	124	93	75	51	30	59	73	63	86	0.47	0.40
Hanssen	Manby	125	88	70	51	27	53	74	61	82	0.37	0.40
Jefferson 25/26	Strubby	125	87	70	57	29	51	68	58	85	0.37	-

Table I

Overall accuracy of thunderstorm forecasts

Method	Accuracy of "Yes/No" forecasts			Accuracy of "Yes" forecasts			Accuracy of "No" forecasts			Skill Score	
	Number of forecasts	Number correct	% correct	Number of forecasts	Number correct	% correct	Number of forecasts	Number correct	% correct	1966	1965
General Practice	63	54	86	31	25	81	32	29	91	0.71	0.45
Boyden 94/95	61	46	75	23	18	78	38	28	74	0.50	-
Rackliff 29/30	62	46	74	22	17	77	40	29	73	0.47	0.34
Boyden 93/94	63	42	67	33	20	61	30	22	73	0.34	0.65
Hanssen	62	41	66	35	21	60	27	20	74	0.33	0.50
Jefferson 27/28	62	40	65	26	16	61	36	24	67	0.28	0.47
Jefferson 26/27	62	40	65	34	20	59	28	20	71	0.25	-
Jefferson 25/26	62	38	61	37	20	54	25	18	72	0.24	-

Table II

Accuracy of forecasts that thunderstorms would or would not occur on frontal or trough occasions

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Method	Accuracy of "Yes/No" forecasts			Accuracy of "Yes" forecasts			Accuracy of "No" forecasts			Skill Score
	Number of forecasts	Number correct	% correct	Number of forecasts	Number correct	% correct	Number of forecasts	Number correct	% correct	
General Practice	56	48	86	16	12	75	40	36	90	0.65
Rackliff 29/30	54	45	83	12	9	75	42	36	86	0.56
Jefferson 27/28	55	45	82	12	9	75	43	36	84	0.52
Boyden 94/95	54	43	80	17	11	65	37	32	87	0.52
Boyden 93/94	55	41	75	18	10	55	37	31	84	0.41
Jefferson 26/27	55	41	75	16	9	56	39	32	82	0.38
Jefferson 25/26	56	40	71	23	11	48	33	29	88	0.38
Hanssen	56	41	73	13	7	54	43	34	79	0.30

Table III

Accuracy of forecasts that thunderstorms would or would not occur in polar maritime air masses

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Method	Accuracy of "Yes/No" forecasts			Accuracy of "Yes" forecasts			Accuracy of "No" forecasts			Skill Score
	Number of forecasts	Number correct	% correct	Number of forecasts	Number correct	% correct	Number of forecasts	Number correct	% correct	
General Practice	49	44	90	26	22	85	23	22	96	0.80
Boyden 94/95	49	41	84	22	19	86	27	22	82	0.67
Rackliff 29/30	49	40	82	20	17	85	29	23	79	0.63
Jefferson 26/27	49	38	78	30	21	70	19	17	89	0.56
Jefferson 27/28	49	37	75	23	17	74	26	20	77	0.51
Boyden 93/94	49	36	73	28	19	68	21	17	81	0.47
Jefferson 25/26	49	36	73	26	18	69	23	18	78	0.47
Hanssen	48	31	65	34	20	59	14	11	79	0.30

Table IV

Accuracy of forecasts that thunderstorms would or would not occur in returning polar maritime air masses

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Method	Accuracy of "Yes/No" forecasts			Accuracy of "Yes" forecasts			Accuracy of "No" forecasts			
	Number of forecasts	Number correct	% correct	Number of forecasts	Number correct	% correct	Number of forecasts	Number correct	% correct	Skill Score
General Practice	21	19	90	3	1	33	18	18	100	0.46
Boyden 94/95	19	17	89	2	0	0	17	17	100	-
Jefferson 27/28	20	16	80	3	0	0	17	16	94	-
Boyden 93/94	20	16	80	5	1	20	15	15	100	0.27
Jefferson 26/27	20	16	80	3	0	0	17	16	94	-
Rackliff 29/30	19	15	79	3	0	0	16	15	94	-
Hanssen	21	16	76	4	0	0	17	16	94	-
Jefferson 25/26	20	11	55	8	0	0	12	11	92	-

Table V

Accuracy of forecasts that thunderstorms would or would not occur in warm and miscellaneous air masses

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Method	All Occasions				Frontal or trough days				Convection days			
	No. of thunderstorms	No. forecast correctly	% correct 1966	1965	No. of thunderstorms	No. forecast correctly	% correct 1966	1965	No. of thundertorms	No. forecast correctly	% correct 1966	1965
General Practice	40	35	87	72	28	25	89	65	12	10	83	76
Jefferson 26/27	40	30	75	-	28	20	71	-	12	10	83	-
Boyden 93/94	40	30	75	73	28	20	71	76	12	10	83	71
Boyden 94/95	40	30	75	-	28	18	64	-	12	12	100	-
Jefferson 25/26	39	29	74	-	27	20	74	-	12	9	75	-
Rackliff 29/30	39	26	67	56	28	17	61	44	11	9	82	63
Hanssen	40	27	67	76	28	21	75	87	12	6	50	70
Jefferson 27/28	40	26	65	62	28	16	57	76	12	10	83	54

Table VI

Inclusion in forecasts of thunderstorms which actually occurred. Frontal or trough days and convection days

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Method	Polar maritime air masses			Returning polar maritime air masses			Warm and miscellaneous air masses		
	No. of thunderstorms	No. forecast correctly	% correct	No. of thunderstorms	No. forecast correctly	% correct	No. of thunderstorms	No. forecast correctly	% correct
General Practice	16	12	75	23	22	96	1	1	100
Jefferson 26/27	16	9	56	23	21	91	1	0	0
Boyden 93/94	16	10	63	23	19	83	1	1	100
Boyden 94/95	16	11	69	23	19	83	1	0	0
Jefferson 25/26	16	11	69	23	18	78	1	0	0
Rackliff 29/30	15	9	60	23	17	74	1	0	0
Hanssen	16	7	44	23	20	87	1	0	0
Jefferson 27/28	16	9	56	23	17	74	1	0	0

Table VII

Inclusion in forecasts of thunderstorms which actually occurred, as related to air masses

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Method	Testing Station	Accuracy of "Yes/No" forecasts			Accuracy of "Yes" forecasts			Accuracy of "No" forecasts			
		Number of forecasts	Number correct	% correct	Number of forecasts	Number correct	% correct	Number of forecasts	Number correct	% correct	Skill Score
General Practice	Linton-on-Ouse	122	115	94	12	7	58	110	108	98	0.64
Jefferson 27/28	Church Fenton	126	112	89	21	8	38	105	104	99	0.48
Rackliff 29/30	Acklington	132	119	90	18	7	39	114	112	98	0.47
Jefferson 26/27	Church Fenton	126	110	87	25	9	36	101	101	100	0.47
Boyden 93/94	Topcliffe	126	109	87	24	8	33	102	101	99	0.43
Boyden 94/95	Leeming	122	103	84	24	7	29	98	96	98	0.36
Jefferson 25/26	Linton-on-Ouse	122	99	81	28	7	25	94	92	98	0.30
Jefferson 24/25	Linton-on-Ouse	122	87	71	42	8	19	80	79	99	0.22

Table VIII

Accuracy of thunderstorm forecasts for Leeming airfield

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Method	Testing Station	Accuracy of "Yes/No" forecasts			Accuracy of "Yes" forecasts			Accuracy of "No" forecasts			
		Number of forecasts	Number correct	% correct	Number of forecasts	Number correct	% correct	Number of forecasts	Number correct	% correct	Skill Score
Boyden 94/95	Stradishall	123	102	83	23	5	22	100	97	97	0.25
Rackliff 29/30	Syerston	122	97	80	29	6	21	93	91	98	0.25
Boyden 93/94	Stradishall	123	94	76	33	6	18	90	88	98	0.21
Jefferson 25/26	Strubby	125	92	74	35	5	14	90	87	97	0.14
Jefferson 24/25	Strubby	125	85	68	42	5	12	83	80	96	0.10
Jefferson 27/28	Oakington	124	102	82	18	2	11	106	100	94	0.07
Jefferson 26/27	Oakington	124	96	77	24	2	8	100	94	94	0.03

Table IX

Accuracy of thunderstorm forecasts for Manby airfield

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