Monthly Areal Precipitation Totals From 24-Hour Computer Forecasts

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ABSTRACT

A preliminary investigation of monthly rainfall patterns analysed from 24-hour computer forecasts of precipitation was performed. These patterns are compared with the observed precipitation and long-term normal patterns. Recommendations are made to incorporate the method into a verification program for the computer product.

1 Introduction

Numerical forecasts of precipitation amounts are produced operationally twice daily at the Canadian Meteorological Centre (CMC) in Montreal. As transmitted over the facsimile network, the forecasts depict areal accumulations of precipitation for two 24-hour periods beginning at 0000 GMT and 1200 GMT using 0.25, 0.5, 1.0, 2.0, 3.0, etc. inch isohyets. The vertical motion field at 700 mb and the precipitable water between 500 and 1000 mb for the beginning and the end of the 24-hour forecast periods are also displayed (Fig. 1). Detailed descriptions of the model may be found in the literature, Davies and Olson (1973), Kwizak and Davies (1969).

Although these precipitation forecasts are designed as input for other forecasts that are issued daily, eg. public, agriculture, forestry and municipal snow removal; if sufficiently accurate, the monthly totals of the computer produced precipitation fields could be used for hydro-meteorological and other climatological projects, particularly where observing networks are sparse. This possibility provided the stimulus for this investigation, which should be considered of a preliminary nature.

As a by-product of the investigation, it became apparent that the comparison between the computer-produced fields and the actual monthly precipitation provides a means for verifying the forecast. Over an extended period of time, systematic biases of the program to over or under-forecast precipitation for particular locations should become noticeable.

2 Investigation of Data

Charts for two months, April and May 1973, were examined separately using the forecast period 0000 GMT to 0000 GMT. This time period was chosen to conform with the observational date with which the forecasts would be compared. The Province of Ontario was taken as the test area and was further sub-divided by a line from Sault Saint Marie to Winisk.

The precipitation that was forecast to accumulate during each 24-hour period was graphically added to that accumulated during the previous days of the month. Since the 0.25 inch isohyet is the lowest value that is shown on the charts, it was necessary to draw the 0.1 inch isohyet subjectively for each 24-hour forecast.

The considerations for locating the 0.1 inch isohyet were:

(a) the symmetry of the computer-produced precipitation pattern, and
(b) the 700 mb vertical velocity pattern at the beginning and end of the forecast period.

3 Results

The total forecast April precipitation for Ontario is shown in Fig. 2 while the actual monthly precipitation[1] appears in Fig. 3. The maximum over northwestern Ontario was predicted by the computer method but the minimum over Georgian Bay and the maximum in the vicinity of Trenton were not; the Trenton maximum might be considered displaced, appearing in the Windsor area.

A graphical subtraction of the actual precipitation from the computer produced monthly total is presented in Fig. 4. The variation is seen to range from −1.5 inches in the northwest to +4.0 inches in the southwest. The computer forecast of the monthly precipitation was within 0.5 inches of the actual precipitation for 64 per cent of the test area. Conversely, the monthly precipitation amounts based on the computer data differed from the actual precipitation by more than 0.5 inches over more than a third of the area.

The normal precipitation[2] for the month was also examined (Fig. 5). It shows a more or less regular increase in precipitation from north to south across the Province.

Subtracting the actual precipitation from the normal shows (Fig. 6) variations ranging from −2.0 inches in the northwest to +1.5 inches near Lake Huron. The actual precipitation was within 0.5 inches of the normal precipitation for approximately 40 per cent of the test area.

In a similar manner, the actual precipitation for May 1973, the precipitation field based on the computer-produced values and the normal precipitation for May were analysed and are shown in Figures 7, 8, and 9.

The computer-based product shows some skill in forecasting the May precipitation pattern in northwestern Ontario but errors in amount in the southwest were as much as 7 inches. This error was mainly due to a 5-inch storm which was forecast to move slowly across the Windsor area during the last week of May and which in fact passed south of the area.

[1]Based on analysis of monthly data from the Climatological Station Network.
[2]Based on analysis of normal data from the Network for the period 1941–1970.

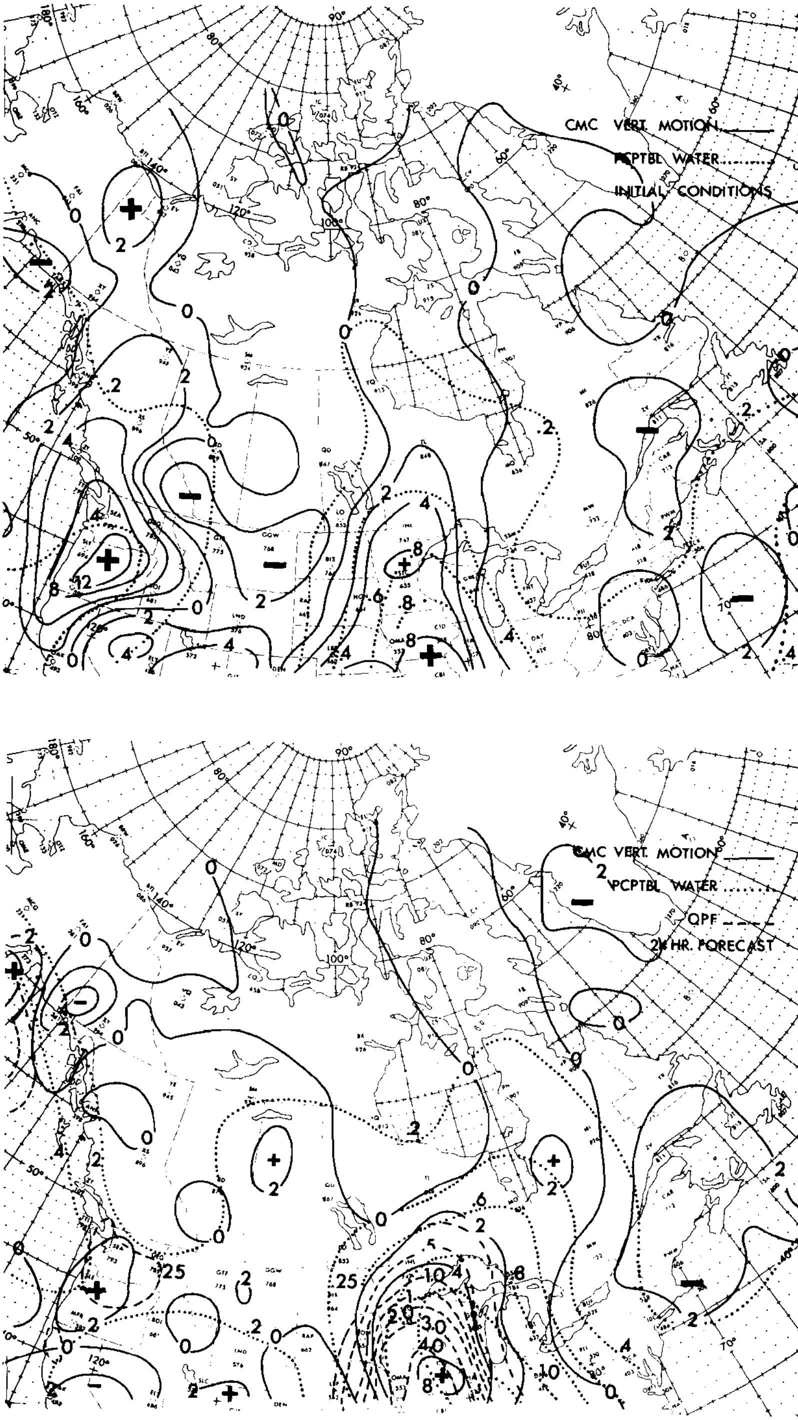

Fig. 1 CMC 24-hour quantitative precipitation forecast.

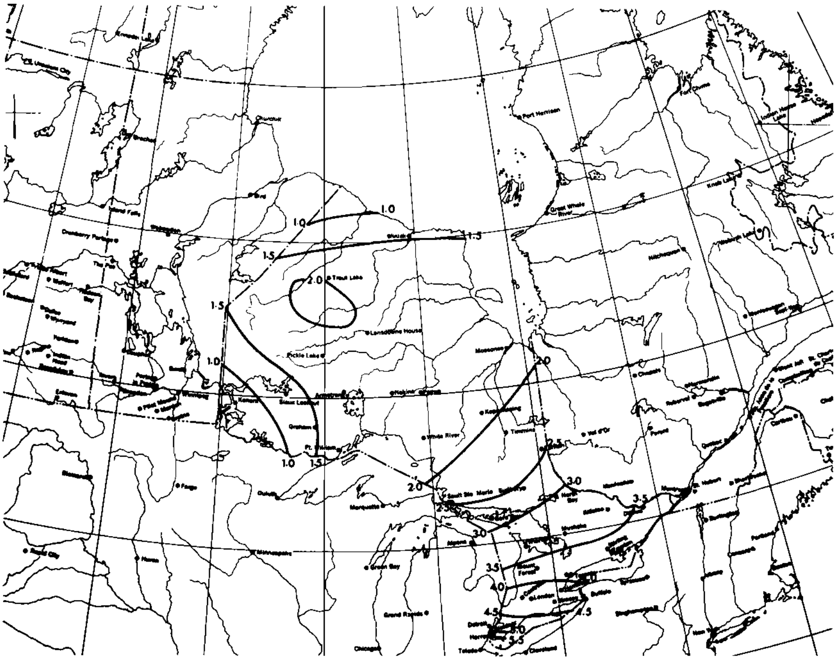

Fig. 2 Computer forecast precipitation – April 1973.

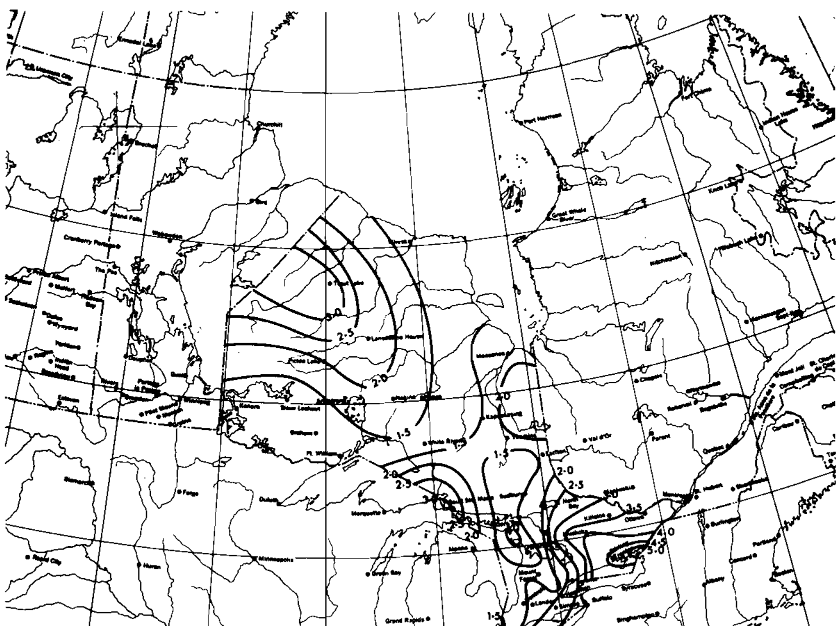

Fig. 3 Actual precipitation – April 1973.

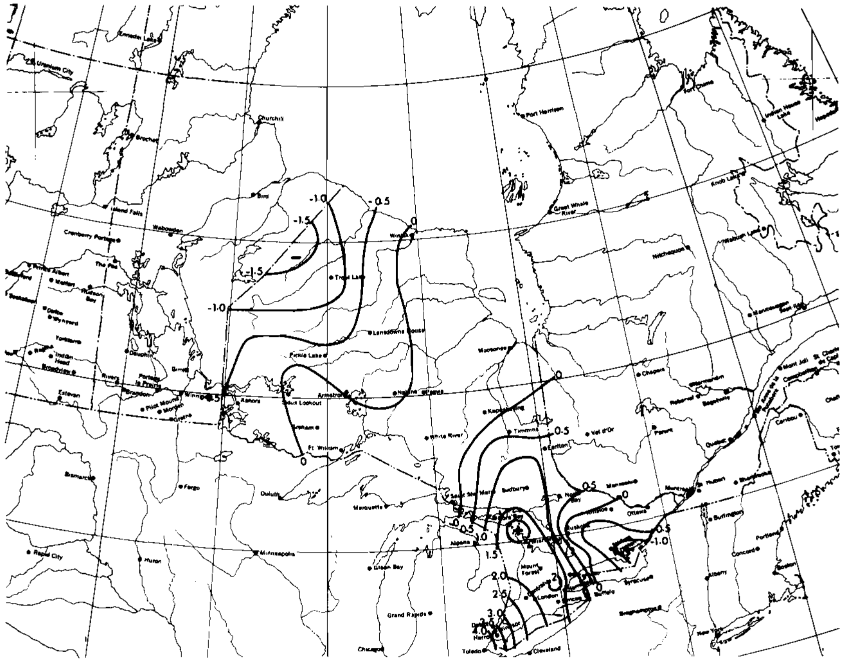

Fig. 4 (Forecast-actual) precipitation – April 1973.

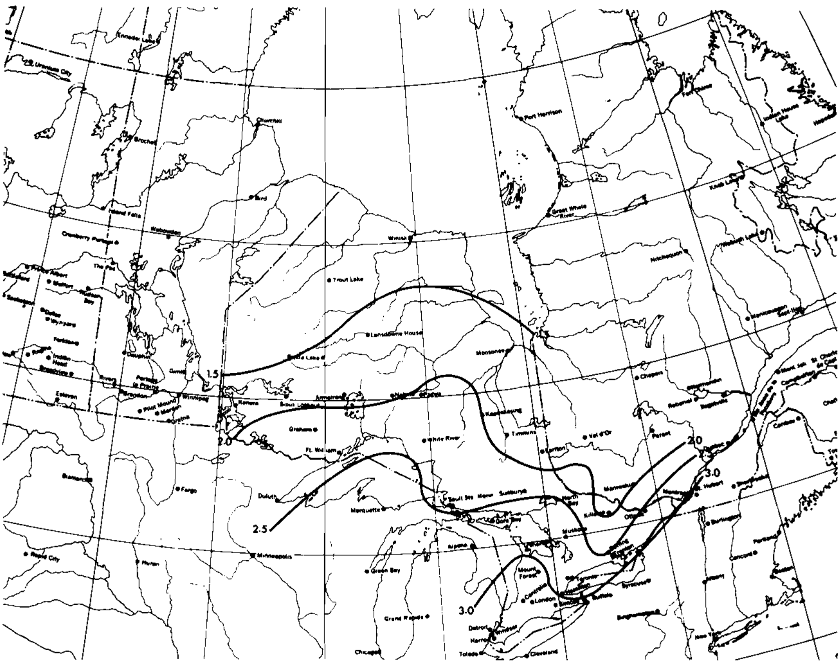

Fig. 5 Normal precipitation – April 1973.

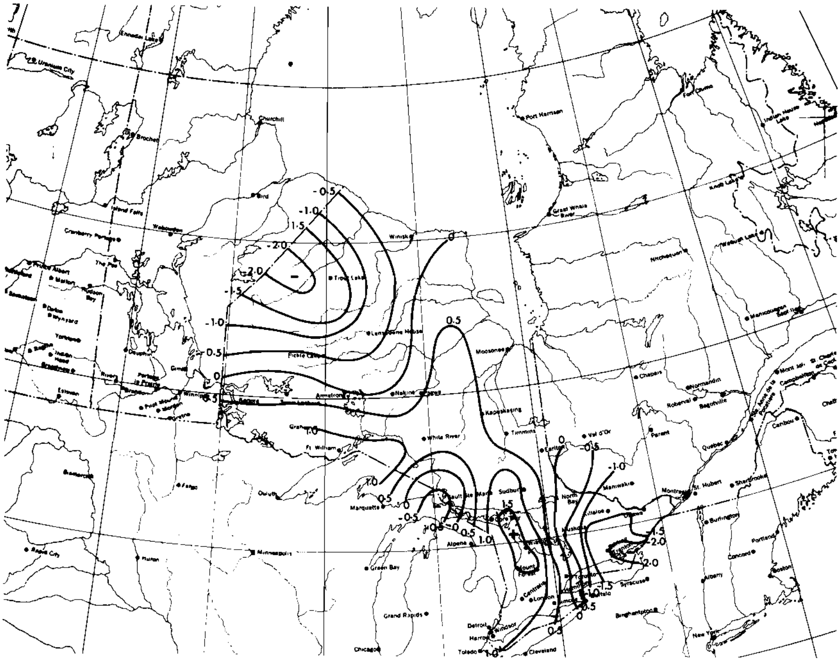

Fig. 6 (Normal-actual) precipitation – April 1973

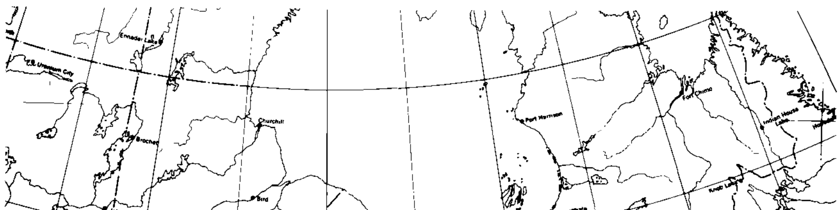

Fig. 7 Actual precipitation – May 1973.

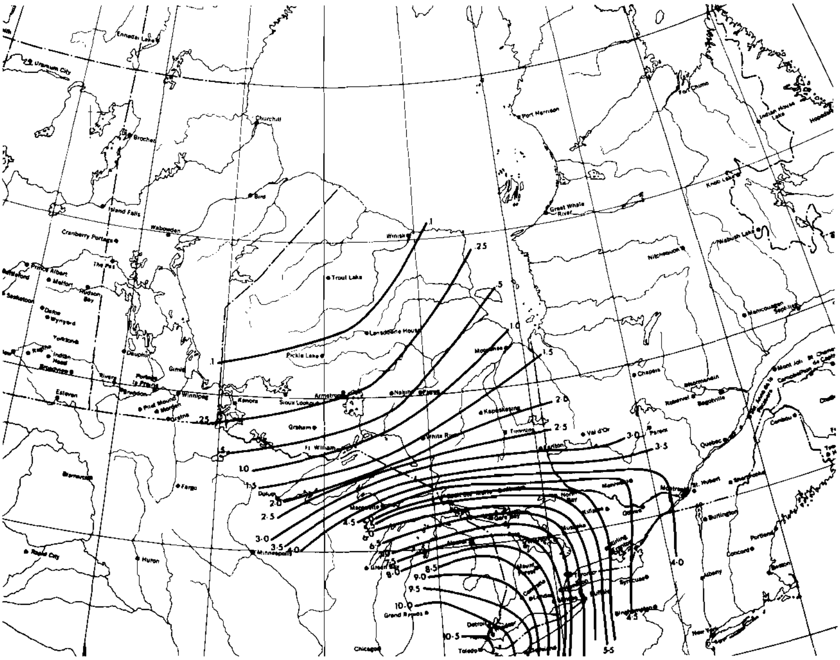

Fig. 8 Computer forecast precipitation – May 1973.

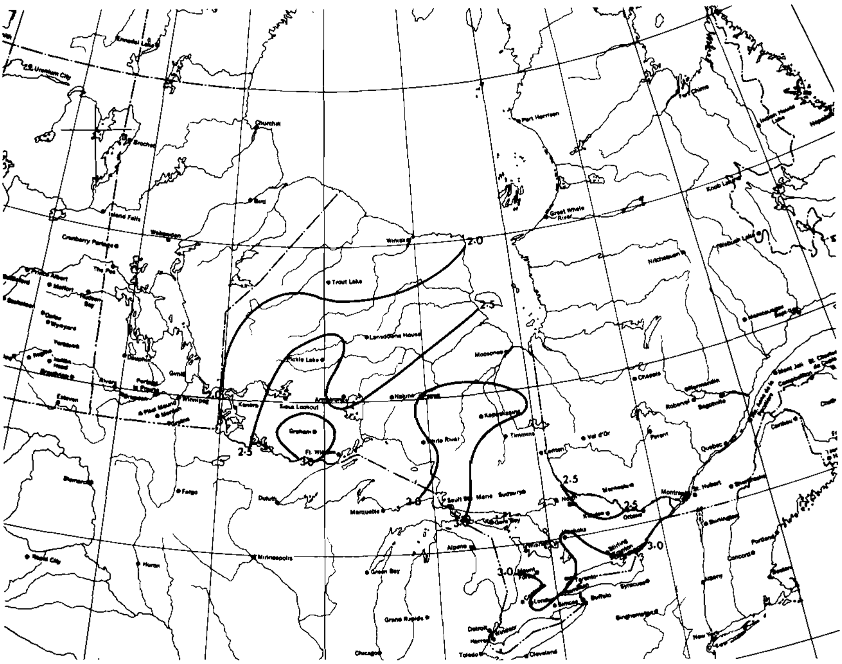

Fig. 9 Normal precipitation – May 1973.

TABLE 1. Monthly volumes of precipitation for Ontario (inches × miles^2 × 10^3).

Month	Area	Actual	Computer	Normal
April	North	418	410 (− 1.9)[1]	362 (−13.4)
	South	404	456 (+12.9)	433 (+ 7.2)
	Total	822	866 (+ 5.1)	795 (− 3.3)
May	North	291	83 (−71.5)	463 (+59.1)
	South	650	766 (+17.9)	607 (− 6.6)
	Total	941	849 (− 9.8)	1070 (+13.7)

[1]Percentage difference from the actual volume.

A comparison was also made between the actual volumes of water which accumulated and those which would have accumulated with the computer-predicted rainfalls and also with the normal rainfalls. To evaluate the volumes, the precipitation patterns were copied onto equal area projections and a cut-and-weigh technique was used. The results are presented in Table I. The North area and the South area are those areas of Ontario divided by a line from Sault Ste Marie to Winisk.

4 Conclusions and recommendations

The method can only be as accurate as the precipitation forecasts; if in certain regions the QPF enjoys high success, so will this method of calculating areal precipitation. On the basis of this limited testing, all one can say is that gross errors over large areas can occur when the monthly areal precipitation is calculated using CMC's 24-hour QPF. Therefore, applying the technique to sparse data areas as a substitute for installing a climatological network does not appear to be feasible. The technique would likely show increased accuracy if 12-hour rather than 24-hour forecasts were used to calculate monthly totals. However, the extent of the improvement cannot be estimated.

The subjective method of estimating the 0.1 inch isohyet and the subjective nature of graphical addition are probable sources of error in this study. To properly evaluate the method, the study should be repeated using the grid points and grid-point values from the original program. This is extremely important since the computer forecasts are most accurate for amounts ranging from 0.01 inches to 0.25 inches (Davies, 1974).

The comparison between the grid-point computed data and actual precipitation observation should also be made on a day-to-day, yes/no basis as an ongoing verification program. The preparation of these data would provide an objective and operationally realistic method of evaluating the CMC/QPF model and would complement existing daily verification programs.

Summaries of daily information as well as weekly, monthly and seasonal comparisons of totals should be collated for regions and for individual areas of responsibility within regions. Distribution of such comparisons would allow operational meteorologists to verify the model within their own areas of responsibility; following which, subjective improvements and quality control within the region could be implemented.

References

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