PACIFIC REGION TECHNICAL NOTES

84-012
November 25, 1984

Verification of the 1982-84 B.C. Fire Weather Probability Forecasts for the Occurrence of Rain

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INTRODUCTION

Fire Weather Forecasts for British Columbia have been issued since 1958 by the Pacific Weather Centre (PWC). Beal (1983) verified the forecast probabilities, for the occurrence of rain at selected sites, issued during the 1982 fire weather season (May to September). With additional forecast data from the past two fire weather seasons, 1983 and 1984, it is of interest to update the earlier forecast assessment.

FORECAST DATA

The PWC issues daily a morning (at 1345 GMT) and an afternoon (2030 GMT) fire weather forecast. However, the afternoon forecast is not prepared on the weekend, only if requested. Each forecast contains the point probability for the occurrence of rain at approximately 33 locations throughout B.C. The forecast probabilities are usually expressed to the nearest 5%. They are valid for a 24 hour period, beginning at 1 P.M. on the same day for those issued in the morning forecast and at 1 P.M. the following day for the afternoon forecast.

For evaluation, all morning and afternoon forecast probabilities, for seven stations, were tabulated for the period May 1 to September 30, from 1982 to 1984. The seven sites selected were Comox, Cranbrook, Kelowna, Prince Rupert, Revelstoke, Terrace and Williams Lake.

OBSERVED DATA

Now for each 24 hour period (1 P.M. - 1 P.M.), at each site, two forecast probabilities of rain were acquired and a corresponding observed precipitation record exists. At each station a "rain event" was deemed to have occurred if a measurable amount of precipitation (0.2 mm or more) was recorded during the 24 hour period from 10 A.M. to 10 A.M. Unfortunately, the above verifying interval, due to the precipitation recording times, had to be taken from 10 A.M. to 10 A.M. instead of over the exact forecast valid period.

CLIMATOLOGICAL DATA

To assess the probability forecasts against climatology, the long-term average number of days with measurable rain during the season May to September was derived from the Canadian Climate Normals (1951-80). The percentage frequency of days with rain for each station considered is shown in Fig. 1.

VERIFICATION METHOD

The well known Brier score (Sanders, 1963) was employed to evaluate the probability forecasts. The Brier score (B) for a single forecast may be expressed as:

$$B = (\text{FCST}-\text{OBS})^2 + \text{OBS}(1-\text{OBS}), \qquad (1)$$

where the FCST is the forecast probability (in tenths) and OBS the observed event which takes a value of 1 or 0 depending upon whether a rain event occurs or does not occur. The total score for N forecasts would simply be obtained by adding the individual scores and dividing by N.

A completely perfect set of forecasts would obtain a Brier score of zero, and a set of absolutely erroneous forecasts would yield unity (1). Notice that if only forecasts of 50% were issued, the score would invariably be 0.25 regardless of whether or not a rain event was encountered.

For evaluation all fire weather forecast probabilities were grouped into 11 probability categories (0, 0.1, 0.2...,1.0). Thus a forecast probability within the range 25 to 34% inclusive was assigned to the 0.3 category.

RELIABILITY

The first term on the right hand side of equation (1) is often called the "reliability". It is a measure of the overall mean error between the forecasts and the observed events. Therefore, a perfectly reliable set of forecasts would have a reliability of zero (no error) and a value of unity (worst case) could only be obtained if all forecasts fell into the categories 0 or 1 and were all incorrect.

RESOLUTION

The "resolution" is defined by the second term on the right hand side of equation (1). For a large number of forecasts, it is a good measure of the forecasters' ability to correctly identify nearly certain events (of rain/no rain) as often as possible. Perfect resolution (zero value) would only be attained if all observed events, for a given forecast, were either all zero (no rain) or unity (rain). Alternatively, the term reaches its worst value of 0.25 if, for a given forecast probability, exactly one-half of the observed events were zero and the other half were unity.

SKILL SCORE

To relate the forecast Brier score (B) to a non-skill forecast, the skill score (S) was employed:

$$S = 100\ (BC-B)/BC, \qquad (2)$$

where BC is the climatological Brier score. This is the Brier score with all the forecast probabilities replaced by the long-term average frequency of days with rain (recall Fig. 1). Optimum skill, S = 100%, is achieved if the Brier Score is zero. A negative or zero skill score implies that the forecasts are worse or no better than climatology.

DISCUSSION OF RESULTS

Since forecasting is not yet an exact science, the fire weather forecast probabilities for rain do not fall into the 0 and 100% categories only. The actual distribution of the percentage of forecasts for each of the 11 probability categories is illustrated in Fig. 2. The forecasters were fairly successful in recognizing rain/no rain situations in that a high proportion of the forecasts lie on either side of the 50% forecast probability value. Furthermore, the forecasters' confidence or ability increases somewhat with a decrease in the forecast lead time. It may be noted that the proportion of forecasts expressing a greater certainty in the occurrence of rain (probability values greater than 50%) is higher for the morning forecasts than the afternoon ones. It should also be observed that the frequency of morning forecast rain probabilities that were 50% or higher (36%) was quite close to the overall climatological frequency of rain (35%) over all stations considered.

Figures 3 to 6 graphically illustrate the various scores obtained, at each station, by the morning and afternoon forecasts. Not surprisingly the morning forecast probabilities are always an improvement over the ones issued the previous afternoon. The Brier score indicates only a slight variation from station to station. It ranges from about 17 to 21% for the morning forecasts and 21 to 25% for the afternoon ones. Similarly the resolution values indicate that the forecasters' ability to correctly identify nearly certain events remains fairly constant throughout the province and is only marginally better for the morning forecasts.

Turning to the skill score and the forecast reliability, these terms do show a marked variability, Figures 3 and 5 respectively. The reliability, a measure of the extent to which the forecast probability agrees with the observed frequency of rain days, is from a user's perspective an important parameter. The forecasts for Williams Lake were most reliable (lowest value). Figures 7 through 14 display the morning forecast reliability in greater detail. Note that if all the points were on the diagonal line, perfect reliability would have been reached. It is of interest to note that in general the points below the 50% forecast probability value tend to lie above the diagonal and points beyond the 50% value below the diagonal.

Therefore, there is a tendency to overforecast rain (i.e. forecast frequency is higher than observed) in the 60-100% categories and to underforecast rain in the 0-40% categories. This general trend is well illustrated in Fig. 14 which summarizes the forecast and observed frequencies over all stations. The reliability for the afternoon forecasts is considerably less than for the morning forecasts, as may be seen from Fig. 5.

On the other hand, the skill score (Fig. 3) reveals that the morning forecasts improve upon climatology. However, the afternoon forecasts show very little skill and even negative skill (worse than climatology) for Prince Rupert and Kelowna. The morning forecasts are quite acceptable, an improvement of 15-25% over climatology is consistently maintained. To examine the skill further the annual scores were compared in Figures 15 and 16. It is immediately evident that the morning forecasts are consistently superior to climatology (except Prince Rupert) and the performance of the afternoon forecasts is irregular and generally poor.

CONCLUSIONS

The analysis of the rain probability fire weather forecasts indicates the following:

(i) The morning forecasts are significantly more reliable (i.e. extent to which the forecast rain probability agrees with the observed frequency of rain) and skillful (i.e. compared to climatology), than the afternoon forecasts issued the previous day and valid for the same time period.

(ii) The forecasters tended to be overconfident, that is, they tended to assign lower rain probabilities than observed in the 0-40% categories, and higher probabilities than observed in the 60-100% categories.

(iii) The performance of the afternoon forecasts (prepared approximately 24 hrs. prior to the commencement of the forecast valid period) is highly variable and generally poor. Thus the forecasters' ability to provide reliable and skillful forecast probabilities 24 hrs. ahead of time might be questionable.

REFERENCES

Beal, H.T., 1983: Verification of the B.C. Fire Weather Precipitation Probability Forecasts for 1982. Pacific Region Technical Note No. 83-028, Atmospheric Environment Service, 8 pp.

Sanders, F., 1963: On Subjective Probability Forecasting. J. Appl. Meteor., 2, 191-201.

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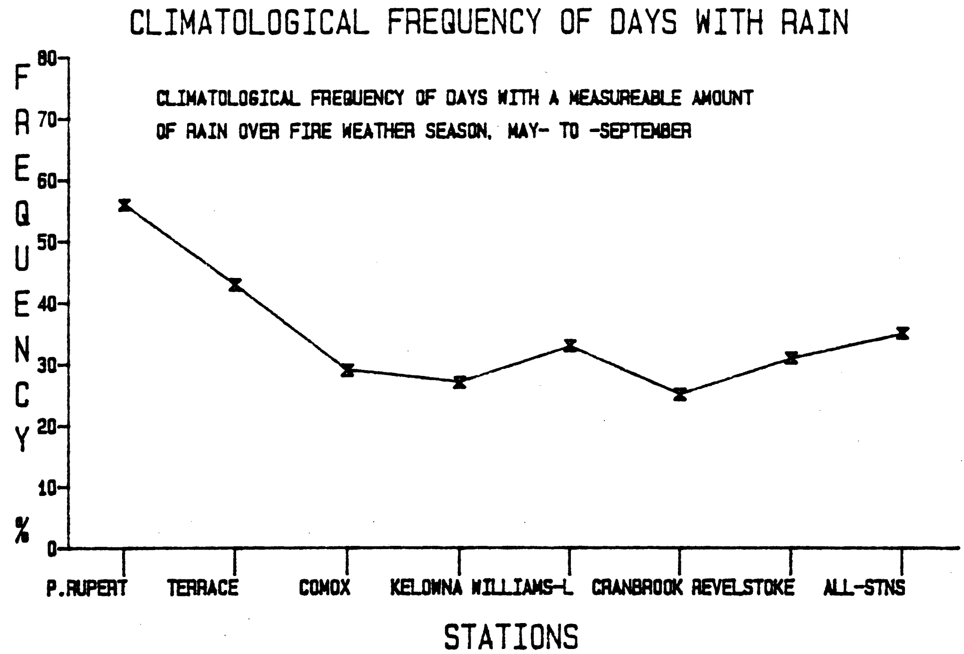


Fig. 1. The long-term, average, relative frequency of the number of days with a measureable amount of rain (0.2 mm or more).

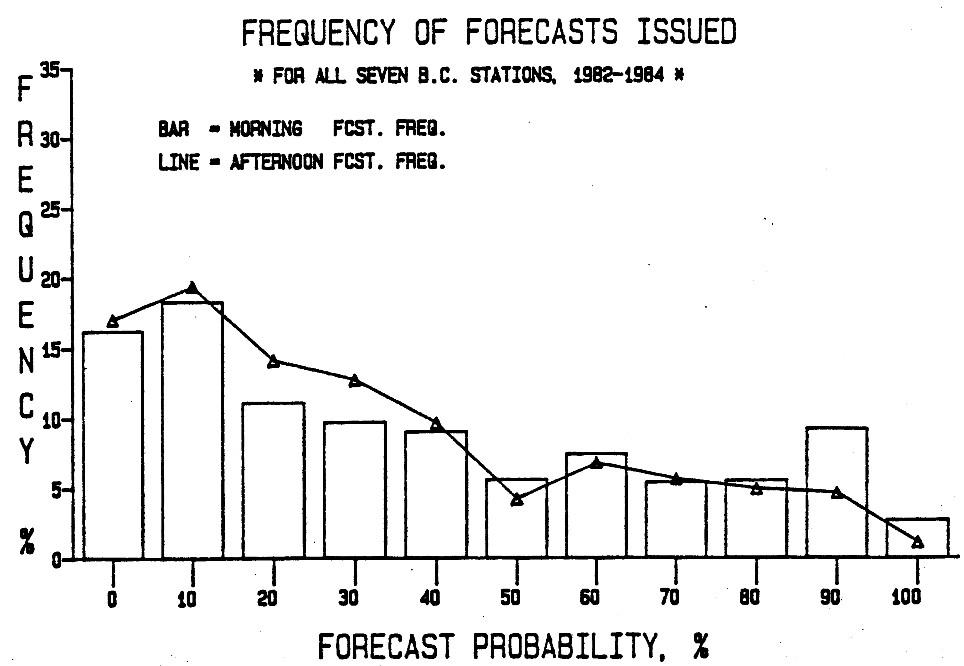


Fig. 2. Frequency distribution for the morning (3195 forecasts) and afternoon (2172) forecasts issued during the fire weather season, May - September, from 1982 to 1984.

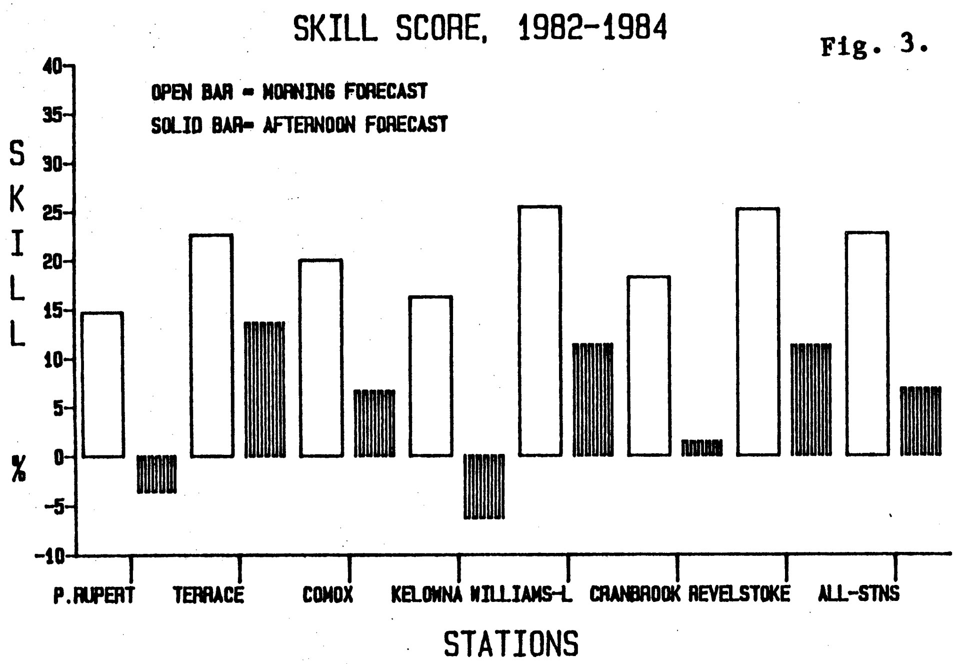


Fig. 3.

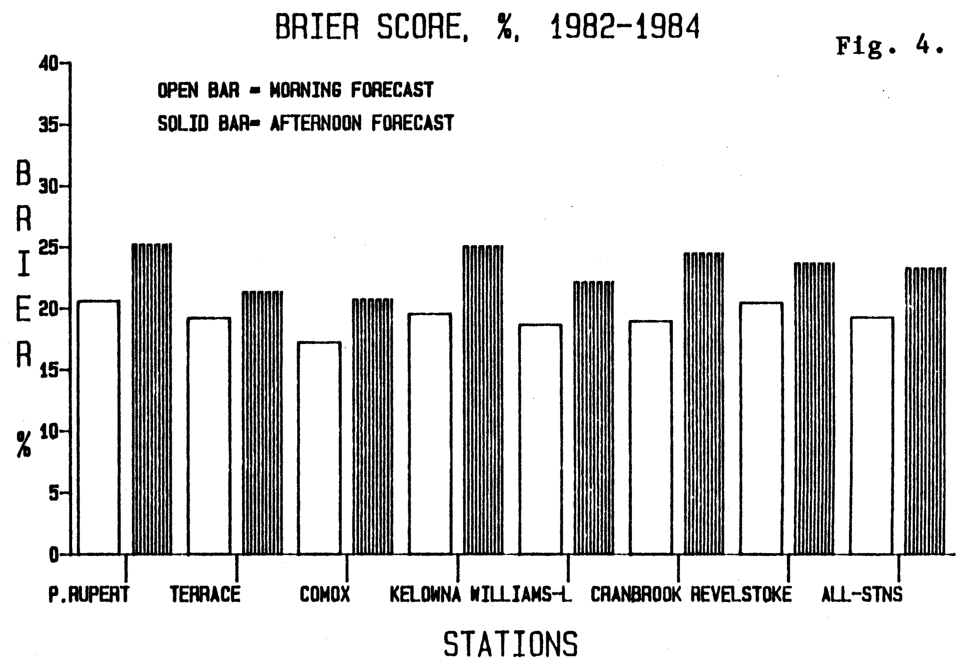


Fig. 4.

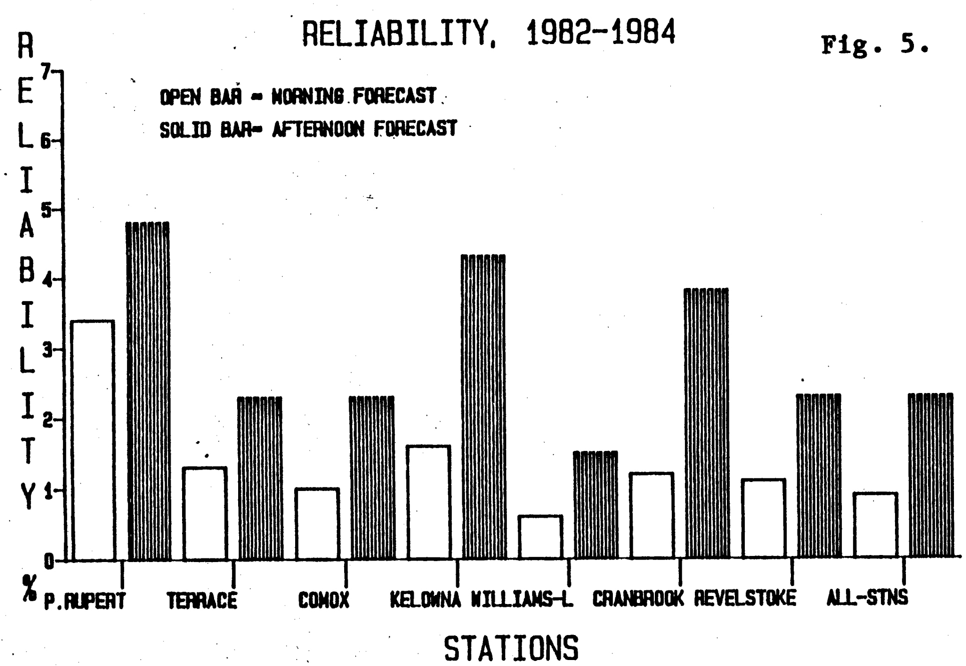


Fig. 5.

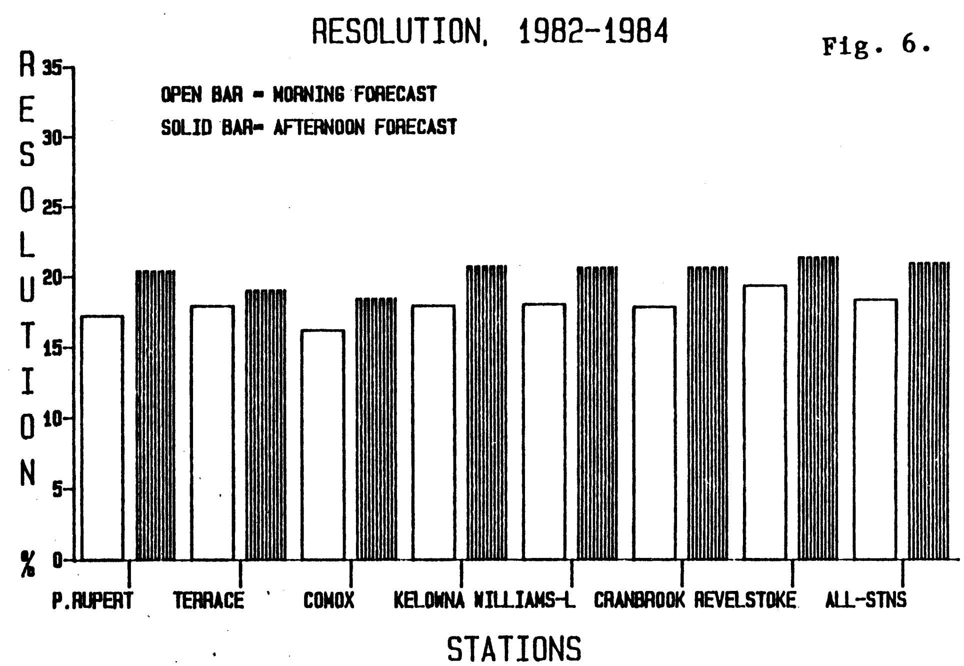
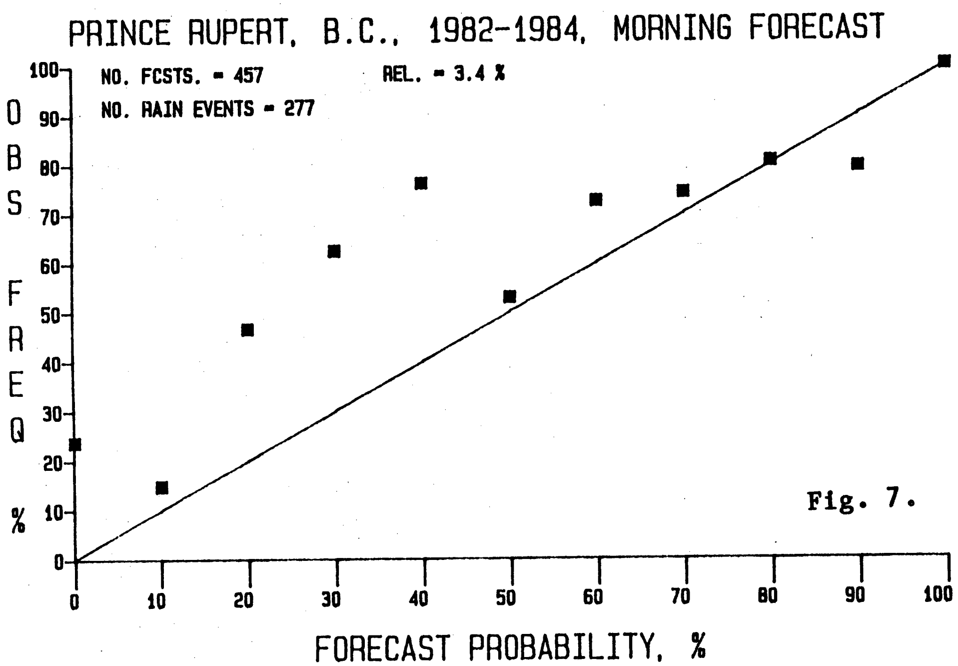
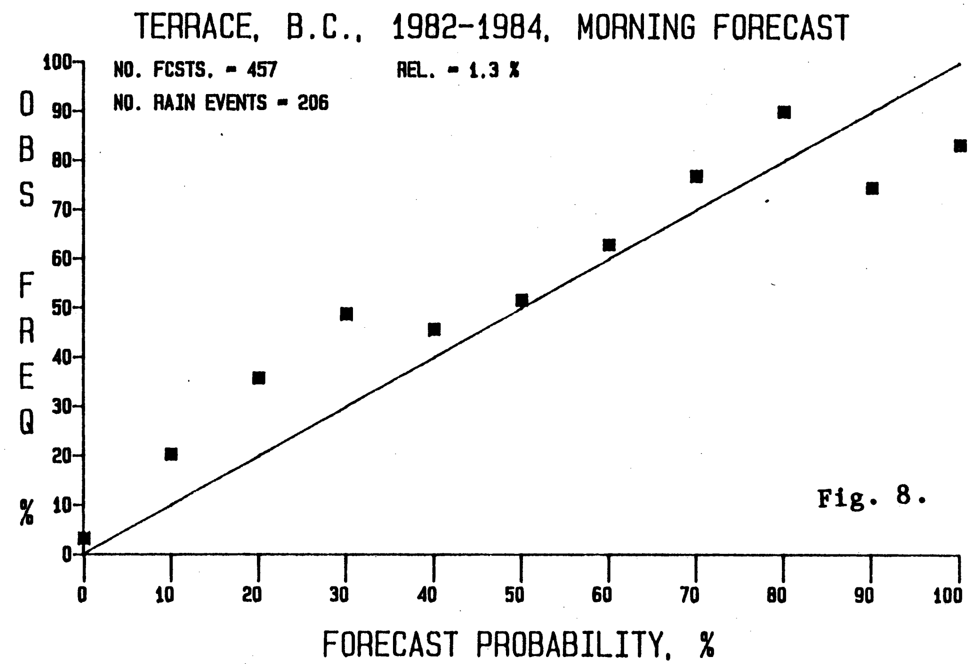
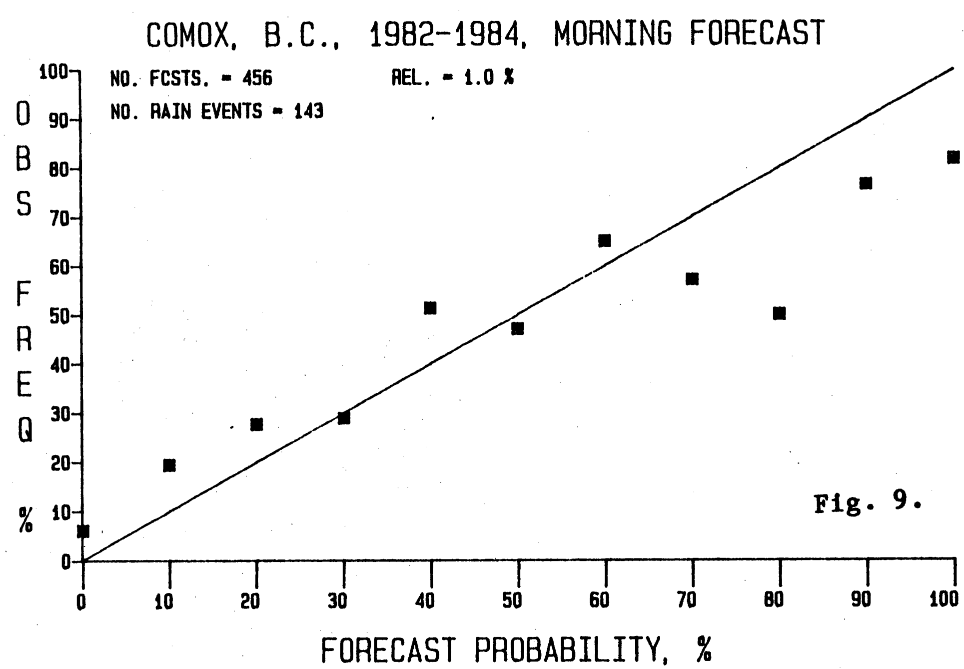


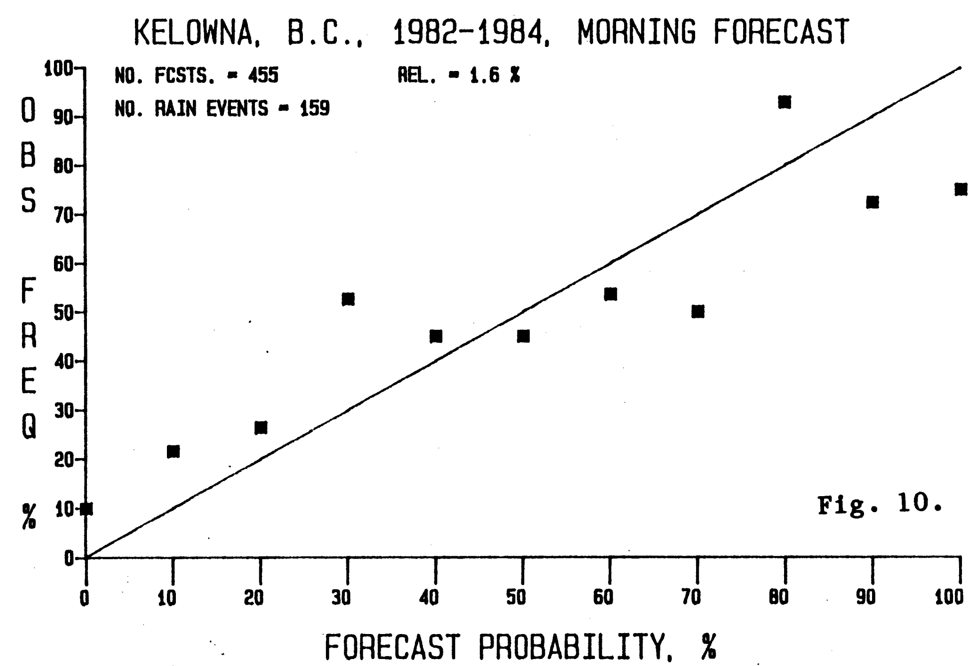
Fig. 6.

Figures 3 to 6. Verification scores obtained by the morning and afternoon weather forecasts for the probability of rain at seven stations. All-stations summarizes the scores over all locations grouped together.

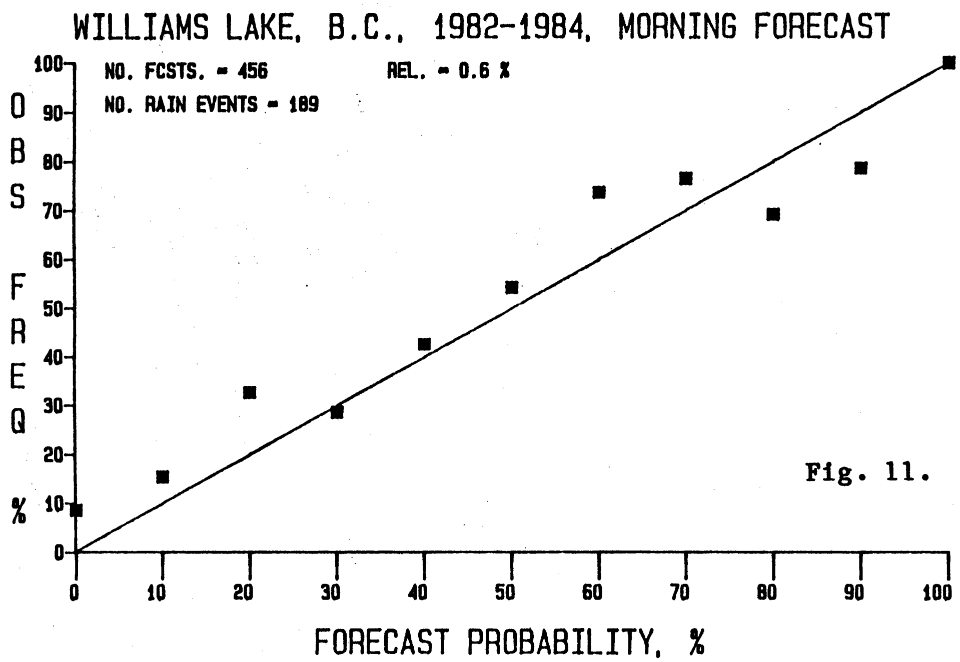


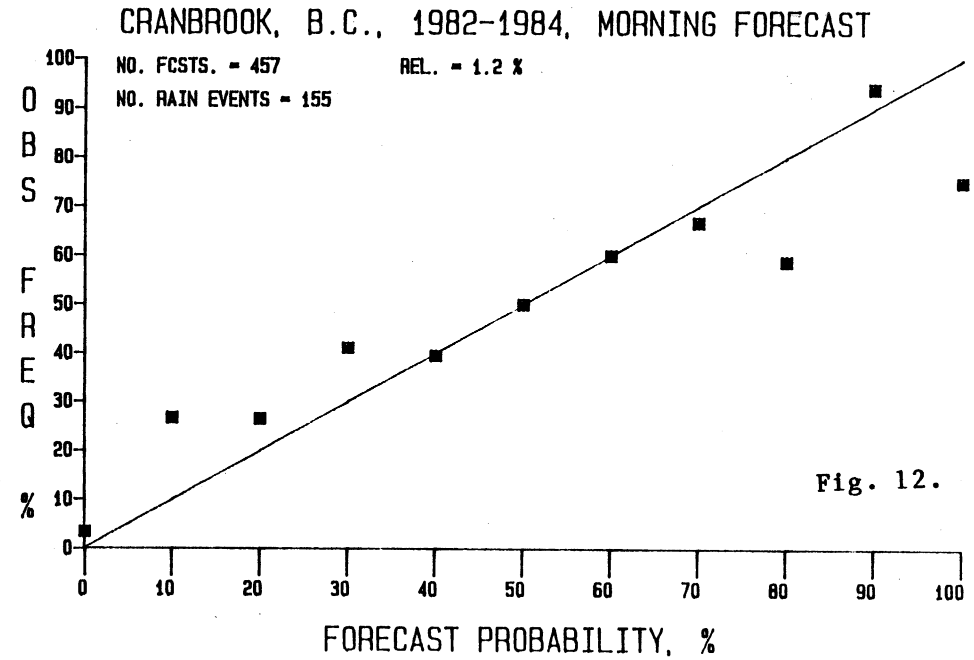


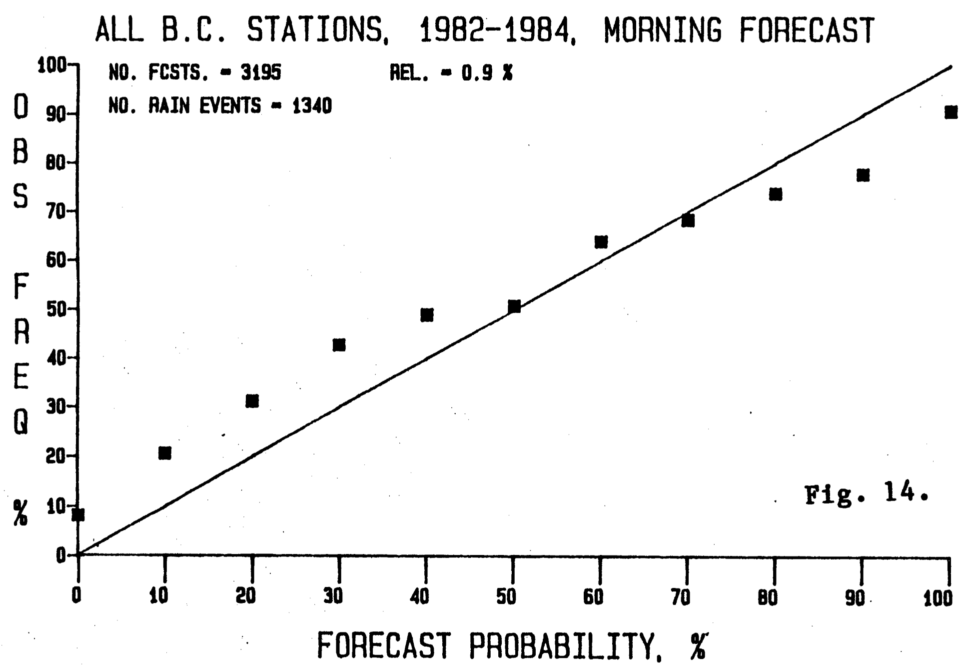


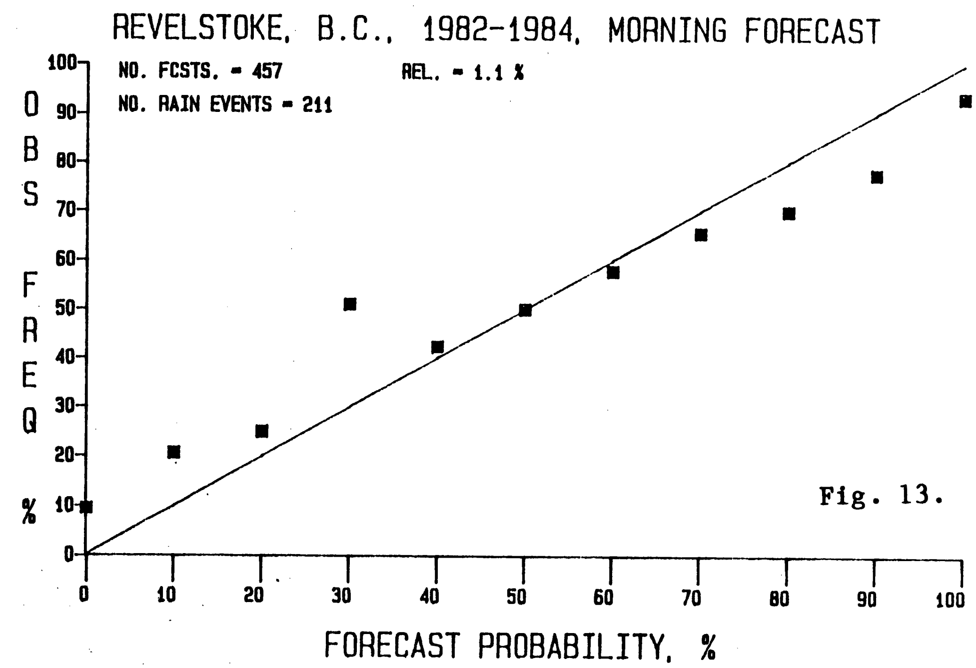


Figures 7 to 10. Forecast rain probability versus the observed frequency of rain. If the observed frequency was identical to the forecast probability, the point would be on the diagonal. Note, REL. is the reliability.









Figures 11 to 14. Forecast rain probability versus the observed frequency of rain. If the observed frequency was identical to the forecast probability, the point would be on the diagonal. Note, REL. is the reliability.

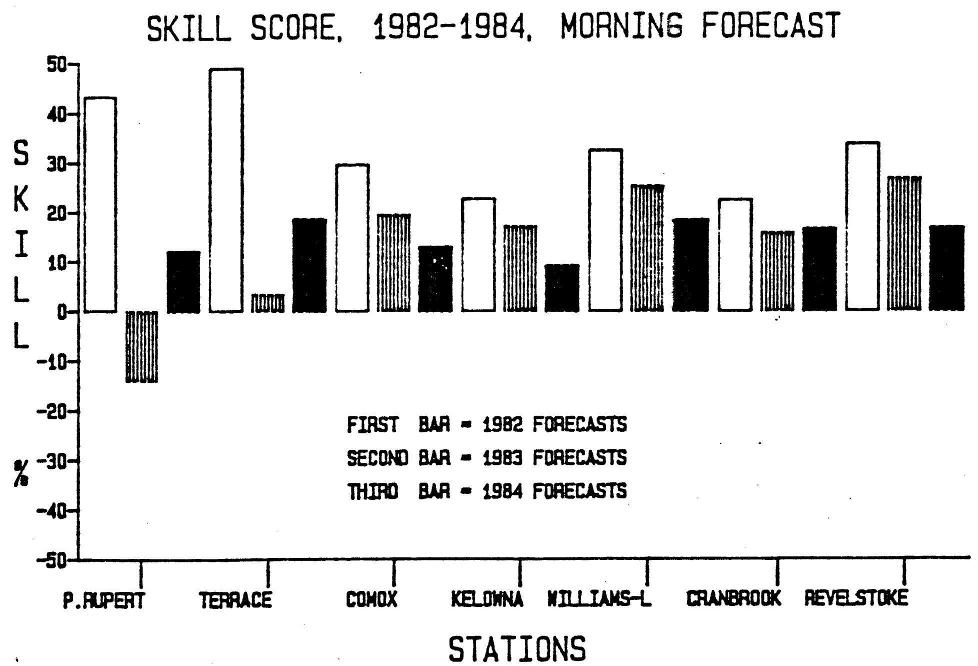


Fig. 15.

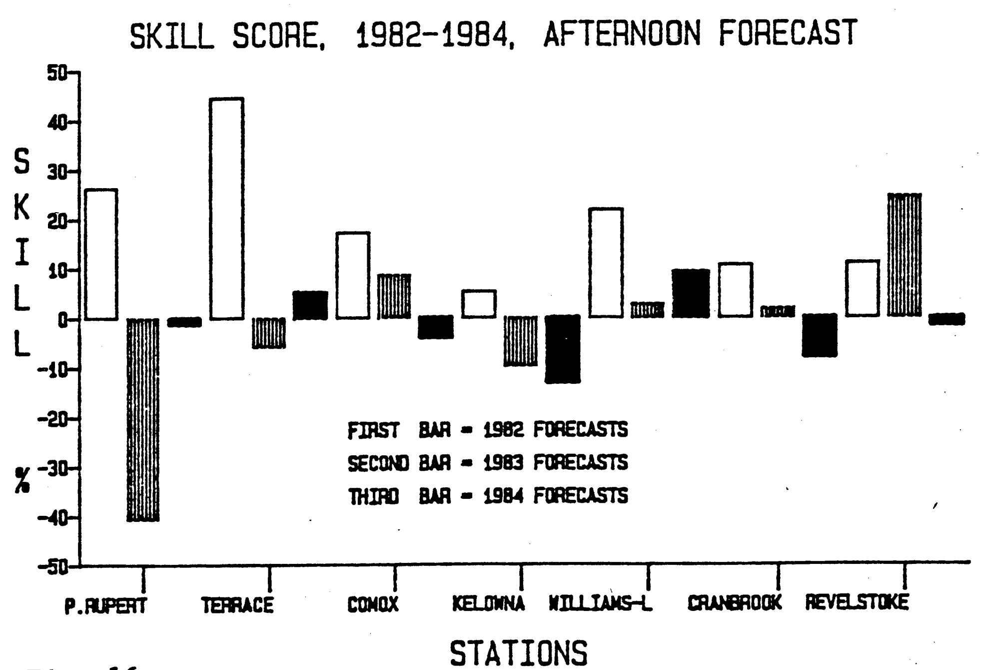


Fig. 16.

Figures 15 and 16. The annual (May - September) variation of the Skill Score obtained by the morning and afternoon fire weather forecasts for each of the seven stations verified.