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Report N.:



* T E C - 7 4 4 *

SKP Box Number: 672672428



CANADA

DEPARTMENT OF TRANSPORT
METEOROLOGICAL BRANCH

Technical Memoranda

ERRORS IN TEMPERATURE FORECASTS
FOR THE ATLANTIC PROVINCES
16 JUNE TO 15 AUGUST, 1970

by

J.A. FITZGERALD

U.D.C. 551.509.53

TEC 744
25 SEPTEMBER, 1970

2,11(7)

CANADA - DEPARTMENT OF TRANSPORT - METEOROLOGICAL BRANCH
315 Bloor Street, West,
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ABSTRACT

The minimum and maximum temperature forecasts produced by Central Analysis Office for several locations in the Atlantic Provinces have been compared with the minimum temperature ranges and maximum temperatures forecast by Atlantic Weather Central for the period 16 June 1970 to 15 August 1970.

ERREURS DANS LES PRÉVISIONS DE TEMPÉRATURE POUR LES PROVINCES
DE L'ATLANTIQUE
PÉRIODE DU 16 JUIN 1970 AU 15 AOÛT 1970

par

J.A. Fitzgerald

RÉSUMÉ

L'auteur a comparé les températures minimales et maximales prévues par le Bureau central d'analyse pour de nombreux endroits dans les provinces de L'Atlantique avec les températures minimales et les températures maximales prévues par le centre météorologique de l'Atlantique pour la période du 16 juin 1970 au 15 août 1970.

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(Manuscript received September 16, 1970)

Introduction

The Halifax Atlantic Weather Central (AtWC) provides temperature guidance for the Weather Offices in the Atlantic Provinces. This guidance consists of forecasts of the range of minimum temperatures for the upcoming night and of the highest maximum temperature expected to be realized the next day in various parts of these provinces. The Central Analysis Office (CAO) issues computer-produced forecasts which include predictions of the night's minimum and next day's maximum temperatures for several specific locations in the Atlantic Provinces, namely, Halifax and Sydney in Nova Scotia; Charlottetown in Prince Edward Island; Saint John, Moncton and Fredericton in New Brunswick; and Gander, Stephenville and St. John's in Newfoundland. A comparison of the relative success achieved by these two Central offices for the summer period 16 June 1970 to 15 August 1970 has been carried out to complement a similar study carried out by Tyner (1) at the AtWC for the winter period 14 November 1969 to 31 January 1970.

The results labelled Atlantic Provinces at the bottom of each of Tables 1, 2 and 3 are the overall values for the four provinces. Because the amount of data abstracted for each province was not always the same, the results shown for the Atlantic Provinces in each of Tables 1, 2 and 3 are the weighted averages of the comparable results of the four separate provinces.

Results

Average forecast errors, standard deviations of the forecast errors, average absolute forecast errors and average absolute persistence errors are presented in Table 1A. A fact which is immediately noticeable is that the CAO minimum temperature forecasts are consistently lower than the observed temperatures. This is evidenced by the negative values for the average errors. One reason for this is that during the period 16 June 1970 to 15 August 1970 the nightly minima were predominantly higher than normal. In Nova Scotia, 78 out of 122 observations were above the mean normal nightly minimum;

in Prince Edward Island, 40 out of 61; in New Brunswick, 125 out of 182; and in Newfoundland, 88 out of 120. Thus, about 70 percent of the observations were warmer than normal. The CAO forecasts are strongly influenced by the climatological mean temperatures as will be shown later, and it may be this characteristic that causes the CAO forecast minimum temperatures to average somewhat below the observed minimum temperature in a period of above normal temperature.

The standard deviations of forecast error for the CAO and AtWC are comparable for both minimum temperature forecasts and for the maximum temperature forecasts, i. e., the forecast errors of the two offices show similar dispersions in this respect.

Examining the average absolute errors, it is seen that, with the exception of the CAO maximum temperature forecasts for Nova Scotia, both offices produced forecasts of a better quality than persistence. In general, more success was experienced with forecast minimum temperatures than with forecast maximum temperatures. With the forecast minimum temperatures, AtWC produced a smaller average error than CAO. Only in Prince Edward Island did the computer-produced forecasts show a slightly smaller error.

Because the CAO produces forecasts for specific stations while the AtWC forecasts for regions, it is difficult to compare the forecasts of the two offices on a "fair" basis, i. e., one form of forecast may be inherently more difficult and thus results should not be expected to be the same.

It is assumed here that the persistence results should give some indication of relative difficulties in producing a forecast so that the improvement over persistence is, perhaps, the best indication of the success of a forecast. With this in mind, Table 1B was compiled which shows the differences between persistence errors and forecast errors. It is seen that for minimum temperature forecasts the computer-produced forecasts issued by CAO consistently show greater improvement over persistence than the forecasts issued by the AtWC. For maximum temperature forecasts, the AtWC averages overall a somewhat greater improvement over persistence than CAO though not for the maximum forecasts for Prince Edward Island and New Brunswick.

The percentage of cases where the forecast temperature was higher than, lower than, or equal to the observed temperature and

the percentage of cases where the forecast error was greater than or equal to 5°F., 10°F., and 15°F. is presented in Table 2. It can be seen that the CAO minimum temperature forecasts were most frequently lower than the observed temperatures. Aside from this characteristic, there is little difference between the CAO and AtWC results. The high percentage of low CAO minimum temperature forecasts is probably due to the fact that from 16 June to 15 August 1970 the nightly minima were most frequently well above the climatological means for the period. The relative incidence of large forecast errors is essentially the same for CAO and AtWC.

The average absolute difference from the climatological mean of the observed and forecast temperatures for all cases, and for those cases where the observed temperature differed by 6°F. or more from the mean are set out in Table 3. It can be seen that the CAO forecasts are consistently closer to the climatological mean than either the AtWC forecasts or the observed temperatures, indicating the considerable weight given to the climatological mean temperature in the forecast equations. As would be expected, the AtWC forecasts seem to be somewhat less conservative.

A count was made of the number of times CAO and AtWC over-estimated the departure from the mean temperature when the departure of the observed temperature was 6°F. or more and the results of this count appear in Table 4. The relatively low incidence of over-estimating departures from climatological means is symptomatic of the tendency of both offices to be conservative in forecasting temperatures which depart considerably from climatological means, a tendency more pronounced in the forecasts issued by the CAO than in those issued by the AtWC (Column 2 of Table 4).

Conclusions

In general during the period 16 June to 15 August 1970 the AtWC maximum temperature forecasts were superior to the maximum temperature forecasts issued by the CAO for the Atlantic Provinces. The AtWC minimum temperature forecasts appeared to be somewhat more accurate than those supplied by the CAO. However, this apparent superiority may be due to temperature ranges for a region being easier to forecast than spot values at individual stations. The AtWC forecasts were apparently not influenced by the values of the climatological mean temperatures to the same extent as the numerically-based forecasts so that when temperatures departed widely from the climatological norms the AtWC forecasts increased their superiority over the

computer-produced forecasts. The incidence of excessively large forecast errors was about the same for the forecasts produced by both offices.

It is of some interest to note that during this summer period the AtWC temperature guidance is somewhat more accurate than the forecasts provided by the CAO, though during the winter period of 14 November 1969 to 31 January 1970 the CAO forecasts appeared to provide more reliable guidance.

APPROVED,



J. R. H. Noble,
Administrator,
Canadian Meteorological Service.

Reference

1. Tyner, R. V. 1970: Errors in the Temperature Forecasts for the Atlantic Provinces, 14 November 1969 to 31 January 1970. Canada, Department of Transport, Meteorological Branch, Technical Memoranda Series, TEC-737.

Table 1A.

TEMPERATURE FORECAST ERRORS

| | Average Error $\frac{1}{N} \sum_1^N (T_{F_i} - T_{\phi_i})$ | Standard Deviation $\sqrt{\frac{\sum_1^N (\text{error } i - \overline{\text{error}})^2}{N-1}}$ | Average Absolute Error $\frac{1}{N} \sum_1^N T_{F_i} - T_{\phi_i} $ | Average Absolute Persistence Error $\frac{1}{N_p-1} \sum_{i=2}^{N_p} T_{\phi_i} - T_{\phi_{i-1}} $ |
|-----------------------------|--|---|---|--|
| <u>NOVA SCOTIA</u> | | | | |
| CAO Minimum | -1.44 | 3.64 | 3.10 | 3.94 |
| CAO Maximum | 2.67 | 6.35 | 5.41 | 5.02 |
| AtWC Minimum | 0.43 | 3.57 | 2.98 | 3.67 |
| AtWC Maximum | -0.20 | 5.16 | 4.22 | 5.26 |
| <u>PRINCE EDWARD ISLAND</u> | | | | |
| CAO Minimum | -1.38 | 3.09 | 2.72 | 3.57 |
| CAO Maximum | -0.57 | 5.41 | 4.31 | 5.60 |
| AtWC Minimum | 0.05 | 3.81 | 2.80 | 3.47 |
| AtWC Maximum | 3.15 | 6.12 | 5.12 | 5.42 |
| <u>NEW BRUNSWICK</u> | | | | |
| CAO Minimum | -0.67 | 3.71 | 2.98 | 5.21 |
| CAO Maximum | -1.63 | 5.69 | 4.83 | 5.12 |
| AtWC Minimum | 0.51 | 4.48 | 3.34 | 4.99 |
| AtWC Maximum | 0.18 | 5.98 | 4.52 | 4.60 |
| <u>NEWFOUNDLAND</u> | | | | |
| CAO Minimum | -2.00 | 4.68 | 4.29 | 5.46 |
| CAO Maximum | 1.00 | 6.99 | 5.49 | 5.63 |
| AtWC Minimum | -0.93 | 4.48 | 3.66 | 3.97 |
| AtWC Maximum | 0.48 | 6.67 | 5.10 | 5.91 |
| <u>ATLANTIC PROVINCES</u> | | | | |
| CAO Minimum | -1.36 | 4.08 | 3.41 | 4.74 |
| CAO Maximum | 0.30 | 6.38 | 5.12 | 5.31 |
| AtWC Minimum | 0.01 | 4.23 | 3.25 | 4.11 |
| AtWC Maximum | 0.82 | 6.00 | 4.73 | 5.33 |

Table 1B.

DIFFERENCE BETWEEN AVERAGE ABSOLUTE PERSISTENCE ERROR
AND AVERAGE ABSOLUTE FORECAST ERROR

| | Nova Scotia | Prince Edward Island | New Brunswick | Newfoundland | Atlantic Provinces |
|-----------------|----------------|----------------------------|------------------|--------------|-----------------------|
| <u>Minimum:</u> | | | | | |
| AtWC | .69 | .67 | 1.65 | .31 | .86 |
| CAO | .84 | .85 | 2.23 | 1.17 | 1.33 |
| <u>Maximum:</u> | | | | | |
| AtWC | 1.04 | .30 | .81 | .81 | .60 |
| CAO | -.39 | 1.29 | .29 | .14 | .19 |

Table 2.

| | Percentage of Cases with Forecast Higher than Observed Temperature | Percentage of Cases with Forecast Lower than Observed Temperatures | Percentage of Cases with Forecast Same as Observed Temperatures | Percentage of Cases with Errors 5°F. 10°F. 15°F. | | |
|------------------------------|--|--|---|--|------|-----|
| <u>Nova Scotia:</u> | | | | | | |
| CAO Minimum | 27.0 | 59.0 | 14.0 | 26.2 | 0.8 | 0.0 |
| CAO Maximum | 67.7 | 27.3 | 5.0 | 53.7 | 14.9 | 3.3 |
| AtWC Minimum | 48.3 | 37.7 | 14.0 | 23.8 | 1.6 | 0.0 |
| AtWC Maximum | 42.1 | 50.0 | 7.9 | 44.8 | 6.6 | 0.0 |
| <u>Prince Edward Island:</u> | | | | | | |
| CAO Minimum | 16.4 | 70.5 | 13.1 | 16.4 | 0.0 | 0.0 |
| CAO Maximum | 41.0 | 55.7 | 3.3 | 37.7 | 11.5 | 1.6 |
| AtWC Minimum | 42.6 | 49.2 | 8.2 | 21.3 | 1.6 | 0.0 |
| AtWC Maximum | 68.4 | 23.3 | 8.3 | 51.7 | 13.3 | 3.3 |
| <u>New Brunswick:</u> | | | | | | |
| CAO Minimum | 30.8 | 56.6 | 12.6 | 22.5 | 1.1 | 0.0 |
| CAO Maximum | 36.3 | 55.5 | 8.2 | 48.3 | 10.4 | 0.0 |
| AtWC Minimum | 48.3 | 36.9 | 14.8 | 33.6 | 3.3 | 0.8 |
| AtWC Maximum | 43.3 | 51.7 | 5.0 | 43.3 | 8.3 | 1.7 |
| <u>Newfoundland:</u> | | | | | | |
| CAO Minimum | 29.1 | 63.2 | 7.7 | 44.5 | 4.4 | 0.0 |
| CAO Maximum | 47.7 | 45.5 | 6.8 | 50.5 | 15.2 | 5.0 |
| AtWC Minimum | 32.0 | 57.3 | 10.7 | 33.6 | 3.3 | 0.0 |
| AtWC Maximum | 45.3 | 48.0 | 6.7 | 45.3 | 13.3 | 2.7 |
| <u>Atlantic Provinces:</u> | | | | | | |
| CAO Minimum | 27.8 | 60.9 | 11.3 | 30.0 | 2.0 | 0.0 |
| CAO Maximum | 47.6 | 46.0 | 6.4 | 49.0 | 13.1 | 2.6 |
| AtWC Minimum | 42.9 | 44.7 | 12.4 | 29.0 | 2.6 | 0.2 |
| AtWC Maximum | 49.1 | 43.9 | 7.0 | 46.1 | 10.3 | 1.8 |

Table 3.

DIFFERENCES FROM CLIMATOLOGICAL MEAN TEMPERATURES

| | Average of Absolute Difference from Climatological Mean of | | For Those Cases Where Observed Temperatures Differed from Climatological Mean by 6°F. or More | |
|------------------------------|--|---------------------------------|--|--|
| | <u>Observed Temperature</u> | <u>Forecast Temperature</u> | <u>Average Absolute Difference of Observed Temperature from Mean</u> | <u>Average Absolute Forecast Error</u> |
| <u>Nova Scotia:</u> | | | | |
| CAO Minimum | 4.27 | 2.68 | 8.00 | 4.92 |
| CAO Maximum | 5.15 | 3.81 | 9.85 | 8.20 |
| AtWC Minimum | 4.60 | 4.29 | 8.37 | 3.42 |
| AtWC Maximum | 6.80 | 6.55 | 9.45 | 4.48 |
| <u>Prince Edward Island:</u> | | | | |
| CAO Minimum | 3.80 | 2.80 | 8.33 | 3.83 |
| CAO Maximum | 5.56 | 3.41 | 8.92 | 5.26 |
| AtWC Minimum | 3.69 | 3.12 | 8.00 | 4.53 |
| AtWC Maximum | 5.68 | 7.06 | 8.96 | 5.19 |
| <u>New Brunswick:</u> | | | | |
| CAO Minimum | 5.02 | 3.28 | 8.48 | 3.79 |
| CAO Maximum | 5.73 | 3.52 | 9.73 | 6.63 |
| AtWC Minimum | 5.00 | 5.11 | 8.52 | 3.82 |
| AtWC Maximum | 6.33 | 6.50 | 10.24 | 4.43 |
| <u>Newfoundland:</u> | | | | |
| CAO Minimum | 4.14 | 2.30 | 9.82 | 6.12 |
| CAO Maximum | 5.38 | 3.31 | 10.30 | 7.31 |
| AtWC Minimum | 6.29 | 4.86 | 9.72 | 4.29 |
| AtWC Maximum | 7.35 | 6.42 | 10.07 | 5.40 |
| <u>Atlantic Provinces:</u> | | | | |
| CAO Minimum | 4.42 | 2.77 | 8.85 | 4.84 |
| CAO Maximum | 5.40 | 3.51 | 9.86 | 6.98 |
| AtWC Minimum | 5.07 | 4.52 | 8.82 | 3.95 |
| AtWC Maximum | 6.60 | 6.62 | 9.72 | 4.90 |

Table 4.

OCCURRENCES OF

$$\frac{|T_{\emptyset} - T_M| \geq 6^{\circ}\text{F.}}{\quad} \quad \frac{|T_F - T_M| > |T_{\emptyset} - T_M| \geq 6^{\circ}\text{F.}}{\quad}$$

| | | |
|--------------|-----|----|
| CAO Minimum | 186 | 1 |
| AtWC Minimum | 166 | 36 |
| CAO Maximum | 223 | 13 |
| AtWC Maximum | 144 | 38 |

T_{\emptyset} - Observed temperature

T_F - Forecast temperature

T_M - The climatological mean temperature.

TEC-744
25 September 1970

UDC: 551.509.53

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