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EVALUATION OF EXPERIMENTAL MESOSCALE FORECASTS DURING CASP

by

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ABSTRACT

During the Canadian Atlantic Storms Programme (CASP), experimental, site-specific, mesoscale forecasts were prepared by the CASP Forecast Centre. Verification of the Shearwater public forecasts and the Sable marine forecasts, each prepared in tabular format, reveals that the CASP Forecast Centre was able to produce forecasts superior to those prepared without the benefit of the special CASP data sets and experimental forecast guidance products. Although it is difficult to individually assess the impact on the forecasts of the CASP data, a significant improvement in the short-range precipitation forecasts is attributed in large part to the forecasters' use of the McIDAS display system.

The use of tabular forecast data input was found to be unsatisfactory by the participating forecasters. Attempts to predict mesoscale detail beyond 6 to 9 hours were unsuccessful.

Introduction

The Canadian Atlantic Storms Programme (CASP) was a major experiment designed to improve the understanding and prediction of the winter storms that affect the Canadian Atlantic Provinces. Of particular interest to the forecasting group was the aim of studying the structure of mesoscale features within these large storms - features of specific interest to the public such as rain-snow boundaries, rainbands and freezing rain areas.

A CASP Forecast Centre was established adjacent to the Maritimes Weather Centre (MWC), in Bedford N.S. This Centre was staffed by experienced forecasters from several Weather Centres and operated throughout CASP.

The setup and workings of the CASP Forecast Centre are set out in detail in Atlantic Region Technical Note 86-001, and will be briefly summarized here.

The forecasters had available to them most of the extensive data-gathering network which was established for the experiment. This included an enhanced network of 3-hourly radiosonde releases, two mesoscale networks of 10 m towers, a specially equipped observing site at Shearwater, N.S., which included a ground-based microwave radiometer, three weather radars including a portable unit on Sable Island and an enhanced observing network manned by volunteer weather observers.

In addition to this extra data, the forecasters had available numerous graphical display devices which were capable of presenting a wide variety of mostly experimental forecast guidance products. These included a 100-km resolution finite-element NWP model centred over the Maritimes (the FE-CASP, developed by RPN), RAINSAT (a satellite image decode display), and various Model Output Statistics (MOS) forecasts covering most of the forecast elements. Most powerful of all, the forecasters had the use of the McIDAS display system which provided satellite image display and field overlay capabilities (ref. Atlantic Region Technical Note (ARTN) 86-002).

The CASP Forecast Centre had three important functions. Its primary responsibility was to give operational forecast support to the CASP Logistics Committee. The forecasters were also to evaluate the usefulness of the extra equipment and data which were provided. These evaluations are given in a series of reports on CASP listed in the bibliography.

Finally, the forecasters were to write special mesoscale forecasts, in an experimental "digital" format. These are the forecasts, and their verification, which are discussed in this paper.

In order to provide as meaningful a comparison to the verification of the forecasts issued by the CASP Forecast Centre as possible, it was necessary to have a control set of forecasts, which would be issued without this extra data and special forecast guidance.

Rather than use the MWC forecasts as a control, which would have meant both rigidly separating the two offices and depriving the Maritimes Weather Centre of valuable information for their area of interest, a special Forecast Centre was set up adjacent to the Newfoundland Weather Centre (NWC) in Gander. For reference in the text, the CASP Forecast Centre in Bedford will be referred to as the MFC, and the one in Gander as the NFC. The NFC prepared the same forecasts as the MFC using the same forms and formats (see Atlc. Rgn. Tech. Note 86-004).

As a control, however, it was less than exact because the NFC forecasters prepared their forecasts under a somewhat different set of circumstances. For example:

i) the NFC forecasters prepared fewer forecasts but had less in the way of technical support,
ii) these forecasts were a primary rather than secondary function for the NFC as the forecasters did not have any additional duties directly in support of the main experiment,
iii) the NFC forecasters were generally junior staff while the forecasters in Bedford were all experienced (though some were not experienced in this region), and lastly,
iv) the forecasters in Bedford were on-site and largely familiar with the area while the Gander forecasters were neither.

Nevertheless, as a control it still had value as the whole Atlantic area certainly has similar forecast problems and the junior staff at Gander was supervised by a very experienced forecaster.

1. Description of the Forecasts

A detailed description of the forecasts is contained in the CASP-Operations Plan. In Appendix 1 are shown the forms used for each of the forecasts. These forecasts were an experimental design, to try and come up with a method of best providing mesoscale forecasts. They were intended to provide a complete picture of the weather elements at a point over short time steps. Briefly, the forecasts can be described as follows:

Site Specific Gridded Public Forecast - This forecast was valid for 18 hours from the issue time, with forecasts of each element at 3 hourly intervals. The forecasts were reissued every three hours. It was specific to Shearwater, N.S. which was the primary base of CASP field operations.

Due to some confusion in the original construction of the forecast forms, the NFC issued these forecasts for 24 rather than 18 hours, as is noted in the report by A. Earle. Their forecasts were only verified for the first 18 hours.

Site Specific Worded Public Forecast - This was for the same site although with only a 6-hour valid period. However it was a worded forecast specifically designed to be concise for rapid dissemination and short-term usage. It was not verified as it expressed part of the same forecast as that of the gridded format.

Site Specific Gridded Marine Forecast - This forecast was valid for 24 hours from the issue time, with forecasts of each element at 3 hourly intervals. The forecasts were reissued every six hours. It was specific to the area near Sable Island, and an oil rig operating in the area was intended as the verifying point.

This site selection was made in order to have some consistency in the verifying data, as elsewhere only varying numbers of ships would be obtainable.

Kennebacasis Enhanced QPF Forecast - This forecast was developed in response to a request from the River Forecast Centre in New Brunswick. The elements were forecast for the Kennebacasis catch basin, centred around Sussex, N.B. These forecasts were sent to the River Forecast Centre and will not be verified locally.

Rain/Freezing Rain/Snow Boundaries - These were isochrone charts of the various boundaries. The isochrones were at 6 hourly intervals and were only produced for the CASP study area. The appended form shows only the checklist that was to accompany the charts.

Total Snowfall - This was another isochrone chart and was a forecast of storm totals for snow. These two isochrone charts will not be verified.

Wave Forecast - In reality, wave forecasts were not prepared. It was found that very little real-time wave data were available at the CASP Forecast Centre and most of the forecasters has no experience in wave forecasting. Instead, simple tabulations of the wave height forecasts at the verifying points were kept. Case studies will be done later by forecasters from the Canadian Forces Meteorological and Oceanographic (MetOc) Centre.

2. Verification Methods

The large number of elements forecast and the unusual format required special programming to be done to verify the gridded forecasts. For this reason, only the major elements in each of the public and marine gridded forecasts were verified.

The verifying data was "raw" observational data taken from MWC archive tapes without quality control. Only those observations which had a forecast "match", and vice versa, were used in the case of wind and temperatures. For precipitation forecasts a three hour verifying window was used.

2.1 Public Forecast Grid (for Shearwater)

The precipitation forecasts were verified in two ways. The first was a two by two contingency table of occurrence or non-occurrence and the second was a simplified precipitation-type contingency table. Mixtures were taken to be "worst case"; the verifying phenomena could occur anywhere in the three hourly period; and very light precipitation of any type was not included.

The forecast temperatures were 3 hourly spot values. Maximum and minimum temperatures were not forecast explicitly. The temperatures were verified in terms of Mean Absolute Error (MAE), Root Mean Square Errors (RMS) and Bias. In addition, to give an indication of usefulness, the frequencies of errors of various magnitudes were tabulated. In these tabulations and others, because of differences in sample sizes (either differences between the MFC and NFC or between forecast projection times) numbers in the tables have been normalized to total 1000.

2.2 Marine Forecast Grid (for Sable area)

Verification of this forecast presented some problems. While in principle, the forecasts were prepared for the site of the Sedco 709 (approximately 100 km east of Sable Island), in practice, because the Sedco 709 was on-site for only 6 of the 9 weeks of the experiment and because wind observations from nearby Sable Island were available much more frequently, many forecasters were in fact attempting to predict conditions occurring at Sable Island. Consequently, forecasts were verified against both the Sable Island observations as well as the reports from the Sedco 709. The anemometers on the 709 are situated approximately 25 m above the sea which is only slightly higher than the average ship anemometer height of 19.5 m, therefore no reductions were done to the rig's wind speeds.

Forecast errors were summarized in two ways. First, standard error statistics (mean error, mean absolute error, root mean square error) were tabulated both for the wind speeds and directions. Second, contingency tables and their related scores for wind speeds and directions were prepared. Due to sample sizes, the wind direction contingency tables have only 4 categories (i.e., 4 quadrants) while the standard marine categories (light, moderate, strong, gale and storm) were used for the speeds. Because of the CASP interest in strong wind situations, the light and moderate wind speed categories were combined, resulting in 4 wind speed categories.

3. Verification Tables

The results of the verification of the gridded public forecasts against the Shearwater observations are shown in Tables 1.1 through 1.4.

The first two tables give MAE/RMS/Bias scores and the magnitude-of-error counts (normalized) respectively. These results are also shown in graphs 1.1 and 1.2.

The second two tables give the precipitation verification results of the CASP Forecast Centre in Bedford (Table 1.3) and the forecast centre in Gander (Table 1.4). Part of these results is also shown in graphs 1.3 through 1.5.

Abbreviations used in the tables:

MFC -- CASP Forecast Centre at the Maritimes Weather Centre

NFC -- CASP Forecast Centre at the Newfoundland Weather Centre

MAE -- mean absolute error

RMS -- root mean square error

Lgt/mdt -- wind speeds between calm and 19 knots

ZR -- freezing rain

R/S -- a mixture of snow and rain

Nil -- no precipitation

4. Discussion of Results

4.1 Public Forecasts

4.1.1 Temperature Forecasts

The temperature forecasts are not identical with the nationally verified maximum and minimum temperatures. Instead they are three-hourly spot values. However the national verification scores for Halifax from MWC are given to provide some comparison.

The MAE's (see Table 1.1 and Graph 1.1) for MFC were consistently better than those from NFC. They both compared favourably with the nationally verified scores for Halifax. The NFC had a bias (see Graph 1.2) that was fairly flat and remained just negative, while the MFC scores became significantly more negative with hours-into-forecast. In fact, for the last nine hours of the forecast, the bias and MAE are nearly equal indicating a strong trend to underforecasting. Because of staffing limitations, the CASP-FC was not manned 24 h/day except during Intensive Observation Periods (IOP's). Since forecasts were valid for an 18-h period, and since most forecasts were prepared during the day, the final hours of the forecast period were usually near the time of minimium temperature. This is consistent with verification scores from the MWC where the minimum temperatures show a large negative bias.

4.1.2 Precipitation Forecasts

The precipitation forecasts were verified both by a yes/no format and for individual precipitation types. In addition, a simple percent correct was calculated for each hour into the forecast.

The precipitation forecasts had a tendency to worsen with time though for snow particularly, the NFC curve is quite flat (see Graph 1.4). The MFC Threat scores were consistently better than those of the NFC. This is evident in both the graphs of the combined percent correct scores (graph 1.5) and the individual graphs for threat scores for rain and snow forecasts (graphs 1.3 and 1.4).

There was a proportionally higher amount of special precipitation and precipitation-type guidance available at MFC than for the other forecast elements and this is reflected in the relative scores of the two offices.

4.2 Marine Forecasts

The wind direction contingency tables are presented in Table 2.1, while Table 2.2 represents the wind speed contingency tables. These tables are composites made from all the forecast projection times.

MAE, RMS and bias (mean error) statistics for speeds and directions, separated by projection time are given in Table 2.3 for the forecasts verified against Sable Island and in Table 2.4 for the forecasts verified against the Sedco 709. Approximately 3 times as many verifying observations are available from Sable Island as from the Sedco 709. The small number of rig observations is reflected by the higher scatter in the verification statistics in comparison to the more stable Sable Island statistics which show the expected growth of MAE with forecast projection time.

In comparing wind speed statistics in Table 2.3 and 2.4, it is apparent, in the shorter time periods (up to 9 h), that the NFC had larger errors than the MFC when verified against Sable Island, but had superior statistics when the Sedco 709 was used. In discussions with forecasters after the project it was found that Newfoundland forecasters made more effort to forecast for the Sedco 709, while MFC forecasters more often considered their forecast to be valid for Sable Island. This helps to explain the above-noted trend.

There is a small positive bias in all wind speed forecasts when verified against Sable Island while all forecasts have a fairly strong negative bias when verified against the Sedco 709. These biases are directly related to the siting of the anemometers at the two locations. Although scarcely more than a sand bar, Sable Island winds are affected by terrain friction. Realizing this, forecasters would inflate their forecasts relative to Sable to represent over-sea conditions. On the other hand, since the Sedco 709 anemometers are situated 25 m above the sea, forecasters would deflate their forecasts in relation to the 709 observations when forecasting for the standard 10 m level.

One item of particular interest in the verification statistics is the accuracy of the gale force wind forecasts. It is apparent from Table 2.2 that gales are seldom observed at Sable Island but are relatively common at the rig. Forecasts appear to fall somewhere in between: with gales being forecast too often in comparison to Sable and too seldom in comparison to the 709. In looking at the gale forecasts from a different perspective another trend is evident. Graph 2.1 shows the number of gales forecast as a function of projection time. Not only is it evident that the NFC forecast gales much more freqently than the MFC, there was also a strong tendency on the part of both offices to forecast gales in the latter parts of the forecast period. Apparently, forecasters were frequently forced to "back-off" from initial predictions of gales as the verifying time drew nearer.

Table 2.3 shows that mean errors (biases) associated with the direction forecasts verified at Sable Island are all quite small (under 10 degrees) and variable. Certain differences are evident when the forecasts are verified against the Sedco 709. In the shorter time periods, direction forecasts exhibit a more consistent negative bias (Table 2.4) meaning that winds were closer to geostrophic (directionally) than forecast. Such a bias is consistent with the fact that many forecasters based their forecasts on the observed conditions at Sable Island. However, this does not explain why the bias disappears at the longer projection times. Since the same basic forecast set is being verified in Table 2.3 and 2.4, it is apparent that the smaller sample size for the Sedco 709 (3 times as many Sable Island forecasts verified) has a destablizing impact on the statistics.

5. Forecasters Comments

5.1 General Comments

The requirements of the Logistics Committee and the scientists always took precedence in the forecasters' time committment and because of the interest in the project the traffic volume through the CASP-FC was inevitably very large. The site specific forecasts were often relegated to a secondary duty due to these demands on the forecasters' time.

The unfamiliar format, the large number of entries to be made (the public grid had 78 elements, the marine 64 and Kennebacasis 56) and the frequency of issue (every three hours for public and every six hours for the marine) made these forecasts very time-consuming to prepare especially as the forecasters were learning to use the new equipment at the same time. The forecasts probably never received as much attention as they might have under different testing conditions.

The forecasters also commented that mesoscale techniques can only be used for the first six to nine hours, and that after that they were, in effect, compressing normal forecast techniques into a mesoscale format or stretching mesoscale techniques beyond their valid period.

5.2 Temperature Forecasts

The forecasters varied quite a bit on their mesoscale temperature forecasting techniques. Generally they would use standard forecast techniques to produce maximum and minimum temperatures and then interpolate the three hourly values. While referenced, the lateness and indeed absence of the statistical products caused them to be used infrequently. (For further details on the usefulness of these products see Atlc. Rgn. Tech. Note 86-006). A general consensus seemed to be that mainly standard techniques were used, and a survey of the support material shows that not much in the way of special temperature guidance was available.

The microwave radiometer (see Atlc. Rgn. Tech. Note 86-009) was useful for confirming frontal passages and obtaining quantitative information on the changes in the freezing levels and thicknesses. Similarly, the FE-CASP forecast temperature profiles were sometimes found useful, particularly later in the project when the forecasters had become more accustomed to the products. (For details on the products and usefulness of the FE-CASP, see Atlc. Rgn. Tech. Note 86-010.)

5.3 Precipitation Forecasts

The FE-CASP (a special higher resolution version of CMC's operational Finite Element Model with a "window" over the CASP study area) was probably most used in the precipitation forecasts. The three-hourly QPF's were very helpful in understanding the patterns. The precipitation rate graphs proved to be reasonably accurate (though it was sometimes difficult to relate the scale used, a confusing "mm per 6 hours" interpolated for that hour, to the actual reports). These graphs showed the change between precipitation types well and were frequently consulted.

One of the biggest problems with the MOS display was that it frequently lacked discrimination, giving each type nearly equal probability in difficult situations. The other major drawback was a lack of a straight "probability of precipitation" forecast.

The radiometer was again useful as a short range tool. For a straight yes/no forecast of precipitation, the McIDAS was heavily used. It was also of some help in forecasting precipitation type, because the hourly observations could be overlaid on the satellite image and rough relationships could be established. The enhanced Halifax radar was also a very useful short range (up to 3 hours) tool for this forecast.

5.4 Wind Forecasts

There was a certain amount of confusion on the part of forecasters perparing the marine wind forecasts. While the forecast site was intended to be the Sedco 709, in practice many forecasters prepared their forecasts for Sable Island because of the more complete observational record. As a result, forecasts in general, and MFC forecasts in particular, verified better against the Sable Island observations than those from the Sedco 709.

The wind stress charts which were produced from FE-CASP were seldom used by the forecasters due to lack of familiarity. As further elaborated in the report by John Pearce, (Atlc. Rgn. Tech.Note 86-010), no documentation was provided for the use of these products. The forecasters, while generally understanding what they meant, were unable in this short time to integrate them into the forecasting process.

The V9 Spectral was the primary guidance for wind forecasting, with normal subjective modification procedures being used. The FE-CASP was also referenced, especially as the fields were available at six-hourly intervals. The radiometer was useful in confirming frontal passages. Some features on the McIDAS allowed the forecasters to get speed of clouds, and make inferences about low level flow. The McIDAS was generally the most used tool for many of the forecast elements.

6. Potential Usefulness

The written public forecast, if converted to regular use, could be a concise, time- and space-limited forecast tailored to the population centres. Quickly updated or amended, distribution could be restricted to the intended audience by dissemination through ATAD's and local commercial radio.

The gridded public forecast would not be an effective way to compose regular public forecasts. The number of representative sites that would be required and the large number of elements within each grid make this method too cumbersome to be used except possibly for special applications.

The gridded marine forecast has that same disadvantage, however the numerical format if modified could prove more acceptable to mariners than the current written format which occasionally is difficult to sort out when heard over the radio.

7. Conclusions

The evaluation reports of the CASP forecasters concerning the extra data, equipment and numerical guidance are available in a series of Atlantic Region Technical Notes (see bibliography) and are also summarized in A.R.T.N. 86-001. The impact of these aids on the products of the CASP forecasters can probably never be completely known, however, the verification results do suggest some conclusions.

The "digital" format was not a success as it was very time-consuming and tended to break up the natural flow of the human thought process. Since forecasters tend to think graphically, a graphical input seems to be logical.

The temperature verification scores of MAE for both offices were somewhat better than those achieved by MWC. In general the MAE of the MFC was superior to that of the NFC, although the latter had a very small bias. The idea of 3-hourly temperatures was interesting to try, however, for an operational 6 to 9 hour mesoscale forecast the best solution might be to have one temperature and a trend, or start and finish temperatures.

The precipitation occurrence and type forecasts were very successful, achieving rates of 75 to 85 percent correct. In this area the MFC consistently outscored the NFC. A fair amount of special guidance was available for these forecasts although unfamiliarity caused some of the FE-CASP outputs to be under-utilized. There was surprisingly little fall-off of skill with forecast projection time for this element.

One notable feature of the wind forecasts was the tendency to forecast gales towards the end of the forecast period, especially beyond 12 hours. Also notable was the fact that the NFC forecast gales several times as often as the MFC. For wind forecasting, such charts as the wind-stress field from the FE-CASP were under-utilized.

The McIDAS display station was very conclusively a highly effective short range forecast tool. As detailed in the report by J. Abraham (A.R.T.N. 86-002) this graphics display station allowed very detailed use of satellite images, both in looping capability and in the ability to overlay meteorological fields to obtain instantaneous relationships. The strength of the precipitation forecasts was strongly aided by this piece of equipment.

Many pieces of equipment and numerical models outputs were both unfamiliar and not as accessible as the McIDAS. More experience with the microwave radiometer, RAINSAT and FE-CASP would have made them more useful. They were increasingly utilized as the experiment progressed.

The experiment showed that mesoscale techniques are not useful beyond 6 to 9 hours. At times, all forecasters had difficulty keeping track of the overall picture because of the overlapping of regular and mesoscale forecast techniques. In some cases it probably resulted in a net loss of skill because the forecasters attempted to stretch mesoscale techniques beyond their useful period or compress regular techniques by interpolation.

The CASP experiment in mesoscale forecasting was a useful exercise and unique for the following reasons.

-It was a complete forecast system comprising observations, analysis and forecasting, data processing and communications.

-The goal was to look for a combined system of data and instrumentation with the emphasis being on determining the system which would best meet the needs of the forecasters.

-The CASP forecasters were dealing with the structure within major systems rather than concentrating on isolated events such as thunderstorms.

-A variety of forecasts for different user groups were prepared.

-Although not perfect, it was a controlled experiment, and intercomparisons can be made.

The format and results of the forecasts combined with evaluations of the forecast aids will be useful in the design of work stations for forecasters, and in the design of future experimental programmes like CASP.

Public Forecasts Verification - Shearwater, N.S.

(i) Temperature Forecasts

Scores

Fcst hr	MAE MFC	MAE NFC	RMS MFC	RMS NFC	Bias MFC	Bias NFC
3	1.16	1.14	1.57	1.91	-0.5	-0.4
6	1.72	1.95	2.26	2.58	-0.8	-0.6
9	2.03	2.32	2.61	2.99	-0.9	-0.8
12	2.26	2.60	2.91	3.25	-1.7	-0.9
15	2.51	2.70	3.20	3.31	-2.2	-0.8
18	2.78	2.73	3.49	3.39	-2.1	-0.6

Maritimes Weather Centre Scores
(from National Verification System)

		MAE	Bias
Jan.	MAX1	3.16	0.97
	MIN	3.84	-0.29
Feb.	MAX1	1.68	0.11
	MIN	3.29	-1.29
Mar.	MAX1	2.29	0.10
	MIN	2.55	-0.00

Table 1.1

Temperature forecasts for Shearwater (cont'd)

Magnitude of Errors

Fcst hr	0		1 to 3		4 to 6		7 to 10		>10		
	MFC	NFC	MFC	NFC	MFC	NFC	MFC	NFC	MFC	NFC	
3	278	249	693	681	25	70	4	0	0	0	277/301
6	176	176	701	661	115	146	7	17	0	0	278/301
9	186	130	627	651	172	186	14	33	0	0	279/301
12	155	94	621	631	199	245	25	30	0	0	277/298
15	135	105	593	611	222	253	51	30	0	0	275/296
18	132	115	538	614	253	234	77	37	0	0	273/295

Table 1.2

Note: In order to facilitate comparisons, numbers have been normalized such that row totals (both for MFC and NFC) are 1000. The actual totals for each row are given in the columns to the right.

Table 1.3

Precipitation Contingency Table

Maritimes CASP Forecast Center Hour 03 Forecasts

	Yes	No	Row Total	Threat Score	Percent Correct
Yes	81	12	93	.7	
No	31	148	179	.8	
	112	160	229		84.

272 Observations

Precipitation Type Contingency Table

Maritimes CASP Forecast Center Hour 03 Forecasts

	Rain	Snow	ZR	R/S	Nil	Row Total	Threat Score	Percent Correct
Rain	19	1	1	0	7	28	.6	
Snow	0	53	0	0	5	58	.6	
ZR	0	2	3	0	1	6	.4	
R/S	0	1	0	0	0	1	0.0	
Nil	4	27	0	0	148	179	.8	
	23	84	4	0	161	223		82.

272 Observations

Precipitation Contingency Table

Maritimes CASP Forecast Center Hour 06 Forecasts

	Yes	No	Row Total	Threat Score	Percent Correct
Yes	64	22	86	.5	
No	36	153	189	.7	
	100	175	217		79.

275 Observations

Precipitation Type Contingency Table

Maritimes CASP Forecast Center Hour 06 Forecasts

	Rain	Snow	ZR	R/S	Nil	Row Total	Threat Score	Percent Correct
Rain	18	0	0	0	8	26	.6	
Snow	0	40	1	0	13	54	.5	
ZR	0	2	2	0	1	5	.2	
R/S	0	0	1	0	0	1	0.0	
Nil	5	29	2	0	153	189	.7	
	23	71	6	0	175	213		77.

275 Observations

Table 1.3

Precipitation Contingency Table

Maritimes CASP Forecast Center   Hour 09 Forecasts

	Yes	No	Row Total	Threat Score	Percent Correct	
Yes	58	23	81	.5		
No	44	153	197	.7		
	102	176	211		76.	278 Observations

Precipitation Type Contingency Table

Maritimes CASP Forecast Center   Hour 09 Forecasts

	Rain	Snow	ZR	R/S	Nil	Row Total	Threat Score	Percent Correct	
Rain	20	1	0	0	4	25	.5		
Snow	0	31	1	0	18	50	.4		
ZR	1	1	2	0	1	5	.2		
R/S	0	0	1	0	0	1	0.0		
Nil	13	29	2	0	153	197	.7		
	34	62	6	0	176	206		74.	278 Observations

Precipitation Contingency Table

Maritimes CASP Forecast Center   Hour 12 Forecasts

	Yes	No	Row Total	Threat Score	Percent Correct	
Yes	53	22	75	.4		
No	47	154	201	.7		
	100	176	207		75.	276 Observations

Precipitation Type Contingency Table

Maritimes CASP Forecast Center   Hour 12 Forecasts

	Rain	Snow	ZR	R/S	Nil	Row Total	Threat Score	Percent Correct	
Rain	17	1	0	0	3	21	.5		
Snow	0	29	2	0	17	48	.4		
ZR	1	0	2	0	1	4	.2		
R/S	0	0	1	0	0	1	0.0		
Nil	12	32	3	0	154	201	.7		
	30	62	8	0	175	202		73.	275 Observations

Table 1.3

Precipitation Contingency Table

Maritimes CASP Forecast Center Hour 15 Forecasts

	Yes	No	Row Total	Threat Score	Percent Correct	
Yes	52	22	74	.4		
No	47	153	200	.7		
	99	175	205		75.	274 Observations

Precipitation Type Contingency Table

Maritimes CASP Forecast Center Hour 15 Forecasts

	Rain	Snow	ZR	R/S	Nil	Row Total	Threat Score	Percent Correct	
Rain	15	2	0	0	3	20	.5		
Snow	1	29	1	0	18	49	.3		
ZR	1	1	2	0	0	4	.3		
R/S	0	0	0	0	1	1	0.0		
Nil	11	34	2	0	153	200	.7		
	28	66	5	0	175	199		73.	274 Observations

Precipitation Contingency Table

Maritimes CASP Forecast Center Hour 18 Forecasts

	Yes	No	Row Total	Threat Score	Percent Correct	
Yes	53	17	70	.5		
No	45	154	199	.7		
	98	171	207		77.	269 Observations

Precipitation Type Contingency Table

Maritimes CASP Forecast Center Hour 18 Forecasts

	Rain	Snow	ZR	R/S	Nil	Row Total	Threat Score	Percent Correct	
Rain	11	5	0	0	2	18	.4		
Snow	2	31	0	0	14	47	.4		
ZR	2	1	1	0	0	4	.2		
R/S	0	0	0	0	1	1	0.0		
Nil	9	34	2	0	154	199	.7		
	24	71	3	0	171	197		73.	269 Observations

Table 1.4

Precipitation Contingency Table

Nfld CASP Forecast Center Hour 03 Forecasts

	Yes	No	Row Total	Threat Score	Percent Correct	
Yes	63	27	90	.5		
No	33	170	203	.7		
	96	197	233		80.	293 Observations

Precipitation Type Contingency Table

Nfld CASP Forecast Center Hour 03 Forecasts

	Rain	Snow	ZR	R/S	Nil	Row Total	Threat Score	Percent Correct	
Rain	18	1	0	0	5	24	.5		
Snow	1	33	1	0	21	56	.4		
ZR	3	1	4	0	1	9	.4		
R/S	0	1	0	0	0	1	0.0		
Nil	9	23	1	0	170	203	.7		
	31	59	6	0	197	225		77.	293 Observations

Precipitation Contingency Table

Nfld CASP Forecast Center Hour 06 Forecasts

	Yes	No	Row Total	Threat Score	Percent Correct	
Yes	58	28	86	.5		
No	40	170	210	.7		
	98	198	228		77.	296 Observations

Precipitation Type Contingency Table

Nfld CASP Forecast Center Hour 06 Forecasts

	Rain	Snow	ZR	R/S	Nil	Row Total	Threat Score	Percent Correct	
Rain	16	3	0	0	5	24	.4		
Snow	1	27	2	0	22	52	.3		
ZR	3	0	5	0	1	9	.5		
R/S	0	1	0	0	0	1	0.0		
Nil	11	29	0	0	170	210	.7		
	31	60	7	0	198	218		74.	296 Observations

Table 1.4

Precipitation Contingency Table

Nfld CASP Forecast Center   Hour 09 Forecasts

	Yes	No	Row Total	Threat Score	Percent Correct	
Yes	56	32	88	.4		
No	42	168	210	.7		
	98	200	224		75.	298 Observations

Precipitation Type Contingency Table

Nfld CASP Forecast Center   Hour 09 Forecasts

	Rain	Snow	ZR	R/S	Nil	Row Total	Threat Score	Percent Correct	
Rain	16	3	0	0	6	25	.4		
Snow	1	27	1	0	24	53	.3		
ZR	5	0	3	0	2	10	.3		
R/S	0	0	0	0	0	0	***		
Nil	12	30	0	0	168	210	.7		
	34	60	4	0	200	214		72.	298 Observations

Precipitation Contingency Table

Nfld CASP Forecast Center   Hour 12 Forecasts

	Yes	No	Row Total	Threat Score	Percent Correct	
Yes	53	31	84	.4		
No	46	164	210	.7		
	99	195	217		74.	294 Observations

Precipitation Type Contingency Table

Nfld CASP Forecast Center   Hour 12 Forecasts

	Rain	Snow	ZR	R/S	Nil	Row Total	Threat Score	Percent Correct	
Rain	13	3	0	0	5	21	.3		
Snow	0	26	1	0	24	51	.3		
ZR	7	1	2	0	2	12	.2		
R/S	0	0	0	0	0	0	***		
Nil	15	30	0	0	164	209	.7		
	35	60	3	0	195	205		70.	293 Observations

Table 1.4

Precipitation Contingency Table

Nfld CASP Forecast Center Hour 15 Forecasts

	Yes	No	Row Total	Threat Score	Percent Correct	
Yes	58	31	89	.4		
No	43	158	201	.7		
	101	189	216		74.	290 Observations

Precipitation Type Contingency Table

Nfld CASP Forecast Center Hour 15 Forecasts

	Rain	Snow	ZR	R/S	Nil	Row Total	Threat Score	Percent Correct	
Rain	15	3	0	0	3	21	.4		
Snow	0	25	1	0	27	53	.3		
ZR	9	1	2	0	1	13	.1		
R/S	0	1	0	0	0	1	0.0		
Nil	12	31	0	0	158	201	.7		
	36	61	3	0	189	200		69.	289 Observations

Precipitation Contingency Table

Nfld CASP Forecast Center Hour 18 Forecasts

	Yes	No	Row Total	Threat Score	Percent Correct	
Yes	55	35	90	.4		
No	41	156	197	.7		
	96	191	211		74.	287 Observations

Precipitation Type Contingency Table

Nfld CASP Forecast Center Hour 18 Forecasts

	Rain	Snow	ZR	R/S	Nil	Row Total	Threat Score	Percent Correct	
Rain	13	3	1	0	3	20	.3		
Snow	0	27	0	0	29	56	.3		
ZR	9	0	1	0	3	13	.1		
R/S	0	1	0	0	0	1	0.0		
Nil	12	28	1	0	156	197	.7		
	34	59	3	0	191	197		69.	287 Observations

Table 2.1
Wind Direction Contingency Tables

a. Sable Island verification site

		Forecast								
		North		East		South		West		
		MFC	NFC	MFC	NFC	MFC	NFC	MFC	NFC	
O	North	161	139	12	18	4	7	58	59	
b	East	26	13	56	70	50	64	4	17	
v	South	3	2	16	11	144	147	47	45	
d	West	81	65	11	4	37	44	284	294	893/934

b. Sedco 709 verification site

		Forecast								
		North		East		South		West		
		MFC	NFC	MFC	NFC	MFC	NFC	MFC	NFC	
O	North	131	106	0	6	10	0	42	65	
b	East	26	16	80	69	48	90	26	9	
v	South	13	6	32	38	173	162	54	75	
d	West	42	56	16	0	89	115	220	196	313/321

Note: Numbers in the table have been normalized to total 1000. The actual number of forecasts is given at the lower right of each table as MFC/NFC.

Table 2.2
Wind Speed Contingency Tables

a. Sable Island verification site

Forecast

		Lgt/Mdt		Strong		Gale		Storm		
		MFC	NFC	MFC	NFC	MFC	NFC	MFC	NFC	
O	Lgt/Mdt	395	427	160	127	4	6	0	0	
b	Strong	116	94	300	300	21	41	0	0	
v	Gale	0	0	3	2	0	1	0	0	
d	Storm	0	0	0	0	0	0	0	0	902/942

b. Sedco 709 verification site

Forecast

		Lgt/Mdt		Strong		Gale		Storm		
		MFC	NFC	MFC	NFC	MFC	NFC	MFC	NFC	
O	Lgt/Mdt	282	292	94	62	0	0	0	0	
b	Strong	130	160	318	292	16	43	0	0	
v	Gale	39	9	88	114	10	15	0	0	
d	Storm	10	0	13	12	0	0	0	0	309/321

Note: Numbers in the table have been normalized to total 1000. The actual number of forecasts is given at the lower right of each table as MFC/NFC.

Table 2.3

Wind Verification Statistics Summary
for verification versus Sable Island

Forecast Time (h)	MAE speed (m/s)		BIAS speed (m/s)		MAE direction (°)		BIAS direction(°)	
	CFC	NFC	CFC	NFC	CFC	NFC	CFC	NFC
3	1.85	2.32	0.56	0.65	22.0	30.1	5.1	3.6
6	2.25	2.67	0.41	0.38	25.3	27.3	-2.4	5.9
9	2.42	2.82	0.31	0.27	24.5	31.8	0.8	5.6
12	2.63	2.74	0.66	0.56	33.0	31.3	-6.0	6.7
15	2.71	2.60	0.41	0.47	32.0	33.5	0.2	9.9
18	2.97	2.83	0.44	0.53	33.9	30.6	2.3	9.4
21	2.94	2.96	0.38	0.14	35.6	27.6	9.7	9.2
24	2.86	3.12	0.76	0.15	36.7	33.0	9.1	7.8

Table 2.4

Wind Verification Statistics Summary
for verification versus Sedco 709

Forecast Time (h)	MAE speed (m/s)		BIAS speed (m/s)		MAE direction (°)		BIAS direction(°)	
	CFC	NFC	CFC	NFC	CFC	NFC	CFC	NFC
3	3.28	3.30	-1.80	-1.72	31.8	25.1	-11.0	1.6
6	4.49	3.69	-3.09	-2.72	32.3	20.6	-20.5	-18.8
9	4.40	3.45	-2.43	-1.80	30.4	27.5	-12.9	-21.3
12	4.42	4.20	-3.25	-2.79	37.9	34.2	-15.2	-11.2
15	4.33	3.82	-2.60	-2.14	40.3	37.4	-4.2	-13.9
18	3.74	4.18	-2.57	-2.51	35.2	36.5	0.2	-5.3
21	3.89	4.40	-2.08	-2.10	38.2	35.1	-0.7	0.6
24	3.40	4.08	-1.29	-2.37	40.0	39.2	-4.7	4.3

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2. Other

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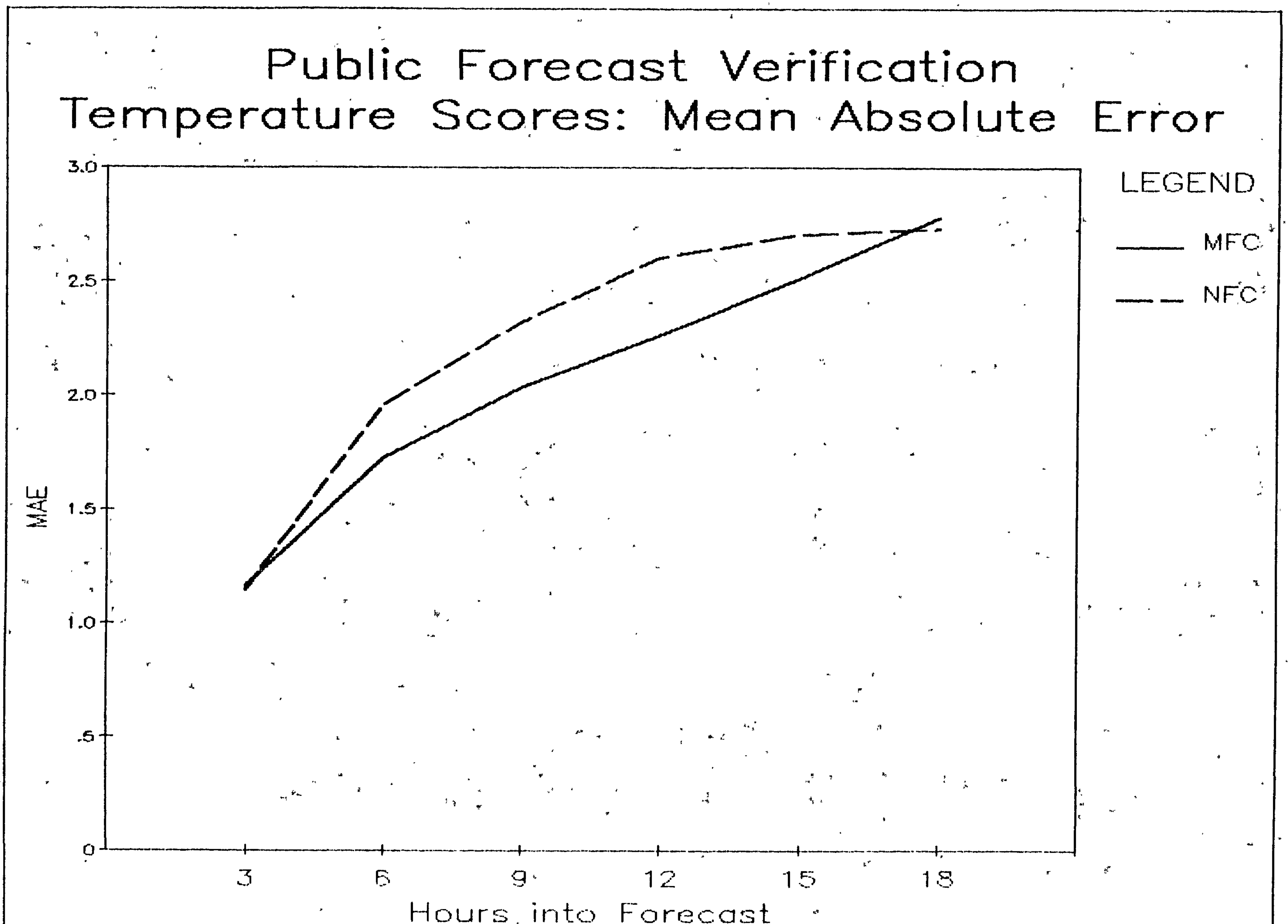
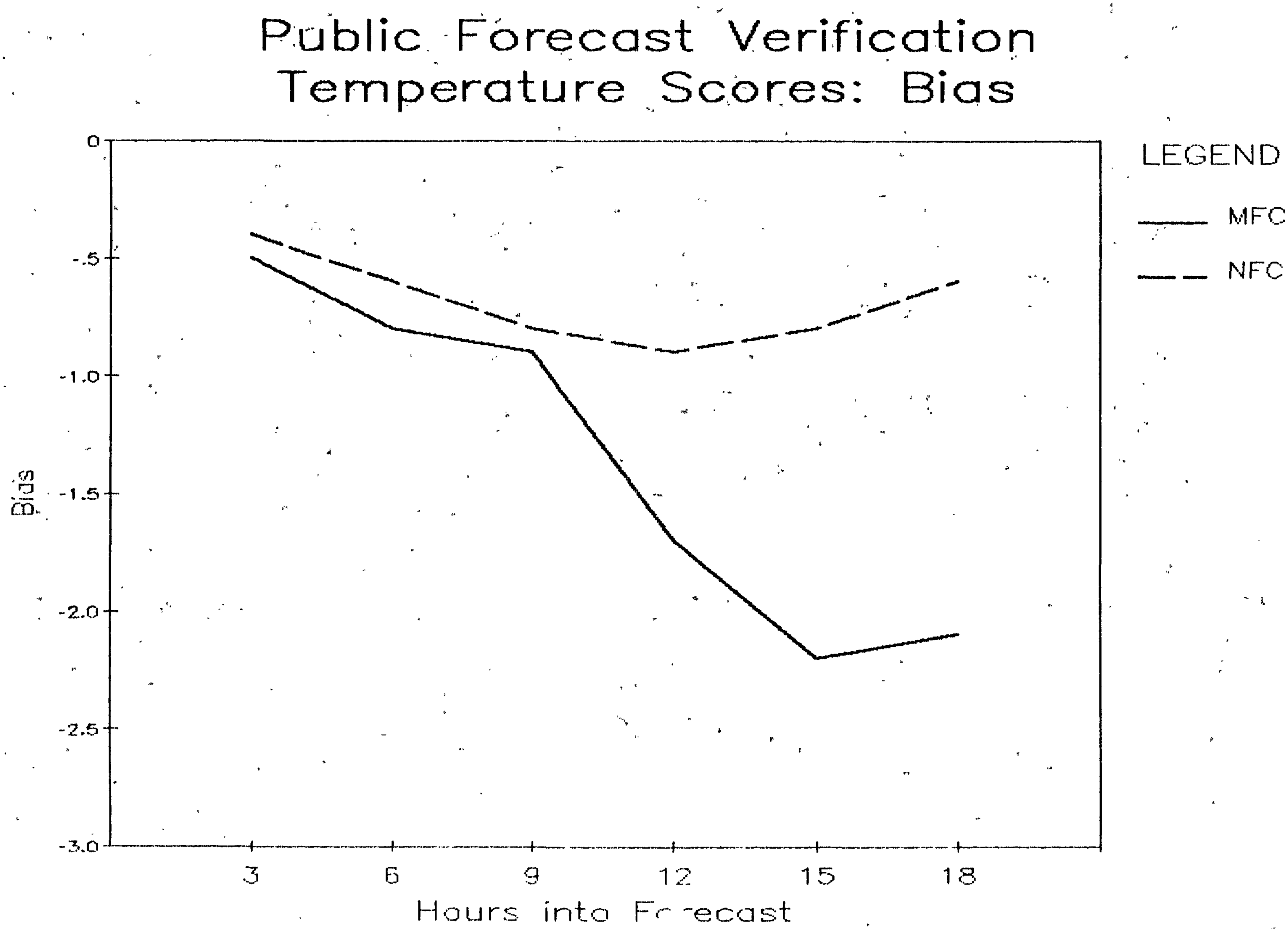


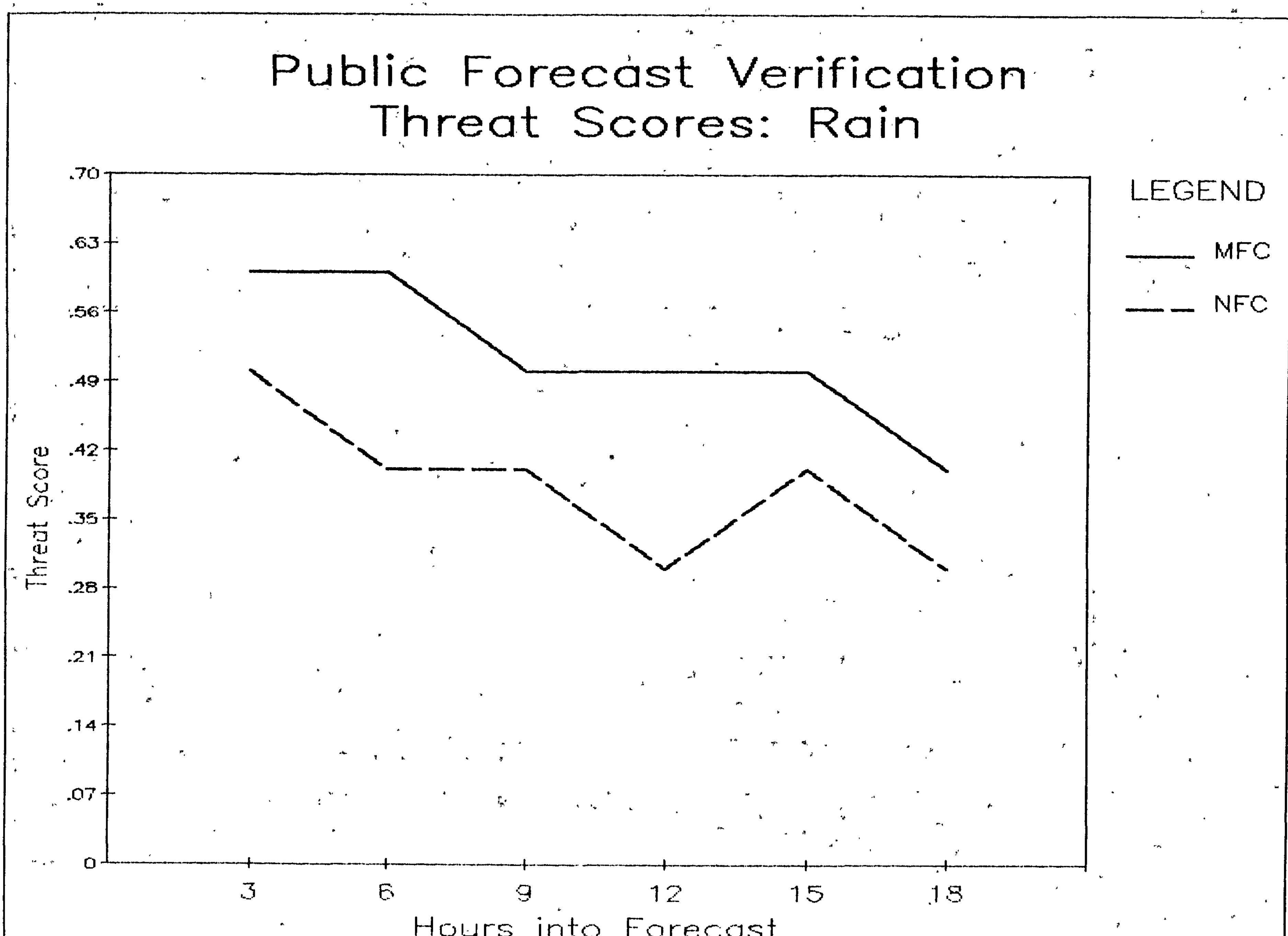
Public Forecast Verification
Temperature Scores: Mean Absolute Error
LEGEND
MFC
NFC
MAE
3.0
2.5
2.0
1.5
1.0
.5
0
3
6
9
12
15
18
Hours into Forecast

Graph 1.1

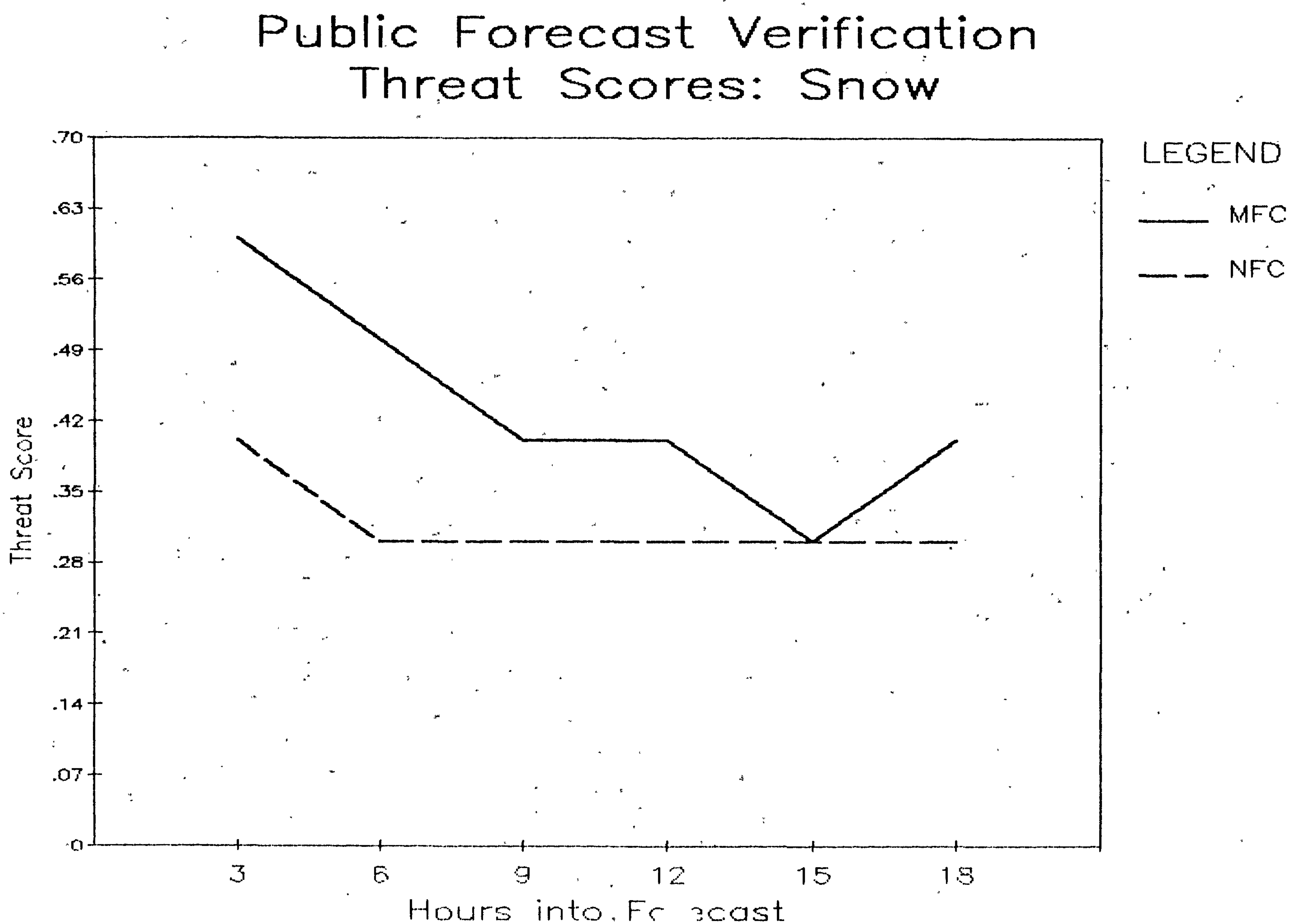


Public Forecast Verification
Temperature Scores: Bias
Bias
0
-.5
-1.0
-1.5
-2.0
-2.5
-3.0
3
6
9
12
15
18
Hours into Forecast
LEGEND
MFC
NFC

Graph 1.2


Public Forecast Verification
Threat Scores: Rain
Threat Score
.70
.63
.56
.49
.42
.35
.28
.21
.14
.07
0
3
6
9
12
15
18
Hours into Forecast
LEGEND
MFC
NFC

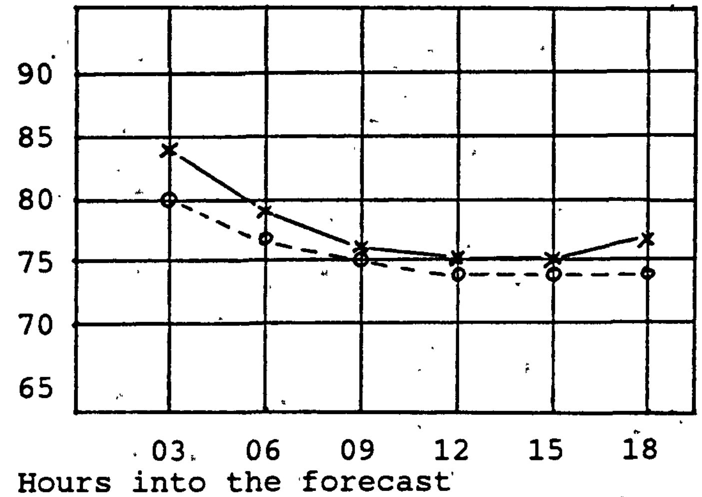
Graph 1.3


Public Forecast Verification
Threat Scores: Snow
.70
.63
.56
.49
.42
.35
.28
.21
.14
.07
0
Threat Score
3
6
9
12
15
18
Hours into Forecast
LEGEND
MFC
NFC

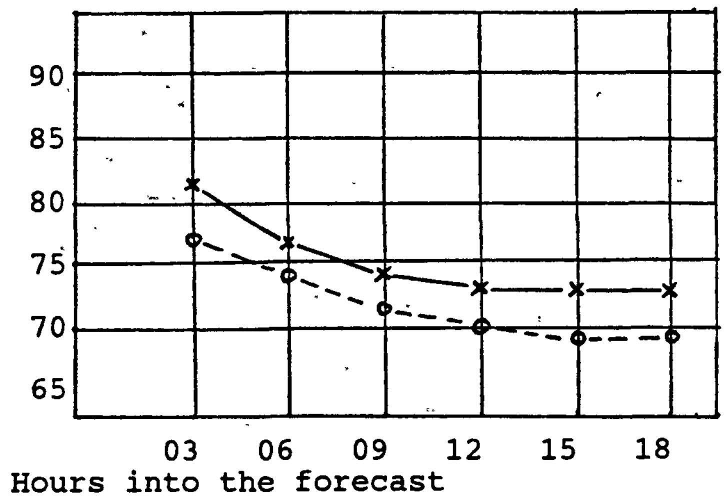
Graph 1.4

Comparison of Precipitation Scores

Percent Correct - Categorical Precipitation Forecasts



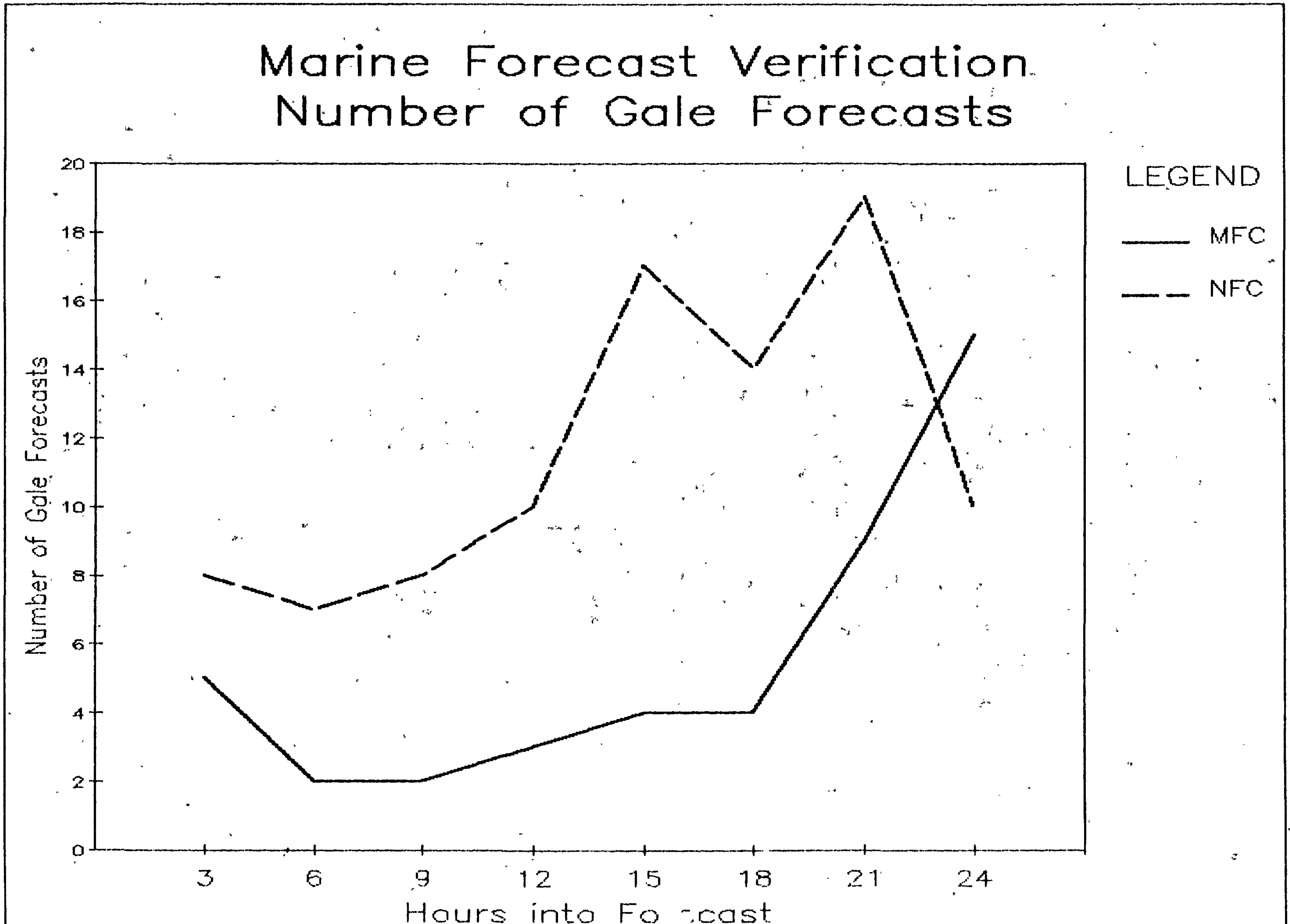
Percent Correct - Precipitation Type Forecasts



X MFC - Bedford

O NFC - Gander

Graph 1.5


Marine Forecast Verification
Number of Gale Forecasts
Number of Gale Forecasts
LEGEND
MFC
NFC
0
2
4
6
8
10
12
14
16
18
20
3
6
9
12
15
18
21
24
Hours into Fo cast
Graph 2.

Appendix 1: Forms used for Gridded Experimental Forecasts

SITE SPECIFIC PUBLIC FORECAST (GRID): Shearwater

Date:

Issue time (circle one) 00 03 06 09 12 15 18 21 z

Forecaster:

IOP (Y/N)

	3	6	9	12	15	18	hrs
Precipitation:							
(i) type/inten							
(ii) 3 hrly accum							
(iii) character							
(iv) POP							
(v) onset (z)							
(vi) change (z)							
(vii) end (z)							
Temperature							
Time 0 cross							
Wind Speed							
Max Wind							
Wind Dir.							
Visibility							

SITE SPECIFIC MARINE FORECAST - SED 709 (   )

Date:

Issue time (circle one)   00   06   12   18 z

Forecaster:

IOP (Y/N)

	3	6	9	12	15	18	21	24 hrs
Mean wind								
Max. wind								
Wind dir.								
Visibility								
Pcpn Type/Inten.								
Frzg spray (Y/N)								
Frzg Spray (inten)								
Temperature								

Forecast onset of Gales/Storms (beyond 24 hours):

Usefulness of products in preparing this forecast:

0 - misleading   1 - not useful   6 very useful   (circle one)

Reg. Fin. Elem. model	0 1 2 3 4 5 6	Halifax radar	0 1 2 3 4 5 6
Frzg. Spray model	0 1 2 3 4 5 6	Sable radar	0 1 2 3 4 5 6
Radiometer	0 1 2 3 4 5 6	Isentropic an.	0 1 2 3 4 5 6
Buoys	0 1 2 3 4 5 6	Streamline an.	0 1 2 3 4 5 6
Extra ships	0 1 2 3 4 5 6	RAINSAT	0 1 2 3 4 5 6
MOS/PP Wx. elements	0 1 2 3 4 5 6	Climat stns	0 1 2 3 4 5 6
FOUS60	0 1 2 3 4 5 6	Extra RADAT	0 1 2 3 4 5 6
McIDAS	0 1 2 3 4 5 6		

NWP most used: Spec. V9   Finite Elem.   Reg. Fin. Elem.   LFM

Comments: