Coastal Influences on Winter Precipitation Events in Southeast Labrador

J.P. NEWELL
62 Sherwood Avenue
Kitchener, Ontario, Canada

ABSTRACT

Paired records from meteorological stations in close proximity are rarely available north of 50 °N. This study takes advantage of precipitation data collected at two stations situated on the southeast coast of Labrador, Mary's Harbour and Battle Harbour Loran, to investigate coastal influences on winter precipitation patterns. These stations provide an ideal situation for investigating coastal influences on precipitation since the latter is situated on a small island off the coast while the former is approximately 17 km inland from the coast.

Analysis of the data focused on cases where the daily precipitation totals equaled or exceeded 20.0 mm at one or both of the stations. The pattern that emerges from this analysis is one where Battle Harbour Loran received 2.87 times the precipitation recorded at Mary's Harbour during cases with strong northerly winds while during the remaining events the same ratio was 0.83. It is proposed that these differences result from a combination of frictional convergence at the coastline and local topographic enhancement.

INTRODUCTION

The existing network of precipitation recording sites in northern Canada contains a disproportionate number of stations with coastal locations. It is generally recognized that these stations may not always be representative of conditions away from the coastal zone; however, almost all the evidence regarding the nature and extent of coastal influences on precipitation comes from research conducted south of 50°N. This dearth of research conducted north of 50°N likely reflects the low density of precipita-

tion recording sites in northern Canada. This study takes advantage of data from two climate stations situated in southeast Labrador to investigate the nature and extent of coastal influences on winter precipitation in this region.

This research is part of a program focusing on the climate of southeast Labrador initiated in 1991 by a group of researchers at the Department of Geography, Memorial University of Newfoundland. The members of the group were Dr. J.D. Jacobs, Dr. C. Banfield and Dr. J.P. Newell. Objectives of the research program included investigations of mesoscale climate variations in a subarctic environment and the nature of the coastal/interior climate transition zone as it might influence the representativeness of coastal stations. Funding for this research was provided by the Canadian Climate Centre, Environment Canada, under a contract with the author.

DATA BASE

The two stations considered in this study are Mary's Harbour and Battle Harbour Loran (Figure 1). These stations operated simultaneously during the winter months from 1957-1983. Battle Harbour Loran is situated on a small island off the coast and is well exposed to marine influences. Mary's Harbour is situated approximately 17 km inland from the coast, almost due west of Battle Harbour Loran. These stations provide an ideal opportunity to investigate marine influence on precipitation in this region.

Following the closure of the Battle Harbour Loran site in 1983 a station was operated at Port Hope Simpson, northwest of Mary's Harbour and approximately 40 km from the coast. Data from this site was compared with later data from Mary's Harbour; however, the results of this analysis are only referred to briefly in this paper.

Analysis of paired reports from Battle Harbour Loran and Mary's Harbour was restricted to the post 1977 period so that the results could be compared with synoptic charts prepared by the Gander Weather office (the post 1977 charts are archived at Memorial University, St. John's, Nfld.). During the period of overlap considered in this study the Mary's Harbour site was a ordinary climate station (once per day reports of liquid precipitation and snow depth) while the Battle Harbour Loran site was a principal climate station (synoptic reports using a Nipher snow gauge).

Ordinary climate stations and principal climate stations use different climate days; therefore, in the detailed comparisons carried out in this study the daily precipitation amounts recorded at Battle Harbour Loran were adjusted to better conform with the day used at Mary's Harbour. This was

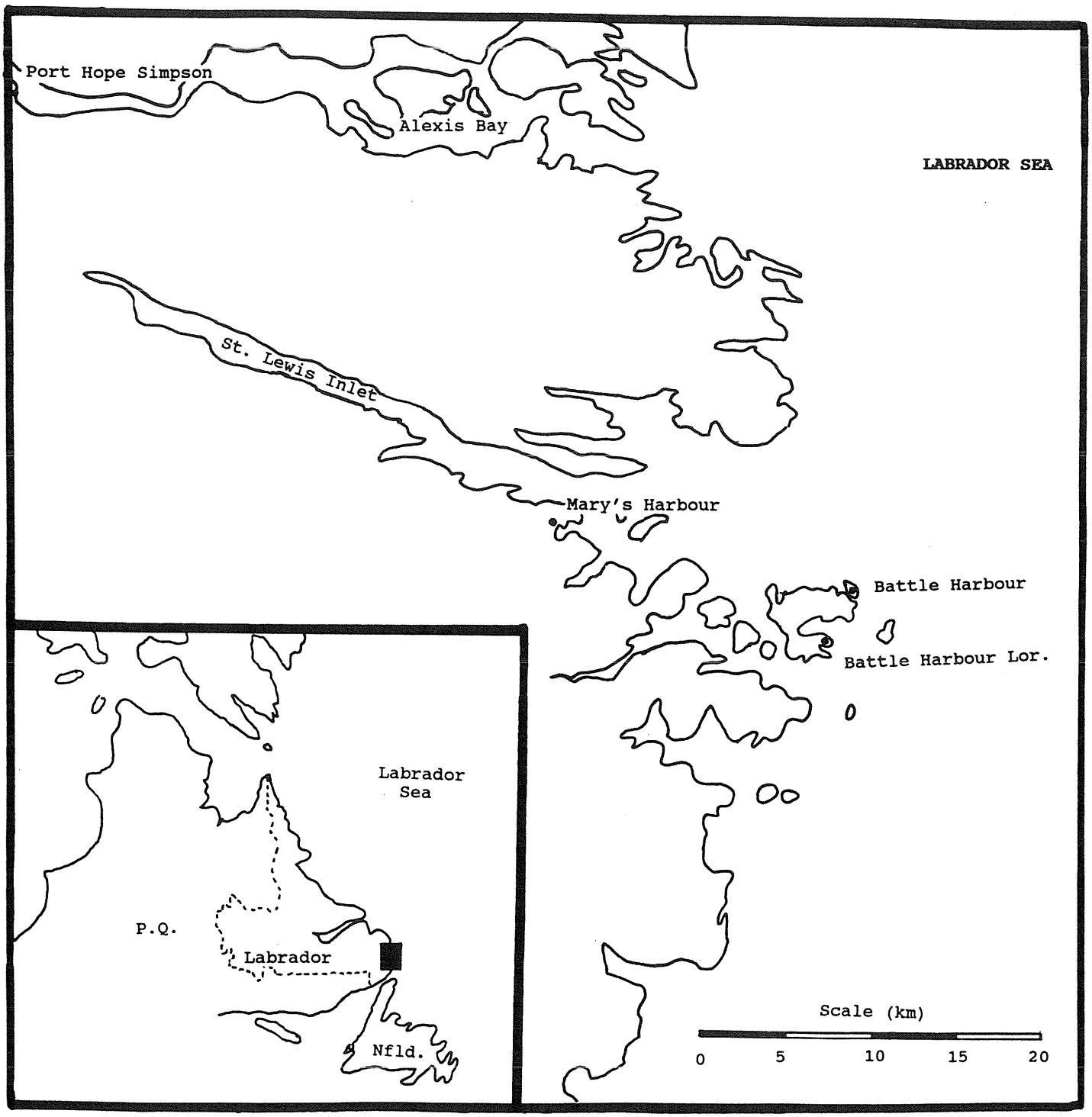

Figure 1. Study Area

carried out by adding the 12Z precipitation amount to the previous days total. If observations at Mary's Harbour were taken at the normal 0800 LST (12Z) then the sum of the 18Z, 00Z, 06Z and 12Z precipitation totals at Battle Harbour Loran should provide an equivalent climate day.

RESEARCH FINDINGS

At the most elementary level there seems to be little difference between the winter precipitation recorded at Battle Harbour Loran and Mary's Harbour. The Climate Normals (Environment Canada, 1982) indicate that the mean October to May precipitation total at Battle Harbour Loran is 636 mm compared to 639 mm at Mary's Harbour. Further analysis of individual daily precipitation totals at the two stations, adjusted as described earlier, revealed that during days when the precipitation totals equaled or exceeded 20.0 mm at one or both of the stations there were significant differences. Twenty eight such events were identified (Table 1) during the months of January to May and December, 1978 to 1983. The pattern that emerges from this analysis is one where Battle Harbour Loran receives almost 1.5 times as much precipitation during such events as Mary's Harbour.

This might at first be seen as evidence of the well known fact that ordinary climate stations under record winter precipitation when compared with stations equipped with Nipher snow gauges. However, examination of Table 1 reveals that there are a number of cases where Mary's Harbour precipitation exceeds that at Battle Harbour Loran, the opposite situation to what would happen if the ordinary station was under recording. In addition, a similar pattern was not apparent from a comparison of later Mary's Harbour (principal climate station) and Port Hope Simpson (ordinary climate station) data.

Analysis of wind and synoptic conditions associated with the events documented in Table 1 provides insights into the processes responsible for the differences between the stations. The wind conditions documented in Table 1 represent an average of the four synoptic hour wind speeds and directions recorded at Battle Harbour Loran each day. In cases where the wind direction varied more than 90 degrees during the day the direction is recorded as variable. Comparison of precipitation ratios between the stations for cases with wind directions between 320^{o} and 030^{o} (32-03 in Table 1) and speeds greater than 40 kph (13 events) and the remaining cases (15 events) revealed that in the former case the precipitation at Battle Harbour Loran was 2.87 times that at Mary's Harbour while in the latter case the same ratio was 0.83. It is apparent from this analysis that during winter precipitation

TABLE 1

Battle Harbour Loran[1]/Mary's Harbour Precipitation Event Comparison (for days with precip. > 20.0 mm. at either station).

NO.	DATE d/m/yr	BHL P. mm	MH P mm	RATIO BHL/MH	WIND dir./sp.(kph)
1.	02/01/78	13.2	25.4	.52	36/54*
2.	23/04/78	37.2	9.9	3.76	03/42*
3.	24/04/78	8.0	31.0	.26	34/38
4.	29/05/78	11.5	31.0	.37	18/31
5.	22/12/78	40.0	14.2	2.82	33/51*
6.	24/01/79	12.6	21.8	.58	01/32
7.	28/01/79	14.1	38.1	.37	08/26
8.	03/02/79	20.0	5.6	3.57	35/72*
9.	04/02/79	37.0	9.9	3.74	35/63*
10.	15/03/79	9.2	27.7	.33	16/62
11.	03/05/79	14.9	27.9	.53	34/34
12.	27/12/79	23.0	5.1	4.51	03/44*
13.	24/01/80	48.0	17.8	2.70	03/75*
14.	25/01/80	39.8	23.9	1.67	02/56*
15.	10/05/80	28.3	14.2	1.99	16/17
16.	30/12/80	25.4	9.2	2.76	03/47*
17.	05/04/81	24.2	22.5	1.08	04/33
18.	10/04/81	27.6	7.5	3.68	34/46*
19.	31/05/81	26.2	23.6	1.11	var/33
20.	06/12/81	21.6	24.2	.89	36/33
21.	07/12/81	23.8	35.5	.67	02/16
22.	10/12/81	60.8	4.0	15.20	01/64*
23	24/02/82	39.6	11.0	3.60	35/49*
24.	02/03/82	14.8	20.0	.78	var/36
25.	08/03/82	24.8	3.5	7.08	33/38
26.	29/04/82	23.6	13.0	1.82	36/37
27.	04/03/83	31.8	11.0	2.89	32/42*
28.	13/03/83	27.6	8.0	3.45	34/31
Total Overall		728.6	496.5	1.47	
Total *		443.4	154.5	2.87	
Total Others		285.2	342.0	0.83	

1. BHL precipitation adjusted to MH observation times.
* Events with wind direction 320°- 030° and speed > 40 km/hr.

events with strong northerly winds recorded at Battle Harbour Loran the precipitation totals will be considerably higher at this station than at Mary's Harbour. Examination of Gander Weather Office surface synoptic charts for these events reveals that in these cases there is generally a low pressure system situated several hundred kilometers to the southeast giving a northeast flow over southeast Labrador. Generally, the winds at Battle Harbour Loran suggest a strong cross isobar flow near the coast.

A number of explanations for this pattern are possible. The first is that the enhancement of precipitation recorded at Battle Harbour Loran, as compared to Mary's Harbour, during these cases is a result of frictional convergence at the coastline. This conclusion is based on work by Roeloffzen et al. (1986) which, when translated to the different land sea configuration in this region, would indicate pronounced vertical motion (precipitation potential) near the coastline in cases with north northeasterly flow. Interestingly, this theory predicts no such activity with a south southeasterly flow, which agrees with the situation documented in case number 10 of Table 1.

A second possible explanation is that local topographic enhancement (Bergeron, 1968) contributes to the pattern. The local topography at Battle Harbour Loran (land rises to the south and west of the station) could contribute to precipitation enhancement during northeasterly events while at Mary's Harbour it may enhance southerly wind events and decrease northerly events (60 m high peak approximately 1 km north of station). A number of other possible explanations for the differences between the stations were considered but were rejected for lack of evidence. Among these was the possibility that a shore lead (area of open water near the coast) might contribute to the increased precipitation at Battle Harbour during northeasterly wind events. However, no indication of a relationship between ice conditions, as recorded on conventional Environment Canada ice charts, and increased precipitation was detected. Another theory considered was the possibility that the "Labrador Frontogenetic Zone" discussed by Kruger and Boucaud (1963) might be responsible for the increased precipitation at Battle Harbour Loran during northerly wind events. Examination of the Gander surface synoptic charts did not provide any evidence for such a situation; however, this does not completely eliminate this process as a possible factor in some situations

DISCUSSION

Analysis of the overlapping climate records at Battle Harbour Loran/Mary's Harbour suggest that during winter storm events the ratio

of precipitation received at the Battle Harbour Loran site compared to the Mary's Harbour site depends on the wind direction and speed. A number of mechanisms may be responsible for the different precipitation conditions recorded at these two sites including frictional convergence at the coastline and local topographic influences. If the latter factor plays an important role then the regional precipitation regime will depend on local topographic conditions. However, if the first factor is primarily responsible for the observed variations, then the strongest variations in precipitation conditions will be confined to the zone immediately adjacent to the coastline. Other research not reported on in this paper (see Newell, 1992) suggests that coastal convergence may be the dominant factor involved. However, further research is needed to identify the nature and causes of the changes in precipitation regime over southeast Labrador.

The differences between Battle Harbour Loran and Mary's Harbour cannot be taken as conclusive evidence of a coastal transition zone since a number of other factors may give rise to similar patterns. One method to resolve these questions is by establishing a network of stations covering the various physiographic environments represented in southeast Labrador. The research team noted in the introduction is attempting to establish such a network. In addition to existing Environment Canada meteorological sites at Goose Bay and Mary's Harbour, the network would incorporate data from climate autostations at the Alexis River stream gauge (operated by the Inland Waters Directorate, Environment Canada) and a new site at the headwaters of the Alexis River (established in the summer of 1991 by the research team noted earlier). A proposed AES autostation on Belle Isle and a new site near the coast (the old Battle Harbour Loran site) would complete the network.

Further research on the nature of the coastal/interior climate transition zone has potential applications in a number of areas. Research on the spatial coherence of meteorological elements (see for example Jacobs, 1989) would be enhanced by a better understanding of the importance of the coastal zone. Likewise mapping of climatological elements would be facilitated by a better understanding of how data collected at coastal stations relate to conditions further inland. Research on climate change would also benefit. This benefit would occur since in more northerly regions the climatological norms, that form the reference point for model results, are based predominately on data from coastal stations. If the data collected at these sites are not representative of conditions at inland sites then the predictions based on the model results may be misleading.

REFERENCE

Bergeron, T., 1968. Studies of the oreigenic effect on the areal fine structure of rainfall distribution. Meteorological Institute Uppsala University, Report No. 6.

Environment Canada, 1982. Canadian Climate Normals 1951-1980, Vol. 3, Precipitation. Environment Canada, Atmospheric Environment Service, Downsview.

Jacobs, J.D., 1989. Spatial representativeness of climatic data from Baffin Island, N.W.T., with implications for Muskoxen and Caribou distribution. Arctic 42 (1), 50-56.

Kruger, H.B. and A.A. Boucaud, 1963. Meteorology of Goose Bay Airport, Labrador. Meteorological Branch, Dept. of Transport, Canada, CIR-3859, TEC-474.

Newell, J.P., 1992. Southeast Labrador Climate Autostation Program, Phase II Report: Research into the Climate of Southeast Labrador. Unpublished contract report prepared for the Canadian Climate Centre, DSS Contract KM170-1-8336.

Roeloffzen, J.C., W.D. Van Den Berg and J. Oerlemans, 1986. Frictional convergence at coastlines. Tellus 38A, 397-411.