RECONSTRUCTION AND TESTING OF HISTORICAL DATES OF FIRST FROST AND FIRST SNOW, JAMES BAY, ONTARIO: 1705-1870

by

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A Thesis Presented to the Faculty
of Graduate Studies
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the Requirements for the Degree
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Department of Geography

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ABSTRACT

This is a study to investigate the climatic validity of historical dates derived from references to first frost and first snowfall events contained in the Hudson's Bay Company post journals recorded on the western shores of James Bay at Moose Factory and Fort Albany between 1705 and 1870.

Content analysis is first applied in an effort to classify the many heterogeneous descriptions of snow and frost phenomena transcribed from the journals of the two former Hudson's Bay Company trading posts. This is shown to be an unsuitable method of examination due to the nature of the information contained in the transcriptions.

Annual dates of first frost and first snow at Moose Factory and Fort Albany are derived from the first references to these phenomena each year. The climatic similarity between Moose Factory and Fort Albany, in terms of their historical dates of first frost and first snow, is examined using the principle of spatial homogeneity testing.

It is shown that the historical dates of first frost are invalid climatological measures while the historical dates of first snow may be valid measures. It is concluded

that historical information of this kind used in climatological studies may not be valid measures and may therefore yield inaccurate or misleading results. It is recommended that rigorous validity tests be applied to such information prior to its use in the analysis or reconstruction of past climatic conditions.

CHAPTER I

INTRODUCTION

A. Objectives of an Historical Climatological Study

In recent years several unusual climatological events have done much to dispel the old belief that climate throughout the world has remained practically unchanged during historical times. The occurrence of the Sahelian drought, the Russian wheat failure of 1972, and the abnormally severe winters of 1977-78 and 1978-79 in midwestern and eastern United States have clearly shown mankind's physical and socio-economic susceptibility to modern day variations of weather and climate and have, as a result, brought about an increased interest in climatic change. The recent acceptance of the idea that "history is more than relationships among people; it involves human beings interacting with their environment" (Claxton and Hecht, 1978) together with the axiom of climatic forecasting, "the past is the key to the future" (Ingram, Underhill and Wigley, 1978) have done much to boost interest in climatic change in the historical period. Extensions of our long-term climatological and meteorological records, according to H.H. Lamb (1974), "are certain to prove of very great value in predicting future climatic changes, whose political, social, and economic importance needs no emphasis".

In the overall task of reconstructing the climatic past, historical climatology is a subdiscipline which focuses on the study of written materials (excluding records of modern standardized instrumental observations) which bear on past climates (Ingram, Underhill and Wigley, 1978). A number of studies have utilized this kind of written evidence in attempts to reconstruct a clearer and more accurate picture of past climate in various parts of the world.

The freezing dates of Lake Suwa in central Japan have been recorded annually since the early 1400's. These dates are phenological indicators and have provided researchers with a 500-year chronology of winter temperature in central Japan (Fujiwhara, 1921; Arakawa, 1954). Similar historical documents containing the dates of first or earliest snow covering for Tokyo since 1632 (Arakawa, 1956, 1957) and others containing twelve centuries of blooming dates of cherry blossoms at Kyoto (Arakawa, 1957) have proven to be valuable phenological data in the reconstruction of Japan's past climate.

In China between 1100 B.C. and 1400 A.D. such phenological indicators as the dates of snowfall, appearance of frost, freezing of rivers, blossoming of trees and flowers, and the migration of birds were documented and are now useful in historical climatic research (Chiao-Min Hsieh, 1976). Even more valuable are the more than 5,000 local gazetteers (accounts of individual cities, towns and counties) from the period 1400 to 1900 A.D. These records of local history and geography contain climatic information such as the freezing of lakes and snow and frost data in addition to many phenology records (Chu K'o-Chen, 1973; Chiao-Min Hsieh, 1976).

A great deal of research into weather variations prior to the beginning of the era of instrumental meteorology has been conducted in Great Britain and Northern Europe. A pioneer in the field of historical climatology, H.H. Lamb, has utilized such historical documents as personal diaries and correspondence, records of public administration and government, private estate records, church annals and chronicles, maritime and commercial records, and also proto-scientific and scientific writings. From these and other sources Lamb has attempted to reconstruct Britain's climatic fluctuations to as far back as 1600 A.D. (Lamb, 1967), and has compiled weather charts of Europe, much of the Atlantic and the eastern seaboard of the United States for the past two centuries (Lamb, 1974). Although these have been massive and admirable undertakings, too little consideration is given to the great variations of accuracy and dependability of the many data sources. The sheer size of Lamb's study areas may also serve to detract from the reliability of his results. Other noteworthy historical climatological studies that have dealt with smaller, more specified locations include studies of monthly mean temperatures in central England from 1698 to 1952 (Manley, 1953), average winter temperatures in the Netherlands from 1634 to 1977 (Van Den Dool, Krijnen and Schuurmans, 1978), and frequencies of days with rain, snow, hail, frost and thunder in Anglesey between 1734 and 1760 (Oliver, 1958).

Unfortunately a great number of historical climatological studies have fallen short of being dependable and accurate. Incompleteness and inaccuracy in the transmission of the original data, errors introduced by the authors or compilers, and failure to adequately distinguish between reliable and unreliable sources are generally the major reasons for their deficiencies (Ingram, Underhill and Wigley, 1978).

The original objective of the present study was to extend the climatic record of the James Bay area in Canada by as much as 150 years. As the research progressed it was realized that to acceptably extend the present record through the study of selected climatic factors a method of analysis to determine the validity of the historical dates would be required. The development of such a method and the subsequent determination of data validity became the prime objectives of this study.

Within Canada, environmental studies based on historical documents have not been entirely absent. In the Northwest Territories MacKay (1961) has used historical freeze-up and break-up data from a number of points along the lower MacKenzie River in attempts to determine long-term trends in open season and the relationship between early and late freeze-ups and break-ups. MacKay concedes that some of the data between 1876 and 1955 (based on published sources, government officers, missionaries, the R.C.M.P. and traders) are of questionable reliability.

In the early 1960's, the Hudson's Bay Company post journals were first used for climatological reconstruction in a study of historical dates of freeze-up and break-up on the Churchill and Hayes Rivers (MacKay and Mackay, 1965). A later study utilized the post journals in an attempt to develop insights into the Canadian climate of the nineteenth century based on air mass climatology (Minns, 1970). Again the historical records were accepted at face value with little consideration given to their validity or reliability. Moodie and Catchpole, in a recent study of historical dates of freeze-up and break-up, first used content analysis to demonstrate that information extracted from the Hudson's Bay Company post journals may compare in accuracy with modern information (Moodie and Catchpole, 1975).

The objective of the present study is to derive annual dates of first snowfall and first frost in fall from two Hudson's Bay Company post journals and to study the quality of these dates as valid climatological measures.

B. Study Area

The area selected for this study, situated between 52.5° and 51.0° north latitude and 82.0° and 81.5° west longitude, comprises most of the southern half of the west shore of James Bay. The two particular sites (Moose Factory

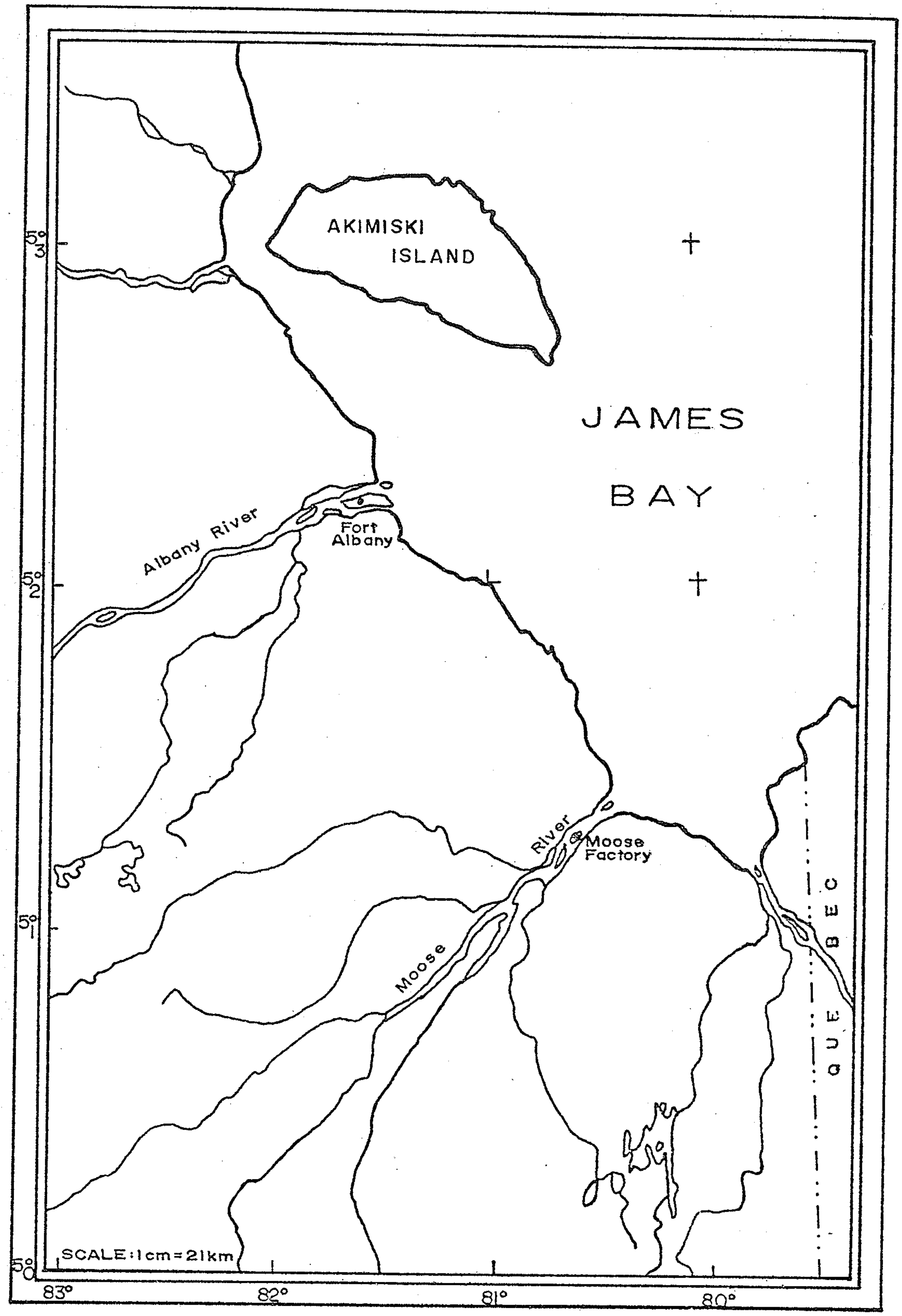


Figure 1.1: Location of the study area

and Fort Albany), at which the historical information was recorded, are situated at 51.20° north latitude and 80.44° west longitude and 52.20° north latitude and 81.20° west longitude respectively. The area is shown in Figure 1.1.

C. Plan of Thesis

Chapter II is a discussion of the data sources pertinent to this thesis. A brief discussion of the Hudson's Bay Company policies concerning record keeping at their settlements in northern Canada is presented along with a general description of the resulting journals and their contents. This is followed by a more detailed examination of the particular journals containing the historical information upon which this study is based. The spatial and temporal distributions of the historical data are outlined.

The transcription of the historical data from the journals and preliminary testing of the quality of the transcriptions are considered in Chapter III.

Chapter IV begins by briefly outlining the successful application of content analysis to derive historical dates in a similar study conducted previously. The attempts to derive viable categories of descriptions of first snowfall and first frost are described followed by a discussion on the circumstances preventing their successful development. This leads to the identification of the dates of the first annual snow and first annual frost as the data to be analysed.

Chapter V describes the attempts to assess the climatological validity of the historical dates of first frost and first snowfall. The data are presented in tables while preliminary comparative analyses of the dates at the two former Hudson's Bay Company posts appear in the form of graphs. Included in this chapter are various statistical and graphical analyses based on the principle of spatial homogeneity testing.

In Chapter VI the purposes of the comparative analyses using modern instrumental data are outlined and are followed by a discussion of the selection of the modern meteorological stations where this information was recorded. The outcome of various statistical and graphical tests applied to the modern data are compared to the results of similar examinations performed on historical dates. The results of these comparative tests are discussed along with the problems they presented.

CHAPTER II

DATA SOURCES

A. Journals of the Hudson's Bay Company

The data pertinent to this study were compiled from manuscript accounts of daily occurrences at selected Hudson's Bay Company settlements in northern Canada during the 18th and 19th centuries. The Hudson's Bay Company was founded in 1670 and has records spanning more than three hundred years of Canadian history. Company policy required regular journals to be kept at all of its overseas settlements and the result has been that these records now exist as sources of historical information unrivalled on this continent in terms of the length and continuity of their coverage. The contents of these journals, made up of observations and evaluations of both natural events and commercial activities, were of great importance to the Company. Occasionally the journal-keeping was considered inadequate and in 1814 the following directive was issued on the manner in which they should be kept:

> These Journals are to contain nothing but a plain and simple memorandum of fact. . . . Among the circumstances, which are always to be noticed in the Journals, is the weather

> & progress of the Season: - the date of the freezing in of the lakes & rivers; the chief falls of snow & their depth; the greatest thickness of the Ice; the commencement of Thaw: the breaking up and clearing away of the Ice . . . the commencement of frost in the Autumn. . . . The observations are not to be considered as a matter of idle curiosity; but may be of very essential use.
>
> (Letter . . . ,Hudson's Bay Company Archives reference A. 6/18, pp. 211-13, 1814)

Since these Hudson's Bay Company settlements were situated in an extremely harsh environment and were tremendously isolated, the success, indeed the very survival of their personnel, demanded that they be conscious of, and adapted for, a variety of weather and climatic conditions. Because of this and the Company's instructions, the post journals contain a plethora of historical references to climatological and meteorological situations although they do differ greatly in style and vary in length as well as content.

B. Journals Used in This Study

The earliest Hudson's Bay Company fur trading posts were established on the shores of Hudson Bay and James Bay and the Company's trading activities were largely restricted to these Bayside settlements during most of the first century of its overseas trade. These Bayside trading posts therefore provide longer periods of record than do those settlements that were established inland at later dates.

The snow and frost data that originally were intended for use in this study were compiled from the post journals of seven Hudson's Bay Company forts. Four of the seven were Bayside forts and comprised the longest and most complete journal records available. The remaining three were inland settlements which had been established later, thus providing significantly shorter records. The seven Hudson's Bay Company forts at which these records were kept are listed in Table 2.1 along with their respective durations. However, it must be noted that these durations do not indicate continuous records as there were many intervals when no mention of weather phenomena were made, and some intervals when the journal record was interrupted.

Although the original intention was to use the data from all seven of the aforementioned trading posts, Moose Factory and Fort Albany were eventually selected as the sites upon which this study concentrated. This decision was derived directly from the methodology employed and was based on two primary considerations. Firstly, the Moose Factory and Fort Albany journals contain the most continuous record of frost and snow references as well as some of the longest records. Secondly, and perhaps most important, is the fact that as Moose Factory and Fort Albany were both situated on the western shore of James Bay and only 130 kilometres apart they offered the greatest opportunity for the application of homogeneity tests.

TABLE 2.1: DATES AND DURATIONS OF THE HUDSON'S BAY COMPANY POST JOURNALS ORIGINALLY SELECTED

HUDSON'S BAY COMPANY POST	DATES	NUMBER OF YEARS OF RECORD
Bayside Locations		
Fort Churchill	1718-1866	148
York Factory	1714-1851	137
Fort Albany	1705-1867	163
Moose Factory	1732-1870	139
Inland Locations		
Cumberland House	1775-1845	70
Norway House	1796-1871	83
Edmonton	1795-1870	75

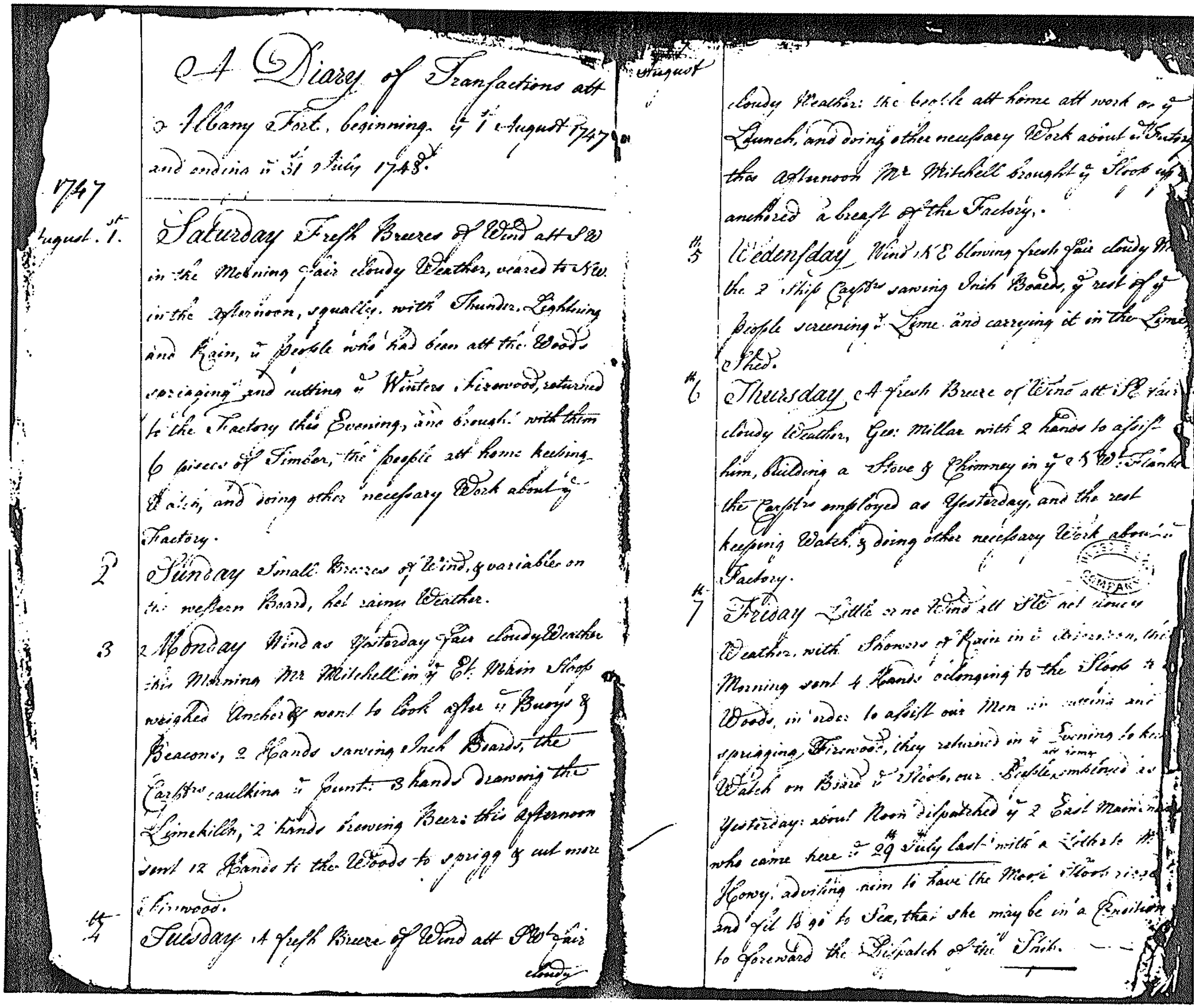
CHAPTER III

TRANSCRIPTION OF INFORMATION

A. Transcription of Data from Hudson's Bay Company Post Journals

This study is based upon snowfall and frost data transcribed from manuscript accounts of daily occurrences at the aforementioned Hudson's Bay Company settlements in northern Canada during the 18th and 19th centuries. The transcription was undertaken by a research assistant (Dr. Barry Kaye) for a study that was originally to be conducted by Dr. D.W. Moodie and Dr. A.J.W. Catchpole at the University of Manitoba. When this transcription was carried out the manuscripts were housed in the Hudson's Bay Company's archives at Beaver House in London, England. They have since been moved to the Manitoba Provincial Archives in Winnipeg, Canada. A specimen from a Fort Albany post journal is shown in Figure 3.1.

Each daily entry in the journals during autumn, between the earliest entry and October 31, 1871, or the dates of termination of the journals, was consulted. Autumn was considered to extend from August 1 to October 31 and all statements in the journals relating directly or indirectly



A Diary of Transactions att ye Albany Fort, beginning ye 1st August 1747 and ending ye 31st July 1748.

1747 August 1st. Saturday Fresh Breezes of Wind att SW in the Morning fair cloudy Weather, veared to NW. in the afternoon, squally, with Thunder, Lightning and Rain, ye People who had been att the Woods sprigging and cutting ye Winters Firewood, returned to the Factory this Evening, and brought with them 6 pieces of Timber, the people att home keeping Watch, and doing other necessary Work about ye Factory.

2 Sunday Small Breezes of Wind, & variable on ye western Board, hot same Weather.

3 Monday Wind as Yesterday fair cloudy Weather this Morning Mr Mitchell in ye Et. Main Sloop weighed Anchor & went to look after ye Buoys & Beacons, 2 Hands sawing Inch Boards, ~~the~~ Carptrs caulking ye punt: 3 hands drawing the Limekiln, 2 hands brewing Beer: this afternoon sent 12 Hands to the Woods to sprigg & cut more Firewood.

4th Tuesday A fresh Breeze of Wind att SWt fair cloudy Weather: the people att home att work on ye Launch, and doing other necessary Work about ye Factory this afternoon Mr Mitchell brought ye Sloop up & anchored a breast of the Factory.

5th Wedensday Wind NE blowing fresh fair cloudy W. the 2 Ship Carptrs sawing Inch Boards, ye rest of ye people screening ye Lime and carrying it in the Lime Shed.

6th Thursday A fresh Breeze of Wind att SE fair cloudy Weather, Geo: Millar with 2 hands to assist him, building a Stove & Chimney in ye SW. Flanker the Carptrs employed as Yesterday, and the rest keeping Watch, & doing other necessary Work about ye Factory.

7th Friday Little or no Wind all SE [illegible] Weather, with Showers of Rain in ye [illegible], this Morning sent 4 Hands belonging to the Sloop to ye Woods, in order to assist our Men in cutting and sprigging Firewood, they returned in ye Evening to keep Watch on Board ye Sloop, our People employed as Yesterday: about Noon dispatched ye 2 East Main [illegible] who came here ye 29th July last with a Letter to Mr Howy, advising him to have the More Sloop ready and fit to go to Sea, that she may be in a Condition to forward the Dispatch of the Ship.

Figure 3.1: Specimen of a Fort Albany post journal, August 1 to August 7, 1747

to the first occurrences of snowfall and frost events during this time period were transcribed verbatim. Thus, a record of relevant comment arranged in chronological order for both Moose Factory and Fort Albany was made available for this study. Any gaps in the records are attributed either to real breaks in the journals or to the failure of authors to refer to snow or frost conditions during the autumn season. References to snow and frost from the two post journals amounted to 66 pages of transcriptions.

B. Testing the Quality of the Transcriptions

As this study was to be based on previously transcribed information it was decided to examine a sample portion of the historical journals in order to check the accuracy of the compiled data.

Nine journals recorded at Moose Factory during the 10-year period between October 27, 1731 and August 29, 1741 were examined. These journals, numbered B 135/a/2 through to B 135/a/10, were very carefully read and all references to snow and frost conditions between August 1 and October 31 were copied verbatim.

The resulting transcription was then compared to the snow and frost information in the corresponding original transcriptions. The results of this comparison were initially disconcerting as the sample testing produced 174 references to snow and/or frost whereas the original transcriptions listed only 50 such references.

At this early stage in the study the significance of such a discrepancy was decidedly unclear but it later became apparent that Dr. Kaye, during the original examination of the post journals, had ceased transcribing shortly after identifying the first references to snow and frost. No attempt had been made to note all such observations between August 1 and October 31 for each year of record, consequently his volume of references (to snow and frost) was significantly less than that resulting from this first investigation into the quality of the transcriptions. The results of a later test (described in Chapter V B.2.) revealed absolutely no discrepancies between the dates of first frost and first snow contained in the original transcriptions and those found in the journals.

CHAPTER IV

CATEGORIZATION OF TRANSCRIBED INFORMATION

This study was conducted following the completion of a study of dates of first freezing and breaking of water bodies by Moodie and Catchpole (1975). In view of the close affinities between the two studies, it was presumed that the general method developed for the derivation of the dates of first freezing and first breaking from the Hudson's Bay Company post journals could be applied to the same sources for the derivation of dates of first snowfall and first frost.

This chapter will begin by briefly outlining the methods utilized in the derivation of first freezing and first breaking. It will indicate that methods of content analysis were used in which the transcribed references to river freezing and breaking were categorized so that homogeneous sequences of dates were obtained. The chapter will then indicate that an attempt was made to interpret the transcribed information pertaining to first snowfall and first frost in a similar manner by devising homogeneous categories of references to these phenomena. It will be shown that the snowfall and frost information could not be classified into viable categories and the reasons for this will be outlined.

This chapter will then conclude with the observation that the only useful information that can be derived from the frost and snow transcriptions are the first references to frost and snow in each year.

A. Method Used to Derive Dates of First Freezing and First Breaking

The transcriptions of references to river breaking and freezing comprised a heterogeneous set of descriptions. Several different components of heterogeneity were apparent in these descriptions. In part, the heterogeneity related to the different stages in the freezing and breaking processes. Some descriptions referred to early stages in the freezing and breaking process, others referred to intermediate or later stages. The descriptions were also heterogeneous in a spatial sense since they referred to different locations in the river estuaries. Finally, the descriptions were heterogeneous in terms of the manner with which they referred to the freezing and breaking of rivers. Some references described the physical appearances of the water body, others referred to the behavior of the water body and a minority alluded to the navigability of the river and the trafficability of the ice surface.

In this study, methods of content analysis were applied in the categorization of the descriptions of freezing and breaking so that homogeneous sequences of dates could be derived from the heterogeneous sources. The major components of this classification were:

i) stages in the freezing and breaking processes to which each description referred;

ii) spatial location to which each description referred.

The results showed that lengthy and continuous records could be obtained for certain stages in the breaking and freezing processes and for certain locations. The stages utilized were first partial freezing, first complete freezing, and first breaking and the locations utilized referred to the places where the forts were situated.

B. Attempts to Apply the Method of Content Analysis to Derive Dates of First Snowfall and First Frost

At the outset of the first freezing and first breaking study the nature of the information contained in the transcriptions was unknown. The development of a method for the interpretation of these transcriptions therefore commenced with the systematic analysis of the types of information contained in those transcriptions.

Similarly, at the outset of the study of the transcriptions of snowfall and frost descriptions the information contained in these transcriptions was unknown. Therefore, the study commenced with the systematic examination of the types of information contained in these transcriptions. Attempts were made to identify viable categories of types of references to first snowfall and first frost. In this context a viable category is one which meets these criteria:

i) meteorological specificity - the category is identified with sufficient meteorological precision that it is clearly distinguished from other categories;

ii) continuous occurrence - the category occurs sufficiently often that continuous records of long duration can be based upon its dates of occurrence.

This section will now describe the methods that were adopted in attempting to identify categories of first frost and first snowfall descriptions. It will be shown that these endeavors were unsuccessful in that viable categories were not derived. The following section will consider the circumstances which prevented the derivation of viable categories in this study and will conclude that the only viable dates are those based upon the references to first snowfall occurrence and the references to the first occurrence of frost.

The first step with regards to the method of approach was to become familiar with the extent of the compiled data. All the transcribed references to snow and frost were plotted in graphical form so as to indicate the frequency of such observations each year as well as their seasonal distribution. The result was a frost graph and a snow graph for both Moose Factory and Fort Albany. Figure 4.1 is an example of this preliminary graphing.

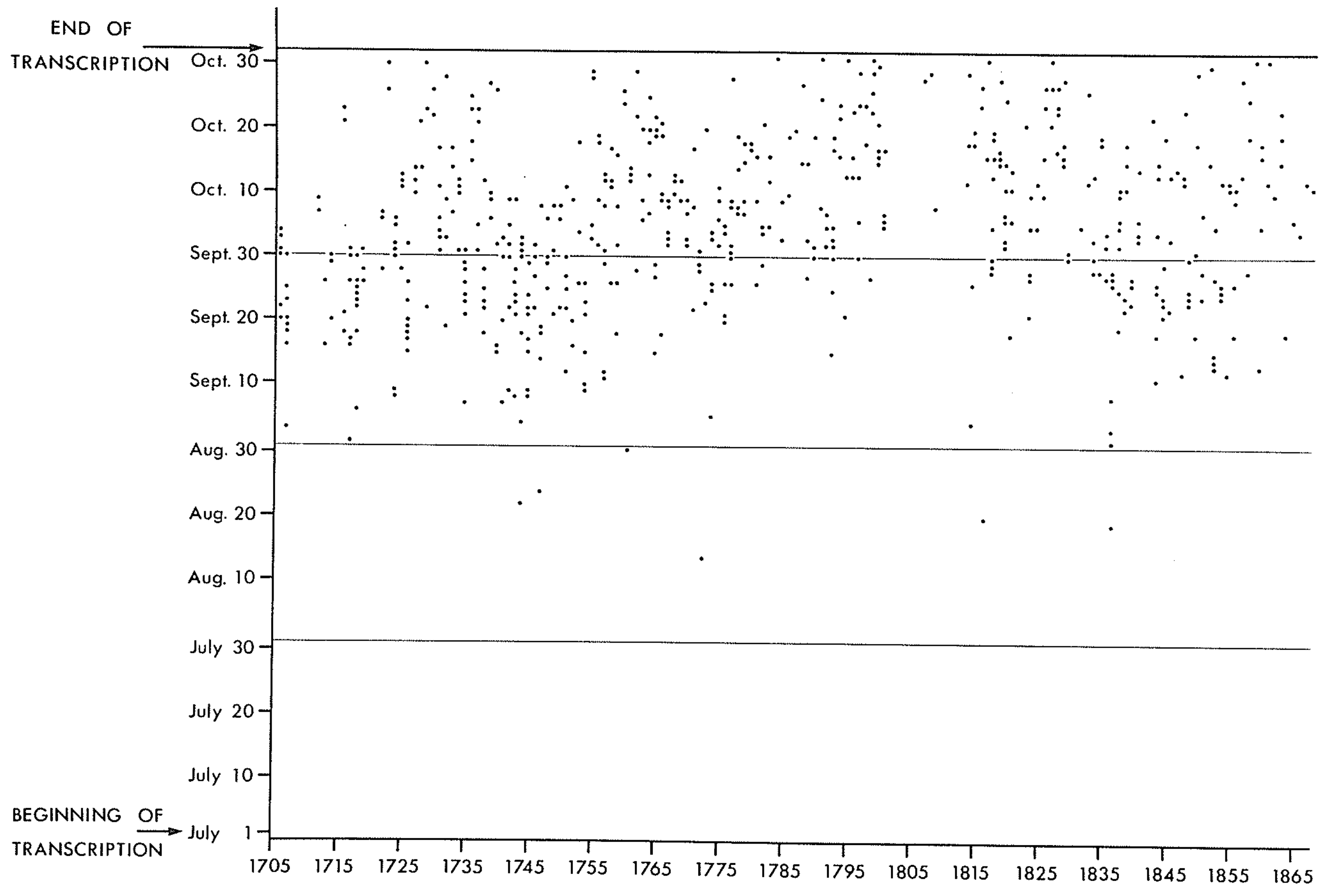


Figure 4.1: Frequency of descriptions of autumn snow events from the transcriptions of the Fort Albany journals not corrected for the Gregorian Calendar reform of 1752.

Originally, the references to snow and snowfall events were grouped into 28 intuitively constructed categories (Table 4.1). The large number of categories presented problems in that they failed to meet the criteria of meteorological specificity and high frequency of occurrence. This intuitive approach to categorization was therefore discarded.

The second attempt at categorization adopted the principle that the categories should be based on a survey of the types of references to snowfall and frost that actually occurred in the transcriptions. Therefore, the transcriptions were read chronologically and lists were made of all the different types of snow and frost references contained therein (Tables 4.2 and 4.3).

Subsequent attempts to construct viable categories for the snow and frost information were based directly on the literal interpretations of the references contained in these lists.[1] Eventually, the classifications were refined to six categories of snow descriptions (snow lying, heavy snowfall, light snowfall, snow with rain, snow with hail, vague references to snow) and four categories of frost description (comments diagnostic of radiation frost, advection frost, recorded sub-freezing temperatures, vague references to frost).

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[1] The literal interpretations of the snow and frost references were determined, as far as possible, with the aid of the Complete Oxford Dictionary, the Universal Dictionary of the Marine, and a number of other relevant publications.

TABLE 4.1: FREQUENCIES OF OCCURRENCE OF THE 28 CATEGORIES OF SNOW REFERENCES AT MOOSE FACTORY AND FORT ALBANY

CATEGORY	FREQUENCY OF OCCURRENCE AT MOOSE FACTORY	FREQUENCY OF OCCURRENCE AT FORT ALBANY
1. Vague reference to snowfall	40	98
2. Light or little snowfall	36	48
3. Heavy or thick snowfall	26	55
4. Nocturnal snow	20	14
5. Morning snow	13	26
6. Day snow	14	9
7. Snow all or most of day	33	40
8. Intermittent snow	39	73
9. Constant or continued snow	3	12
10. Snow with cold weather or frost	26	50
11. Snow with mild weather	1	1
12. Calm with snow	0	0
13. Wind with snow	18	14

TABLE 4.1 Continued

CATEGORY	FREQUENCY OF OCCURRENCE AT MOOSE FACTORY	FREQUENCY OF OCCURRENCE AT FORT ALBANY
14. Wind with snow and frost	5	4
15. Squalls with snow	5	10
16. Gales with snow	8	6
17. Gales with snow and rain (sleet)	12	1
18. Gales with snow, rain and hail	2	0
19. Gales with snow and frost	1	1
20. Snow turns to rain	0	1
21. Rain turns to snow	40	1
22. Rain and snow (sleet)	53	65
23. Rain, hail and snow	5	6
24. Snow and hail	7	7
25. Much snow on ground	3	3
26. Little snow on ground	1	3
27. Vague reference to snow on ground	12	9
28. Snow measured (in feet or inches)	6	8

TABLE 4.2: LIST OF ALL TYPES OF SNOW REFERENCES CONTAINED IN THE TRANSCRIPTIONS FROM THE MOOSE FACTORY AND FORT ALBANY JOURNALS

---

fell a little snow

showers of rain /and snow

squalls of rain and snow

snowed and froze

small matter of snow

snow weather (thick)

snowed - morning, today, last night, etc.

snow (some - very much)

flurries of snow and rain

snow and rain (some)

hail and snow

squalls of snow

gale with snow

frost and snow (freezing)

snow continued

squalls of hail and snow

small flight of snow

small winters snow

snow and cold (weather)

hail, rain, and snow (gales of)

blowing, snowing, and freezing

TABLE 4.2 Continued

snowed hard
snows and blows very hard
misling snow
great flight of snow
drizzling snow (and rain)
snowing drifting weather
snow /(and rain) at times
sleet and snow
much snow fell
rain, sleet and snow
gales with frost and showers of snow
snow /(and rain) all day (most of day)
great deal of snow
small snow
blows hard with snow
(some) light snow
a little (lot) snow on the ground
____ inches (foot /feet) of snow fell (is on the ground)
gale with snow, hail and rain (sleet)
abundance of snow
sometimes snow

TABLE 4.3: LIST OF ALL TYPES OF FROST REFERENCES CONTAINED IN THE TRANSCRIPTIONS FROM THE MOOSE FACTORY AND FORT ALBANY JOURNALS

---

freezes morning and evening

froze a little last night

a white frost . . . but soon was gone

a white frosty morning

clear frosty weather

froze hard in the morning

clear weather with frost

last night we had a (hard) black frost

froze in the shade

a (hard) frost last night

last night we had a (hard) frost

snowed and froze (a little)

cold freezing weather all this day

froze with all wind in the (N.W.) quarter

rain and snow and froze (morning and evening)

a fine gale with frost

cloudy with frost

frost and snow

cold freezing weather and a continued snow

blowing, snowing and freezing (all day)

a little frost

TABLE 4.3 Continued

frosty weather
froze (hard)
(cold) freezing weather
freezes hard
a small frost
frost
frosty
hard white frost
cold freezing weather
a hard frost
sharp freezing weather
____ degrees of frost (freezing weather)
slight frost
(sharp, smart) frost

The snow and frost descriptions from the entire period of record at Moose Factory and Fort Albany were fitted into these final categories (Tables 4.4 and 4.5). From this preliminary grouping it seemed apparent that each of the snow and frost categories occurred sufficiently often that continuous records of long durations could possibly be based on their dates of occurrence. However, when the occurrence of these phenomena were examined in terms of their frequencies per decade it became evident that these categories of snow and frost references did not meet the criterion of continuous occurrence (Tables 4.6 and 4.7).

The criterion of meteorological specificity was also not met by these final categories of snowfall and frost descriptions. Four of the six snowfall categories essentially provided no more than a record of the dates of snowfall events each year because they possessed insufficient meteorological precision to clearly distinguish them from each other. The two remaining categories represented those historical descriptions which only referred to the presence of snow on the ground or vague mentions of snow and which often did not even provide dates of the actual snowfall events.

The frost categories displayed a lack of sufficient meteorological precision to clearly distinguish them from each other. The possible exceptions to this were the categories of radiation frost and advective frost but they also proved unsatisfactory as inference was the basis for distinguishing between the two. For example, if frost had been

TABLE 4.4: FREQUENCIES OF OCCURRENCE OF THE FINAL 6 CATEGORIES OF SNOW REFERENCES AT MOOSE FACTORY AND FORT ALBANY 1730-1869

FINAL 6 CATEGORIES	FREQUENCY OF OCCURRENCE AT MOOSE FACTORY	FREQUENCY OF OCCURRENCE AT FORT ALBANY
1. Snow lying	16	17
2. Heavy snowfall	75	128
3. Light snowfall	70	130
4. Snow with rain	88	92
5. Snow with hail	22	11
6. Vague references to snow	114	181

TABLE 4.5: FREQUENCIES OF OCCURRENCE OF THE FINAL 4 CATEGORIES OF FROST REFERENCES AT MOOSE FACTORY AND FORT ALBANY 1730-1869

FINAL 4 CATEGORIES	FREQUENCY OF OCCURRENCE AT MOOSE FACTORY	FREQUENCY OF OCCURRENCE AT FORT ALBANY
1. Radiation frost	162	175
2. Advective frost	76	97
3. Recorded sub-freezing temperatures	80	31
4. Vague references to frost	40	58

TABLE 4.6: FREQUENCIES OF OCCURRENCE PER DECADE OF THE FINAL 6 CATEGORIES OF SNOW REFERENCES AT MOOSE FACTORY AND FORT ALBANY 1730-1869

CATEGORY	1730 - 39	1740 - 49	1750 - 59	1760 - 69	1770 - 79	1780 - 89	1790 - 99	1800 - 09	1810 - 19	1820 - 29	1830 - 39	1840 - 49	1850 - 59	1860 - 69
1. Snow lying														
Moose	0	1	0	2	0	0	2	0	2	1	4	2	1	1
Albany	1	0	0	0	0	0	0	0	1	1	3	2	7	1
2. Heavy snowfall														
Moose	1	8	5	6	9	6	3	2	6	3	10	5	6	5
Albany	11	8	10	8	11	6	12	4	10	7	11	8	5	3
3. Light snowfall														
Moose	4	1	1	3	8	6	8	2	12	3	3	4	7	8
Albany	12	12	12	3	7	8	10	0	8	8	9	13	14	3
4. Snow with rain														
Moose	7	4	9	6	12	11	15	1	2	4	9	6	1	1
Albany	8	12	10	8	3	5	3	2	1	10	3	6	3	1
5. Snow with hail														
Moose	3	1	4	3	2	2	4	1	1	0	1	0	0	0
Albany	0	1	1	2	2	1	0	0	0	0	0	0	1	0
6. Vague snow references														
Moose	7	16	4	9	6	13	12	3	14	3	10	6	8	3
Albany	16	18	11	20	17	9	16	2	9	5	11	6	6	5

TABLE 4.7: FREQUENCIES OF OCCURRENCE PER DECADE OF THE FINAL 4 CATEGORIES OF FROST REFERENCES AT MOOSE FACTORY AND FORT ALBANY 1730-1869

CATEGORY	1730 - 39	1740 - 49	1750 - 59	1760 - 69	1770 - 79	1780 - 89	1790 - 99	1800 - 09	1810 - 19	1820 - 29	1830 - 39	1840 - 49	1850 - 59	1860 - 69
1. Radiation frost														
Moose	9	10	25	5	12	11	26	4	8	7	12	9	13	11
Albany	23	13	17	9	15	16	11	0	5	9	14	5	24	15
2. Advective frost														
Moose	8	2	6	6	6	9	11	1	6	2	9	5	4	1
Albany	10	20	11	8	7	3	2	1	5	4	11	7	5	3
3. Recorded sub-freezing temperatures														
Moose	0	0	0	0	0	0	4	1	8	0	27	21	19	0
Albany	0	0	0	0	0	3	2	0	5	8	3	10	0	0
4. Vague references to frost														
Moose	10	6	0	5	6	2	0	0	4	4	3	0	0	0
Albany	7	14	10	6	8	3	2	3	0	0	1	0	2	2

described as occurring under clear skies it was classified as radiation frost whereas if frost had been noted as occurring under cloudy skies it was classed as advective frost.

In view of the above discussion it must be concluded that the endeavors to classify the descriptions of first snowfall and frost were unsuccessful in that viable categories were not derived.

C. Circumstances Preventing the Derivation of Viable Categories of Descriptions of First Snowfall and First Frost

The classifications of types of reference to first frost and snow were much simpler than the classifications of references to first freezing and breaking of water bodies developed by Moodie and Catchpole (1975). There are two major factors contributing to this contrast. Firstly, the processes of freezing and breaking of water bodies are protracted, intermittent processes in which several days or weeks elapse between the first appearance of ice or manifestation of breaking, and complete freezing or clearing of ice. At the outset of the freezing and breaking study the objective was to identify the dates of the major stages in these processes and all references bearing upon the various stages were therefore deliberately transcribed from the post journals. The processes of development of the winter snowpack, and of freezing conditions in the air and in the ground are also prolonged, intermittent processes extending over periods of days or weeks. The first occurrence of frost and the first snowfalls in the autumn are most often only the prelude to the full onslaught of the continuous freezing conditions of winter and the development of the winter snowpack. As the season progresses, the increasingly longer nights and the shorter days, with their reduced intensity of sunlight, decrease the potential for snowmelt while increasing the potential for prolonged freezing conditions. The continuation of these circumstances eventually results in the seasonally permanent snowpack and the freezing conditions of winter. However, the initial objective of the snow and frost studies was to identify merely the initiation of these processes and only the information bearing upon their initiation was transcribed. Therefore, the transcriptions of the first snow and first frost descriptions embodied a narrower range of information than the transcriptions of the first freezing and first breaking descriptions.

Secondly, there are substantial spatial variations in the times of freezing and breaking within the estuaries of rivers draining into Hudson Bay. Topographical and hydrological conditions determine these variations which tend to follow similar patterns from year to year. It is for this reason that the places to which the freezing and breaking descriptions referred are important components of the classification of these phenomena. This spatial component has not entered into the classification of first snowfall and frost descriptions, because significant, regular, local-scale variations in these elements were not apparent in the transcriptions from the post journals.

The relative simplicity of the classifications of snow and frost references, together with their failure to meet the criteria of meteorological specificity and continuous occurrence, make it apparent that the transcriptions used in this study do not contain a sophisticated range of information that can form the basis of viable categories of first reference to snowfall and first reference to frost.

One of the two following explanations may account for this shortcoming:

i) More sophisticated snow and frost information may be available in the post journals, however, this is not contained in the transcriptions due to the simple framework in which these transcriptions were made.

ii) The post journals are deficient of more sophisticated information because snowfall and frost were described by the journalists in more simple terms than were break-up and freeze-up.

Which of these two explanations is correct will remain uncertain until such time as the journals are re-examined.

In view of the fact that viable snowfall and frost categories could not be derived it must be concluded that the dates of first snowfall and first frost are the only useful information available from the transcriptions. These dates are listed in Table 4.8.

TABLE 4.8: DATES OF FIRST SNOWFALL AND FIRST FROST AT MOOSE FACTORY AND FORT ALBANY 1705-1870*

	DATES OF FIRST SNOWFALL		DATES OF FIRST FROST	
Year	Moose Factory	Fort Albany	Moose Factory	Fort Albany
1705		63†		72
06		46		18
07		-		-
08		-		-
09		-		-
1710		-		-
11		80		72
12		59		59
13		63		35
14		94		-
15		61		68
16		44		49
17		49		61
18		69		61
19		-		-
1720		-		-
21		71		65
22		99		43
23		51		56
24		71		71
25		58		64
26		83		75
27		87		77
28		65		74
29		95**		49

TABLE 4.8 Continued

Year	DATES OF FIRST SNOWFALL		DATES OF FIRST FROST	
	Moose Factory	Fort Albany	Moose Factory	Fort Albany
1730	-	74	-	68
31	-	62	-	63
32	80	80	61	37
33	74	74	75	75
34	45	50	40	65
35	-	88	-	86
36	49	74	50	62
37	-	61	-	42
38	-	79	-	61
39	58	58	59	59
1740	50	50	43	51
41	66	52	66	44
42	60	50	79	67
43	46	34	62	23
44	58	51	87	59
45	65	65	47	65
46	59	36	76	59
47	79	68	-	57
48	65	64	66	58
49	77	65	88	63
1750	65	55	66	55
51	60	59	49	49
52	59	57	58	58
53	40	40	77	41
54	35	64	63	63
55	70	63	36	36
56	44	42	44	40
57	73	57	67	37
58	56	49	50	64
59	85	85	21	48

TABLE 4.8 Continued

Year	DATES OF FIRST SNOWFALL		DATES OF FIRST FROST	
	Moose Factory	Fort Albany	Moose Factory	Fort Albany
1760	80	31	78	77
61	96	59	91	66
62	47	62	62	62
63	51	68	75	-
64	58	46	100	83
65	49	49	71	65
66	64	63	62	62
67	61	71	71	19
68	68	70	79	8
69	61	63	63	64
1770	61	53	70	50
71	44	59	60	42
72	82	14	83	11
73	58	36	59	42
74	70	63	79	79
75	51	51	73	61
76	69	57	45	89
77	57	68	33	70
78	68	68	67	71
79	100	78	44	61
1780	56	57	92	-
81	66	60	-	64
82	43	66	63	77
83	52	92	93	86
84	81	64	70	75
85	70	71	62	77
86	86	81	79	52
87	64	76	65	64
88	57	58	48	60
89	62	61	82	46

TABLE 4.8 Continued

Year	DATES OF FIRST SNOWFALL		DATES OF FIRST FROST	
	Moose Factory	Fort Albany	Moose Factory	Fort Albany
1790	69	69	53	66
91	64	63	64	67
92	47	46	30	57
93	76	77	14	78
94	52	52	60	-
95	73	74	52	62
96	61	61	50	68
97	75	79	14	69
98	58	58	31	59
99	66	76	35	79
1800	50	66	48	-
01	-	-	-	78
02	-	76	-	-
03	-	78	-	-
04	-	-	-	-
05	-	-	-	85
06	87	89	-	-
07	84	90	53	-
08	57	69	67	69
09	-	-	-	-
1810	53	-	-	-
11	-	-	-	-
12	74	-	-	-
13	73	73	80	-
14	66	35	79	-
15	66	85	50	8
16	75	20	25	27
17	44	59	22	60
18	77	76	48	77
19	63	64	73	68

TABLE 4.8 Continued

Year	DATES OF FIRST SNOWFALL		DATES OF FIRST FROST	
	Moose Factory	Fort Albany	Moose Factory	Fort Albany
1820	98	49	-	49
21	-	-	-	-
22	-	82	-	81
23	-	52	-	52
24	72	66	67	69
25	71	71	42	77
26	99	82	91	83
27	85	78	78	-
28	74	75	59	-
29	82	61	-	47
1830	110	112	64	-
31	60	66	47	86
32	-	68	37	75
33	-	59	-	59
34	42	59	42	59
35	59	58	45	54
36	19	19	79	8
37	64	50	64	51
38	53	53	33	56
39	54	54	29	29
1840	52	64	42	48
41	74	100	48	58
42	50	83	48	50
43	74	42	37	15
44	-	52	-	51
45	-	53	-	73
46	89	44	-	78
47	98	73	7	74
48	-	54	-	57
49	54	49	-	-

TABLE 4.8 Continued

Year	DATES OF FIRST SNOWFALL		DATES OF FIRST FROST	
	Moose Factory	Fort Albany	Moose Factory	Fort Albany
1850	45	55	-	-
51	86	76	46	46
52	55	44	57	41
53	75	55	68	55
54	83	43	14	44
55	74	49	-	50
56	74	74	92	26
57	91	59	49	-
58	44	92	39	-
59	53	45	46	-
1860	80	73	-	42
61	71	71	-	85
62	48	76	33	18
63	-	79	50	32
64	-	67	-	-
65	-	65	-	-
66	44	73	-	-
67	-	72	13	82
68	57	-	-	-
69	86	-	65	-
1870	-	-	84	-

* All dates prior to September 14, 1752 have been adjusted to accommodate the Gregorian Calendar reform.

† Day 1 is August 1st.

** Due to their infrequent occurrence those years having recorded dates of first snow or first frost later than October 31 have been included.

CHAPTER V

TESTING THE QUALITY OF THE HISTORICAL DATES OF FIRST SNOWFALL AND FROST

The principle of spatial homogeneity testing was applied to the dates of first snowfall and frost transcribed from the Moose Factory and Fort Albany post journals. This method of testing is based on the assumption that locations within a particular climatic region tend to experience similar climatic changes. The closer such points are together, and the greater the physical similarity between them, the greater will be the parallelism between the climatic changes that they experience.

Moose Factory and Fort Albany are situated on river estuaries on the west shore of James Bay and are only separated by approximately 130 kilometres. Due to their close proximity to each other in an area of subdued topography and the fact that both of the posts are situated within the same climatic region, it is anticipated that similar climatic changes will occur at these two places. Homogeneity testing of the temporal variations of the dates of first frost and first snowfall at Moose Factory and Fort Albany will indicate the degree of similarity between the two places. If similar trends are detected this will indicate not only that the climatic conditions at the two places are homogeneous, but also that the historical data derived in this study may be valid. If dissimilar trends are detected this result may show that the climatic conditions are not homogeneous, or it may be evidence that the historical data are not valid measures of climatic conditions.

In applying homogeneity tests it is not anticipated that climatic trends detected at adjacent stations will be identical. Rather it is assumed that the degree of similarity in the data to be tested will be comparable with that displayed by equivalent modern data which are known to be valid.

A. Homogeneity Tests of Historical Dates

As numerical information is often the working medium of homogeneity testing, the dates of the first snowfall and first frost events were converted to numbers of days after July 31 with adjustments made to account for the change from the Julian to the Gregorian Calendar which occurred in 1752. Thus, August 1, the earliest date considered to be within the autumn season (for the purposes of this study) is Day 1 and October 31, the last date within this season is Day 92.

1. Graphical analysis

Using this system of numbering, the dates of first frost and first snowfall at Moose Factory and Fort Albany were examined in graphical form (Figures 5.1 and 5.2). Clearly, there are large differences between the dates of both first frost and first snowfall recorded at the two locations. It is evident that in some periods there are strong similarities (even identical patterns) between the yearly fluctuations in the dates of these meteorological events at Moose Factory and those at Fort Albany while other periods exhibit extreme discrepancies between the two locations. However, it is evident that there is a greater similarity between Moose Factory and Fort Albany in terms of their respective dates of first snowfall than exists in terms of their dates of first frost.

2. Comparison of 10-year running means

The statistical technique of 10-year running means was then applied to the dates of first frost and first snow at Moose Factory and Fort Albany (Figures 5.3, 5.4, 5.5 and 5.6). This was undertaken in order to smooth out small year-to-year fluctuations in the dates of first snowfall and frost so that their overall patterns of variations and any major discrepancies between the dates at each location would be more apparent. Figure 5.3 indicates that, even with the smoothing effect of this technique, there appears to be few significant similarities between the patterns of

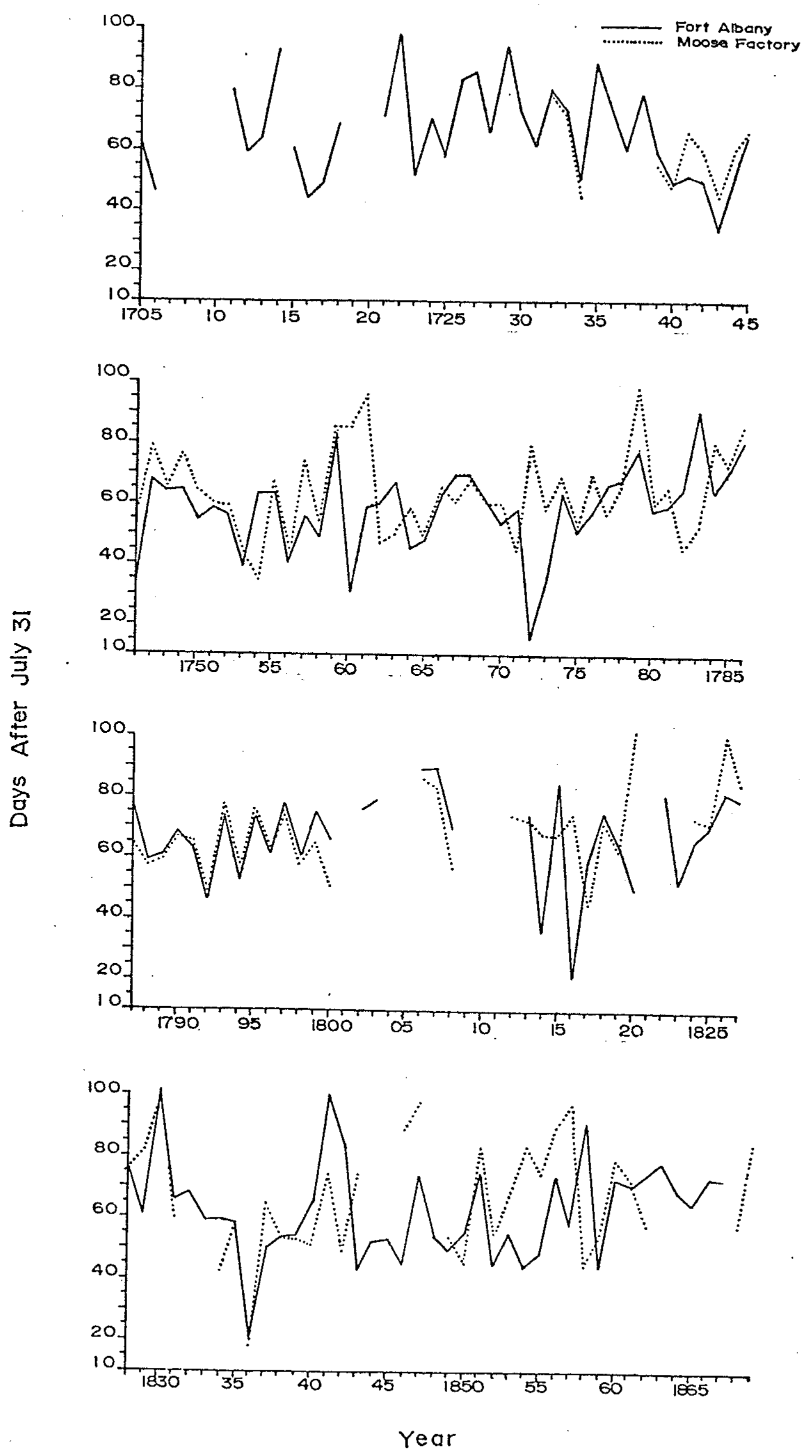

Figure 5.1: Date of first snowfall after July 31, Moose Factory and Fort Albany, 1705-1869.

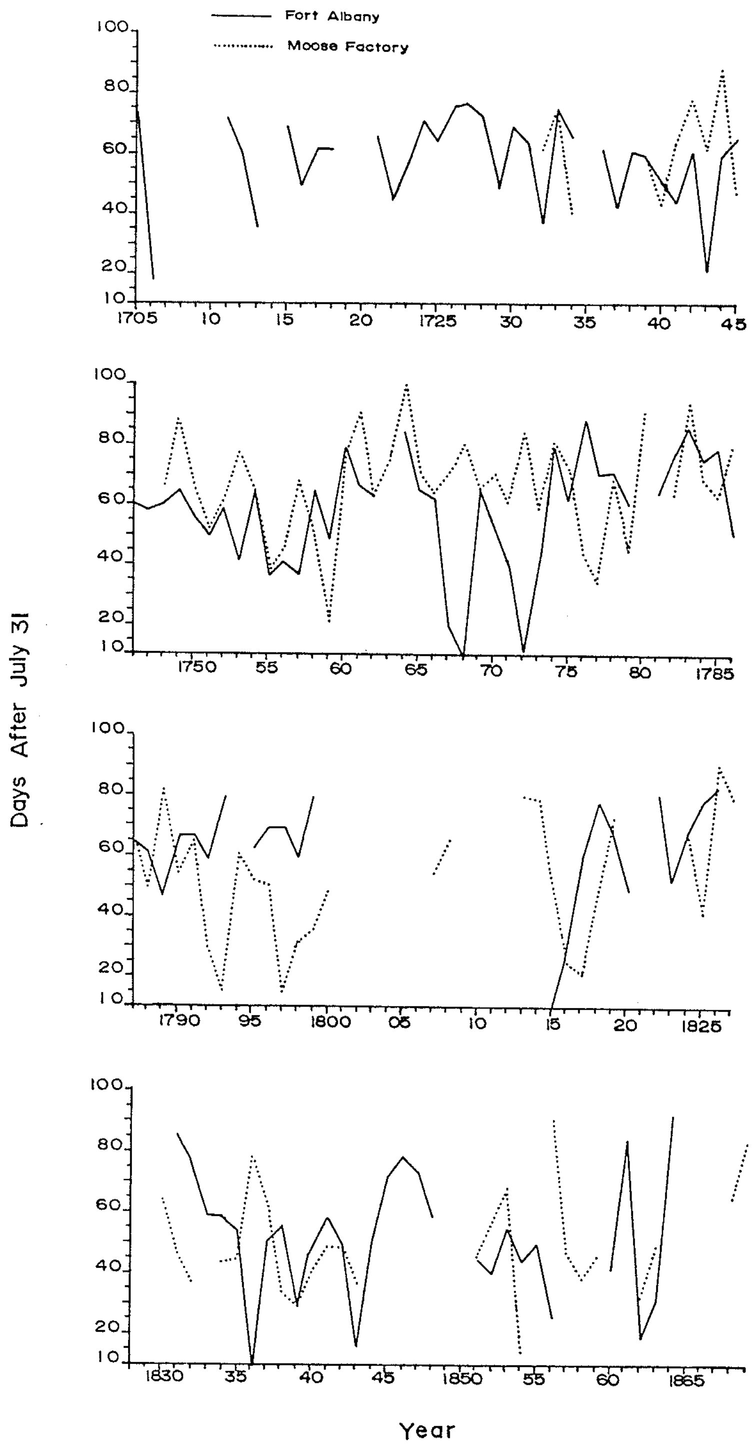

Figure 5.2: Date of first frost after July 31, Moose Factory and Fort Albany, 1705-1869.

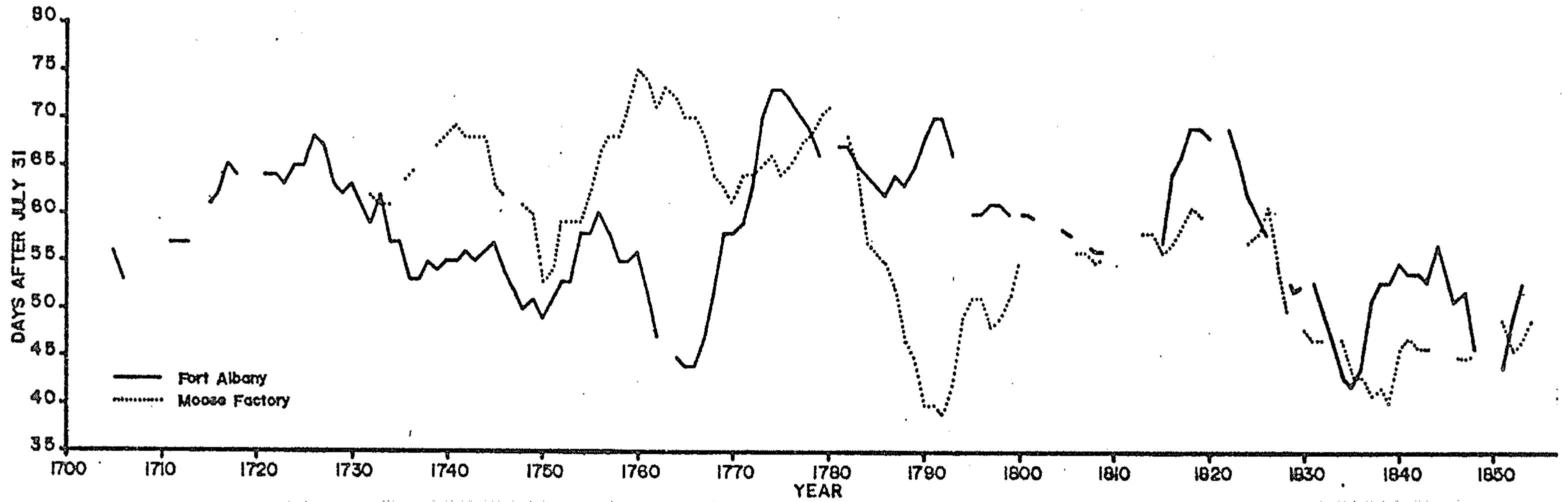

Figure 5.3: 10-year running means of dates of first frost after July 31, Moose Factory and Fort Albany, 1705-1869.

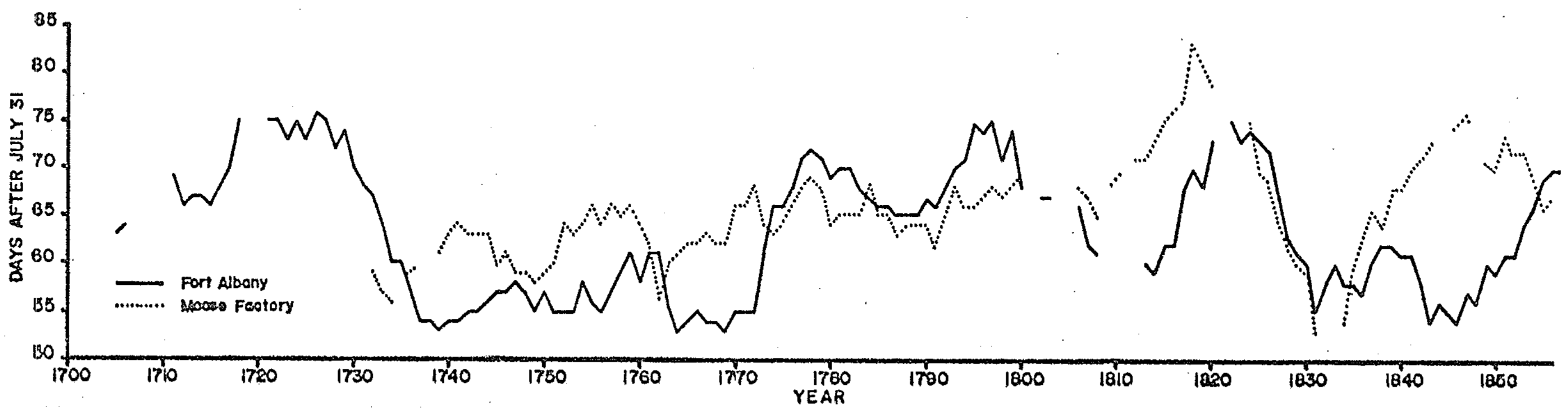

Figure 5.4: 10-year running means of dates of first snowfall after July 31, Moose Factory and Fort Albany, 1705-1869.

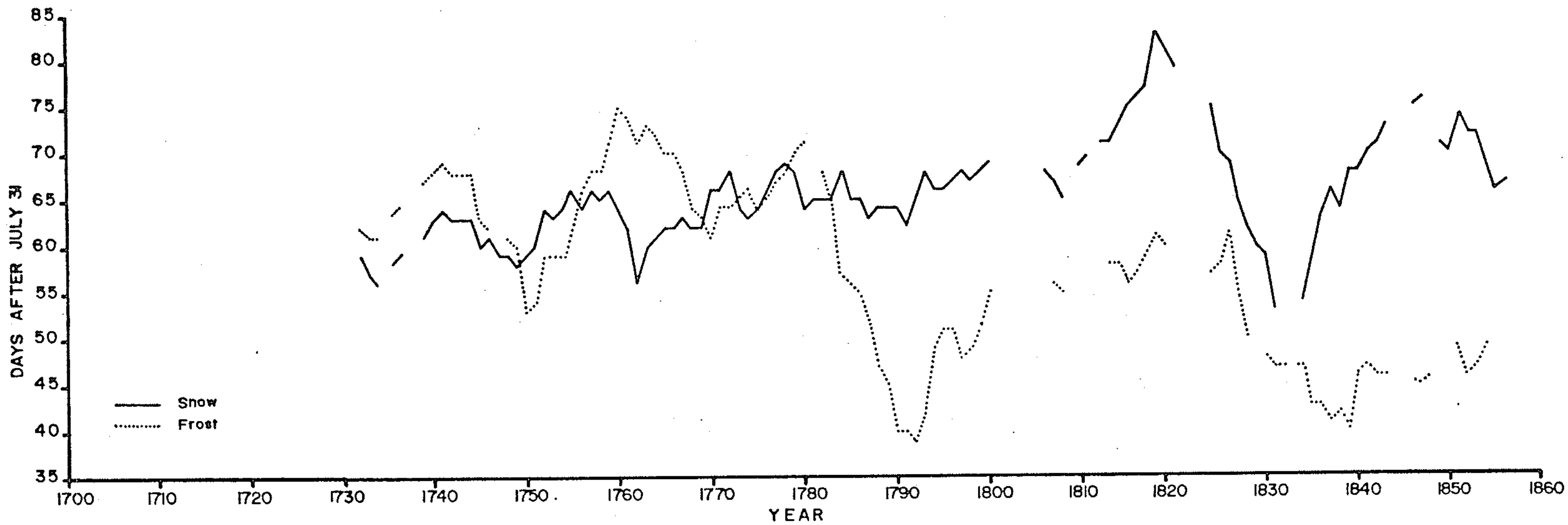

Figure 5.5: 10-year running means of dates of first frost and first snow after July 31, Moose Factory, 1732-1869.

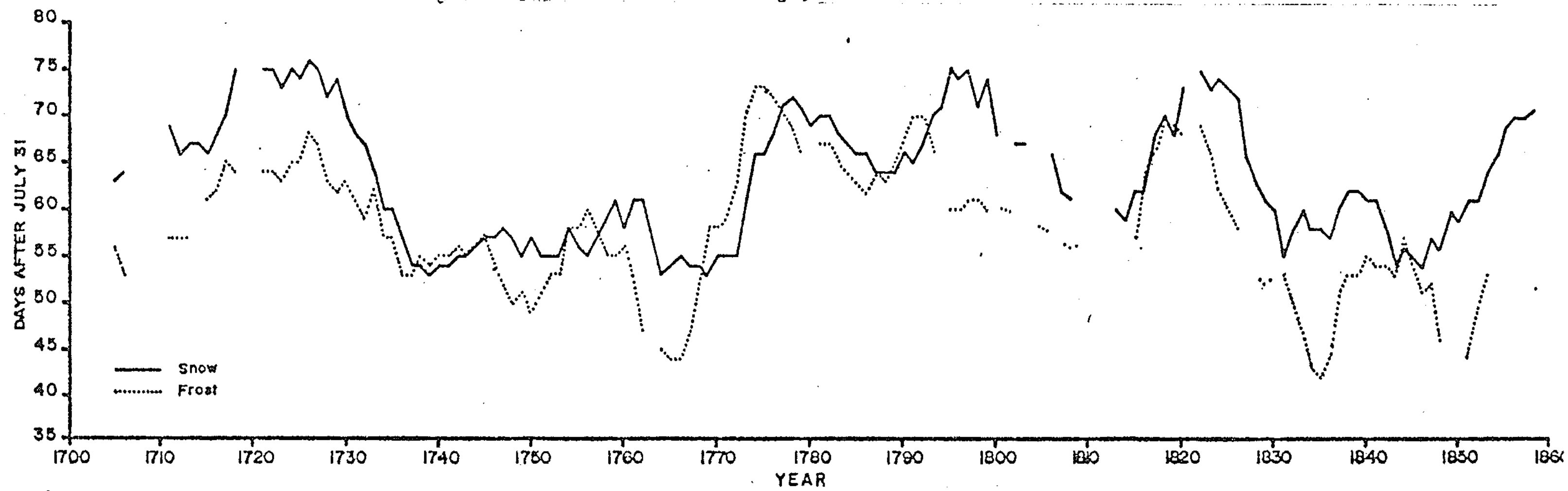

Figure 5.6: 10-year running means of dates of first frost and first snow after July 31, Fort Albany, 1705-1867.

first frost dates at the two locations. As is evident in Figure 5.4 there is an overall similarity between the patterns of first snowfall dates at Moose Factory and Fort Albany although there are also periods of significant discrepancy. The graphical comparison depicted in Figure 5.5 reveals little or no significant similarity between the dates of first snowfall and first frost at Moose Factory. Conversely, there appears to be a marked degree of similarity between the yearly fluctuations in the dates of the two meteorological events recorded at Fort Albany as is seen in Figure 5.6.

Although these preliminary graphical and running mean comparisons are relatively unsophisticated and by no means conclusive, two very obvious observations can be made from them. Firstly, it is apparent that there is a greater degree of homogeneity between the Moose Factory and Fort Albany snowfall dates than is evident for the dates of first frost. This result may indicate that the spatial variations of dates of first snowfall in the James Bay region are less than the spatial variations of dates of first frost. Alternatively, this result may indicate that the dates of first snowfall are more valid as true measures than are the dates of first frost. Secondly, it is noteworthy that a comparison between the trends of dates of first snowfall and first frost reveals greater similarities between those at Fort Albany than at Moose Factory. This contrast also may be attributable to real climatic causes, or it may indicate that the Fort Albany dates are more valid measures than the Moose Factory dates.

3. Comparison of long-term means and decadal means

Further attempts to ascertain the validity of the historical data of first frost and first snow at Moose Factory and Fort Albany involved the calculation of the long-term and decadal mean dates of each event at both locations.

The number of years of record of the Fort Albany journals is 163 (1705-1867) while the Moose Factory journals span a period of 139 years (1732-1870). As this undertaking was to be a comparative examination, the Fort Albany dates prior to the first recorded entries in the Moose Factory journals were excluded. Similarly, the Moose Factory dates extending past the latest entries in the Fort Albany journals were also excluded.

By using the previously mentioned system of numbering, the mean dates and standard deviations of first snowfall and first frost at both Bayside ports for the entire 130-year record (1735-1864) were calculated from the following equations:

$$\overline{X} = \frac{\Sigma X}{N} \qquad (1)$$

where: $\overline{X}$ = mean date

X = the individual dates making up the series of data

N = total number of observations

$$S = \sqrt{\frac{\Sigma(X-\overline{X})^2}{N}} \tag{2}$$

where S = standard deviation

The results, shown in Tables 5.1 and 5.2, were encouraging in that the long-term mean dates of both first snowfall and frost at Moose Factory were very similar to those at Fort Albany. To determine whether the differences between these means are significant or not the following equation was employed:

$$S.E.(\overline{X}_1-\overline{X}_2) = \sqrt{\frac{S_1^{\,2}}{N_1} + \frac{S_2^{\,2}}{N_2}} \tag{3}$$

where S.E. = the Standard Error of the Difference

$\overline{X}_1$ = mean date at Moose Factory

$\overline{X}_2$ = mean date at Fort Albany

S_1 = standard deviation of Moose Factory data

S_2 = standard deviation of Fort Albany data

N_1 = number of observations at Moose Factory

N_2 = number of observations at Fort Albany

As is seen in Table 5.3, the results reveal that the standard error of the difference between the mean dates of first frost at Moose Factory and Fort Albany is 3.1 and the actual difference is only 1.0. Therefore, according to this statistical test the difference of one day between the two locations in terms of their long-term mean dates of first

TABLE 5.1: MEANS AND STANDARD DEVIATIONS OF DATES OF FIRST FROST FOR 130 YEARS OF RECORD 1735-1864

	MOOSE FACTORY	FORT ALBANY
Number of references to first frost	99	105
Mean date of first frost	September 29	September 28
Standard deviation	26.7	15.9

TABLE 5.2: MEANS AND STANDARD DEVIATIONS OF DATES OF FIRST SNOW FOR 130 YEARS OF RECORD 1735-1864

	MOOSE FACTORY	FORT ALBANY
Number of references to first snow	110	122
Mean date of first snow	October 5	October 2
Standard deviation	8.3	8.2

TABLE 5.3: STATISTICS ON THE SIGNIFICANCE OF THE DIFFERENCES BETWEEN THE LONG-TERM MEANS OF FIRST FROST AND FIRST SNOW AT MOOSE FACTORY AND FORT ALBANY

	FROST	SNOW
Actual difference between mean dates	1	3
Standard error of the difference	3.1	1.1

frost is possibly not significant. Conversely, the results show that the difference between the mean dates of first snow at Moose Factory and Fort Albany is significant.

If a difference is said to be statistically significant this means that it is extremely improbable that such a difference could have occurred by chance. If the difference between the mean dates of first snowfall did not occur by chance then it implies that, on a long-term basis, the difference between the two locations with regards to first occurrences of snow is real. Although there is a possibility that the difference between the mean dates of first frost occurred by chance, it is noteworthy that, based on 130 years of record, this difference is as little as one day. In terms of the principle of spatial homogeneity testing the great similarity between the long-term means at the two locations reinforces the possibility that historical information (more particularly the snowfall dates) may be a valid climatological measure.

Fort Albany is the northern-most of the two former Hudson's Bay Company posts and therefore is likely to be influenced by the southward movement of the Arctic Front earlier than Moose Factory. In view of this situation, the fact that the earliest mean dates of both first frost and first snow were recorded at the more northerly station of Fort Albany further reinforces the indication that the derived dates are valid.

The 130 years of record extending from 1735 to 1864 was then divided into thirteen 10-year periods. The dates of first frost and first snow in each 10-year period for both Moose Factory and Fort Albany were tallied and recorded. The average dates of first frost and of first snow for each 10-year period at both locations were calculated by the application of equation (1). The results are shown in Tables 5.4 and 5.5 and in graphical form in Figures 5.7 and 5.8.

Table 5.4 and Figure 5.7 indicate that the decadal mean dates of first frost vary by as much as 35 days with both Moose Factory and Fort Albany recording October 16 as the latest decadal mean while the earliest decadal mean of September 11 was recorded at Fort Albany. Moose Factory is shown to have had the earliest decadal mean date of first frost five times to Fort Albany's six while both locations are shown as having the same decadal mean date twice.

Table 5.5 and Figure 5.8 reveal that the decadal mean dates of first snow vary by as much as 25 days with Moose Factory recording October 18 as the latest decadal mean and Fort Albany recording the earliest decadal mean of September 23. Fort Albany is shown to have had the earliest decadal mean date of first snow seven times to Moose Factory's four while both locations recorded the same decadal mean date twice.

These observations tend to further indicate that the historical dates of first snowfall and frost may be valid

TABLE 5.4: DECADAL MEAN DATES OF FIRST FROST 1735-1864

	NUMBER OF DATES OF FIRST FROST PER DECADE		MEAN DATES OF FIRST FROST PER DECADE	
Decade	Moose	Albany	Moose	Albany
1735-44	7	10	Oct. 3	Sept. 26
1745-54	9	10	Oct. 5	Sept. 26
1755-64	10	9	Oct. 1	Sept. 26
1765-74	10	10	Oct. 9	Sept. 11
1775-84	9	9	Oct. 3	Oct. 12
1785-94	10	9	Sept. 25	Oct. 2
1795-1804	5	6	Sept. 15	Oct. 8
1805-14	2	2	Oct. 16	Oct. 16
1815-24	6	9	Sept. 17	Sept. 24
1825-34	7	7	Oct. 8	Oct. 8
1835-44	9	10	Sept. 16	Sept. 11
1845-54	8	8	Sept. 28	Sept. 21
1855-64	7	7	Sept. 18	Sept. 19

TABLE 5.5: DECADAL MEAN DATES OF FIRST SNOW 1735-1864

	NUMBER OF DATES OF FIRST SNOW PER DECADE		MEAN DATES OF FIRST SNOW PER DECADE	
Decade	Moose	Albany	Moose	Albany
1735-44	7	10	Sept. 24	Sept. 29
1745-54	10	10	Sept. 29	Sept. 26
1755-64	10	10	Oct. 5	Sept. 25
1765-74	10	10	Oct. 1	Sept. 23
1775-84	10	10	Oct. 3	Oct. 5
1785-94	10	10	Oct. 4	Oct. 4
1795-1804	6	8	Oct. 3	Oct. 10
1805-14	7	5	Oct. 10	Oct. 10
1815-24	7	9	Oct. 10	Sept. 30
1825-34	8	10	Oct. 18	Oct. 12
1835-44	9	10	Sept. 24	Sept. 27
1845-54	8	10	Oct. 12	Sept. 24
1855-64	8	10	Oct. 9	Oct. 8

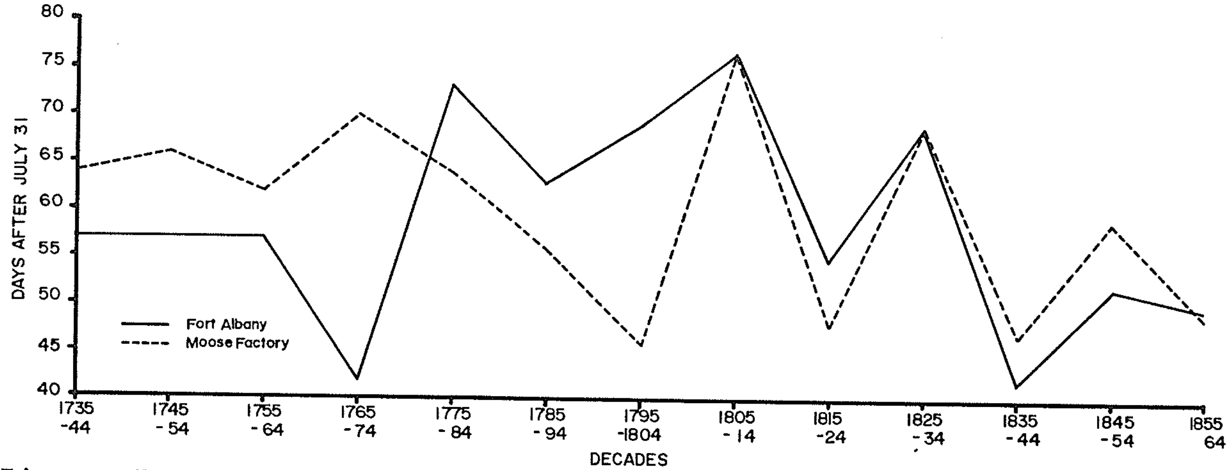

Figure 5.7: Decadal mean dates of first frost after July 31, Moose Factory and Fort Albany, 1735-1864.

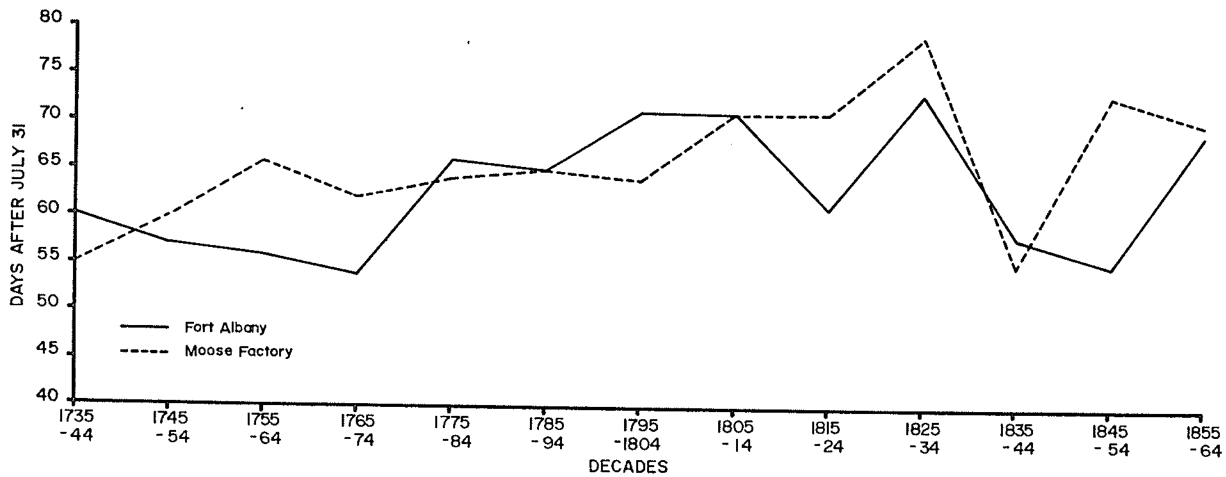

Figure 5.8: Decadal mean dates of first snow after July 31, Moose Factory and Fort Albany, 1735-1864.

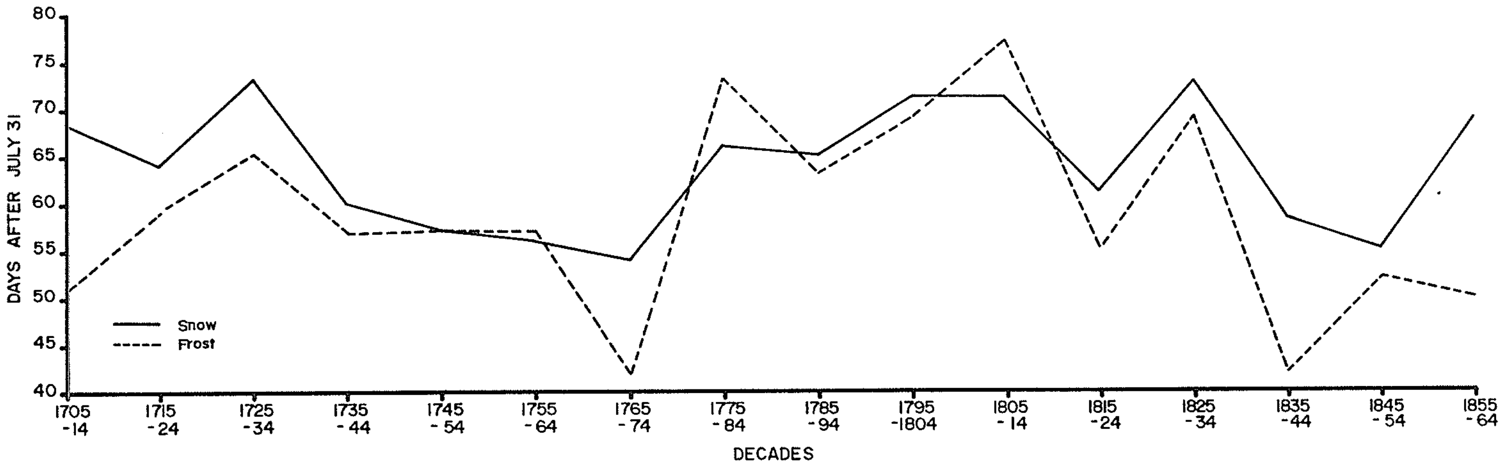

Figure 5.9: Decadal mean dates of first frost and first snow after July 31, Fort Albany, 1705-1864.

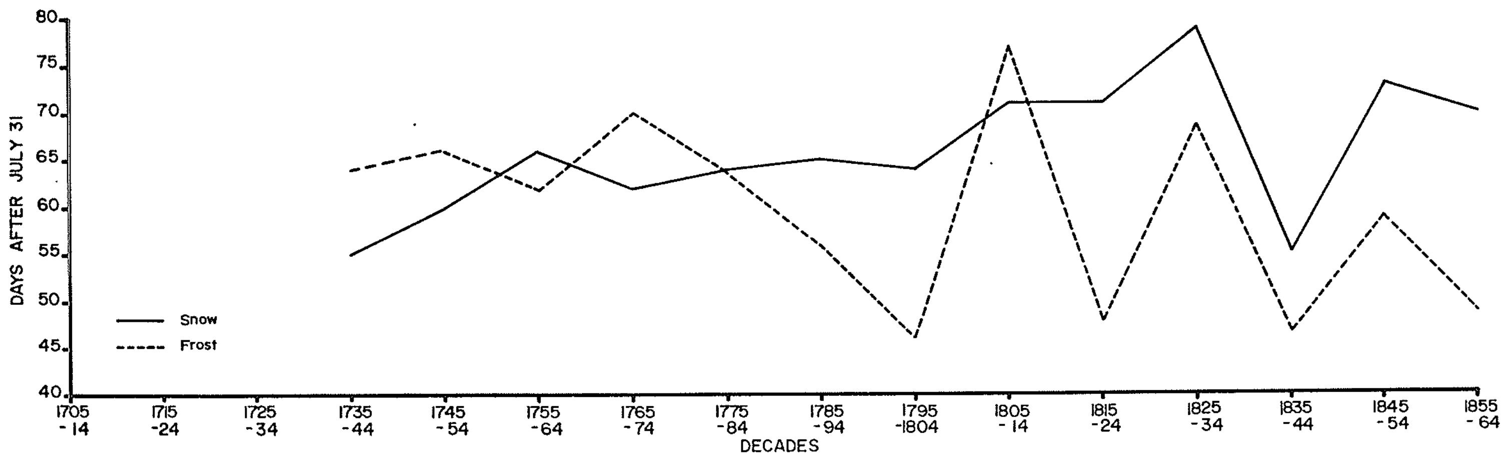

Figure 5.10: Decadal mean dates of first frost and first snow after July 31, Moose Factory, 1735-1864.

climatological measures in view of the previous discussion on the likelihood of Fort Albany being influenced by the Arctic Front earlier than Moose Factory.

Careful examination of Figures 5.7 and 5.8 shows that there appears to be greater homogeneity between the decadal mean dates of first frost at Moose Factory and Fort Albany and the decadal mean dates of first snow at the two locations, than is evident from the 10-year running means displayed in Figures 5.3 and 5.4. However, it is again apparent (Figures 5.7 and 5.8) that there is a greater variation in the decadal mean dates of first frost than in the means of first snow. As previously mentioned, the cause of this is not clear.

The final graphical comparisons involving decadal mean dates of first snow and first frost are shown in Figures 5.9 and 5.10. There is an obviously greater similarity between the decadal mean dates of first snow and first frost at Fort Albany than between those dates recorded at Moose Factory. This contrast is also apparent in Figures 5.5 and 5.6.

4. Correlation analysis

In order to further discern the extent of any existing climatological homogeneity between the two former Hudson's Bay Company posts a correlation analysis was performed on their dates of first frost and first snow. Using the aforementioned system of numbering the historical dates whereby August 1 is Day 1, August 2 is Day 2, etc. the dates of first frost at both Moose Factory and Fort Albany were listed as were the dates of first snow at the two locations. A correlation coefficient was then calculated for both sets of dates using equation (4) below:

$$r = \frac{\Sigma xy}{\sqrt{(\Sigma x^2)\ (\Sigma y^2)}} \tag{4}$$

where r = correlation coefficient

$x = X - \overline{X}$

$y = Y - \overline{Y}$

The very low values of the correlation coefficients indicate that Moose Factory and Fort Albany cannot be considered climatologically homogeneous on the basis of their historical dates of first snow and frost (Table 5.6). In terms of the principle of spatial homogeneity these results, at first sight, appear to preclude the possibility that the historical dates of first frost and first snow are valid as climatological records. This result seemingly negates the observations from some of the previous homogeneity tests.

There is a generally higher correlation between the historical dates of first snow than between the dates of first frost. This may be attributed to physical causes but it may also be an indication that the historical dates of first snow are more valid measures than the frost dates. Therefore, the snowfall dates were selected for further correlation analysis in an attempt to look more deeply into the

TABLE 5.6: RESULTS OF PEARSON'S CORRELATION ANALYSIS OF DATES OF FIRST SNOW AND FROST AT MOOSE FACTORY AND FORT ALBANY 1732-1866

	FIRST SNOW	FIRST FROST
Number of pairs of observations	111	90
Correlation coefficient	+0.32	-0.01
Significance level	99%	*

* Not significant

apparent lack of homogeneity between Moose Factory and Fort Albany. The 135-year period of record was divided into nine 15-year intervals and correlation coefficients were calculated for each of the nine divisions by the application of equation (4). The results, displayed in Table 5.7, appear to be extremely erratic while in some 15-year periods the data are highly correlated, in other periods they are uncorrelated.

This result implies either that the historical dates derived in this study are not valid measures or that the low correlation reflects real differences between the climatic conditions at the two locations.

As regards the latter possibility it is, of course, noteworthy that the Pearson's product-moment correlation coefficient is highly sensitive to the influence of exceptional extreme values. Thus occasional large differences between dates of occurrence at Moose Factory and Fort Albany may have a large negative impact upon the values of the correlation coefficient. To test the frequency of occurrence of large differences, frequency distributions of differences between annual dates of first snowfall at the two posts, and of annual dates of first frost were studied (Figures 5.11 and 5.12).

Figure 5.11 indicates that there seems to be an observable, although somewhat weak, inverse relationship between the frequency of occurrence and the magnitude of the difference between dates of first snowfall at Moose Factory

TABLE 5.7: RESULT OF PEARSON'S CORRELATION ANALYSIS OF DATES OF FIRST SNOW AT MOOSE FACTORY AND FORT ALBANY IN 15-YEAR INTERVALS

15-YEAR PERIOD	NUMBER OF PAIRS OF OBSERVATIONS	CORRELATION COEFFICIENT	SIGNIFICANCE LEVEL
1732-1745	12	0.597	95%
1747-1761	15	0.353	*
1762-1776	15	-0.391	*
1777-1791	15	0.253	*
1792-1806	10	0.923	99.9%
1807-1821	10	-0.021	*
1822-1836	11	0.913	99.9%
1837-1851	12	0.157	*
1852-1866	12	-0.259	*

* Not significant

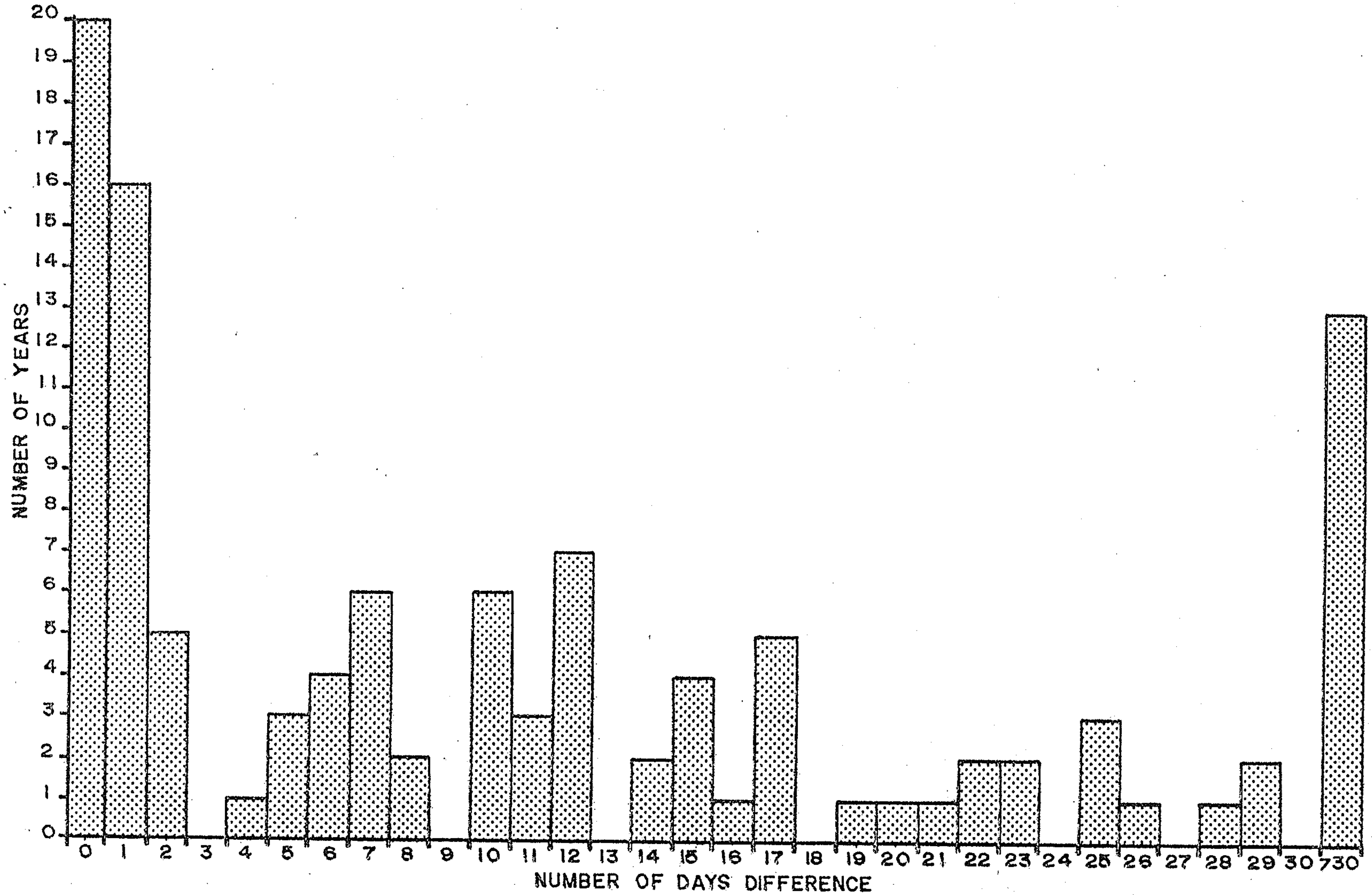

Figure 5.11: Frequency distribution of differences between dates of first snow at Moose Factory and at Fort Albany.

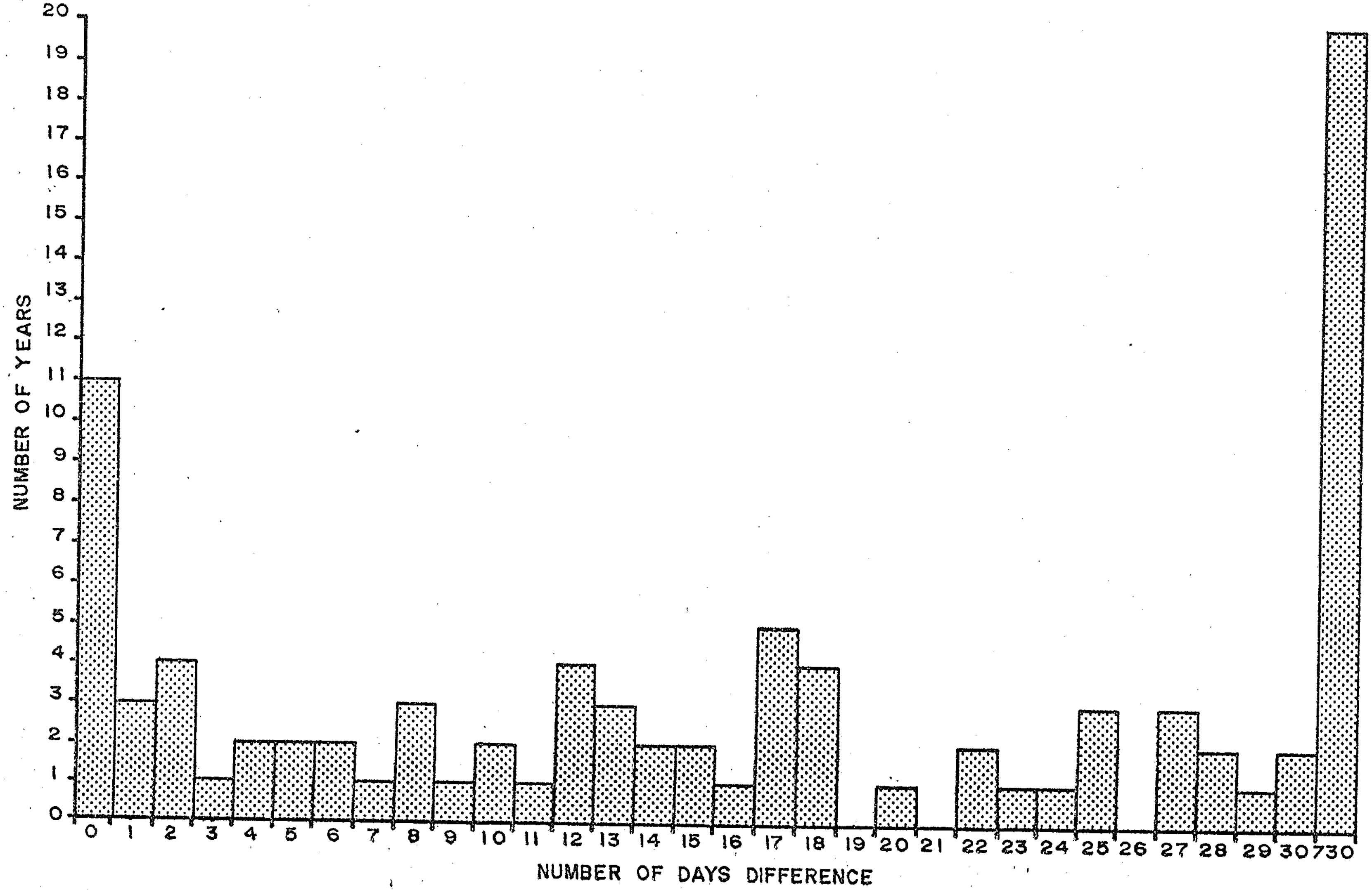

Figure 5.12: Frequency distribution of difference between dates of first frost at Moose Factory and at Fort Albany.

and those dates at Fort Albany such that the greatest frequencies are associated with the smallest differences. Figure 5.12 indicates that there appears to be no such relationship between the dates of first frost at the two locations.

B. Discussion

These homogeneity tests applied to first snowfall data have indicated that in certain time intervals there is a high degree of homogeneity between Moose Factory and Fort Albany, while in other time intervals the trends from the two stations are inhomogeneous. In general the tests have revealed that the trends of dates of first frost at the two places are inhomogeneous. The causes of these results may be physical in nature or they may relate to deficiencies in the data sources or in the method of the interpretation of the data sources. If the causes can be shown to be physical this would indicate that annual dates of first snowfall and first frost do indeed vary considerably over short distances in northern and central Canada. In this event the results of this homogeneity test would not necessarily imply that the derived data are invalid. However, if the low homogeneity between Moose Factory and Fort Albany is not due to physical causes this would demonstrate that the data derived in this study are not valid climatological measures.

1. Physical causes

It may very well be that the first snowfall and frost events at the two locations are, in fact, poorly related. Indeed, in terms of first annual frost events this is very possibly the case. There are two very different meteorological processes that can produce freezing conditions and frost. Advective frosts are the result of the presence of cold air masses which normally migrate over great distances affecting large areas for prolonged periods of time. However, radiation frosts are the result of radiation cooling, a meteorological process which is often very localized and, as it is primarily dependent on clear nocturnal skies, is a much more temporally and spatially erratic phenomenon. As the two Bayside posts were separated by 130 kilometres it is entirely possible that conditions conducive to the occurrence of radiation frost did not always exist at both locations at the same time. In fact, radiation frosts occurring very early in the autumn seasons (beginning August 1 for the purposes of this study) at one of the locations and not at the other may very well account for a significant number of the discrepancies between Moose Factory and Fort Albany with respect to their dates of first frost.

The occurrence of snow, like that of advective frost, is most often associated with the presence of cold air masses and therefore the great differences between Moose Factory and Fort Albany with regards to some of their respective dates of first snow cannot be accounted for in terms of highly localized phenomena.

2. Causes related to the historical sources

The low homogeneity between the dates derived from Moose Factory and Fort Albany may indicate that these dates are not valid measures of first annual snowfall and frost. If this is the case it may have arisen because the journals contain insufficient information to yield valid dates, or because the contents of the journals have been interpreted inadequately.

During the period of time between 1705 and 1870 a great many Hudson's Bay Company employees were responsible for making the daily entries in the journals at Moose Factory and Fort Albany. Certainly all of these journalists were not equally observant or equal in the manner in which they carried out the Company's instructions. It is also possible that the dates of first annual snowfall events were more accurately or consistently recorded than were the dates of frost merely due to the fact that, as meteorological phenomena, snowfall events are more visible than are frost events.

Additionally, the transcriptions may not accurately reflect the information contained in the journals. The great differences between the historical dates at Moose Factory and those recorded at Fort Albany may, at least in part, be a result of the inaccuracy or inconsistency of the transcriber.

In order to assess the reliability of the transcriptions, a sample of the journals was re-examined. This sample included all those years displaying a two week or greater difference between the dates at Moose Factory and those at Fort Albany of both first snow and first frost. This criterion was satisfied for first frost in 48 out of a total of 90 years in which a record existed at both locations. Similarly, out of a total of 112 years in which dates of first snowfall had been recorded at both locations, 37 displayed a 14-day or greater difference between Moose Factory and Fort Albany.

The results of this examination were encouraging in that absolutely no discrepancies were found between the transcribed dates of first frost and first snowfall and the actual information contained in the journals.

The possibility that the journalists were not adequately consistent or perceptive was more difficult to verify or discount. It is assumed that at least some of the historical dates recorded during the 165-year period of record are not accurate. Based on this assumption, the sample of the sources was also checked to discern whether or not there were accountable errors in the dates originally recorded in the journals. The effort proved fruitless as no clear evidence of errors by the journalists was found. This, of course, does not eliminate the possibility of error on the part of the journalists and therefore incorrect dates in the historical record, but it does emphasize the difficulty involved in attempting to distinguish those individual historical dates which may be considered valid from those that may not.

Although no concrete evidence of invalid dates was thus found it seems highly unlikely that the Hudson's Bay Company journalists made no errors in recording first frost and snowfall events over a period of 165 years. However, without a suitable method for correctly identifying possible incorrect dates it cannot, at this time, be unequivocally stated that the apparent lack of homogeneity between the Moose Factory and Fort Albany dates is solely due to errors on the part of the original journalists.

CHAPTER VI

COMPARISON WITH MODERN STATIONS

In Chapter V it was hypothesized that the apparent lack of homogeneity between Moose Factory and Fort Albany in terms of their historical dates of first frost and first snowfall might be attributed to physical causes or to causes related to the historical sources. There was found to be no evidence of error in the transcription and the interpretation of the data sources. Similarly, no obvious deficiencies, which would indisputably render first frost and first snowfall dates invalid, were discerned in the data sources. To determine if the erratic nature of the historical dates might be attributed to physical causes it is instructive to compare them to dates of first snowfall and first frost recorded at similarly juxtaposed modern meteorological stations.

A. Objectives of Comparison with Modern Stations

The historical data derived at Moose Factory and Fort Albany have indicated that there is a lack of spatial homogeneity in dates of first snowfall and first frost between locations separated by 130 kilometres in the James Bay region. It is important to ascertain whether this is a real spatial inhomogeneity due to real physical causes or whether it is an apparent spatial inhomogeneity attributable to errors in the historical data. The objective in interpreting modern data is to determine whether the modern network of stations displays a similar spatial inhomogeneity between points separated by approximately 130 kilometres. Within the framework of modern standards of observation, we can assume the modern data to be valid measures of dates of first frost and first snowfall. If similar spatial inhomogeneity is revealed by the modern data, this will indicate that the spatial inhomogeneity has real physical causes. Such a result would provide evidence that the historical dates may be valid measures.

B. Selection of Modern Meteorological Stations

Moose Factory and Fort Albany are separated by 130 kilometres and climatic comparisons between them comprise mesoscale climatic studies, as opposed to macroscale or microscale studies. It is important that the modern comparative studies be also conducted at the mesoscale and this requires pairs of stations located within approximately 100 kilometres of each other. The nature of the comparative test requires that the records of dates of first frost and first snowfall should extend over several decades.

Unfortunately, no modern data meeting these criteria are available from the James Bay region or, indeed from the climatic region in which James Bay occurs (Figure 6.1). There are modern daily temperature records for the Moose River estuary (recorded at Moose Factory and later at Moosonee) from 1916 to the present and these have been incorporated in this study but other settlements in the immediate area surrounding James Bay, including Fort Albany, lack suitable modern records of both first snowfall and first frost.

At first sight this lack of modern records in the James Bay region implies that the tests envisioned cannot be undertaken. However, a decision was made to undertake these tests using modern records available from the populated parts of central Canada where stations occur in close proximity. Southern Manitoba was finally selected because of its topographical similarity with the James Bay lowlands. It is true that there are significant macroscale differences between the climates of southern Manitoba and the James Bay region. The former is classified as Dfb by Köppen--humid microthermal (cold climate with humid winters and cool summers) and the latter is classified as Dfc--humid microthermal (cold climate with humid winters and cool short summers). However, the test to be undertaken does not constitute a macroscale climatic comparison but rather a mesoscale climatic comparison. It is submitted that the topographic similarities between southern Manitoba and the James Bay lowlands permit the making of these mesoscale comparisons.

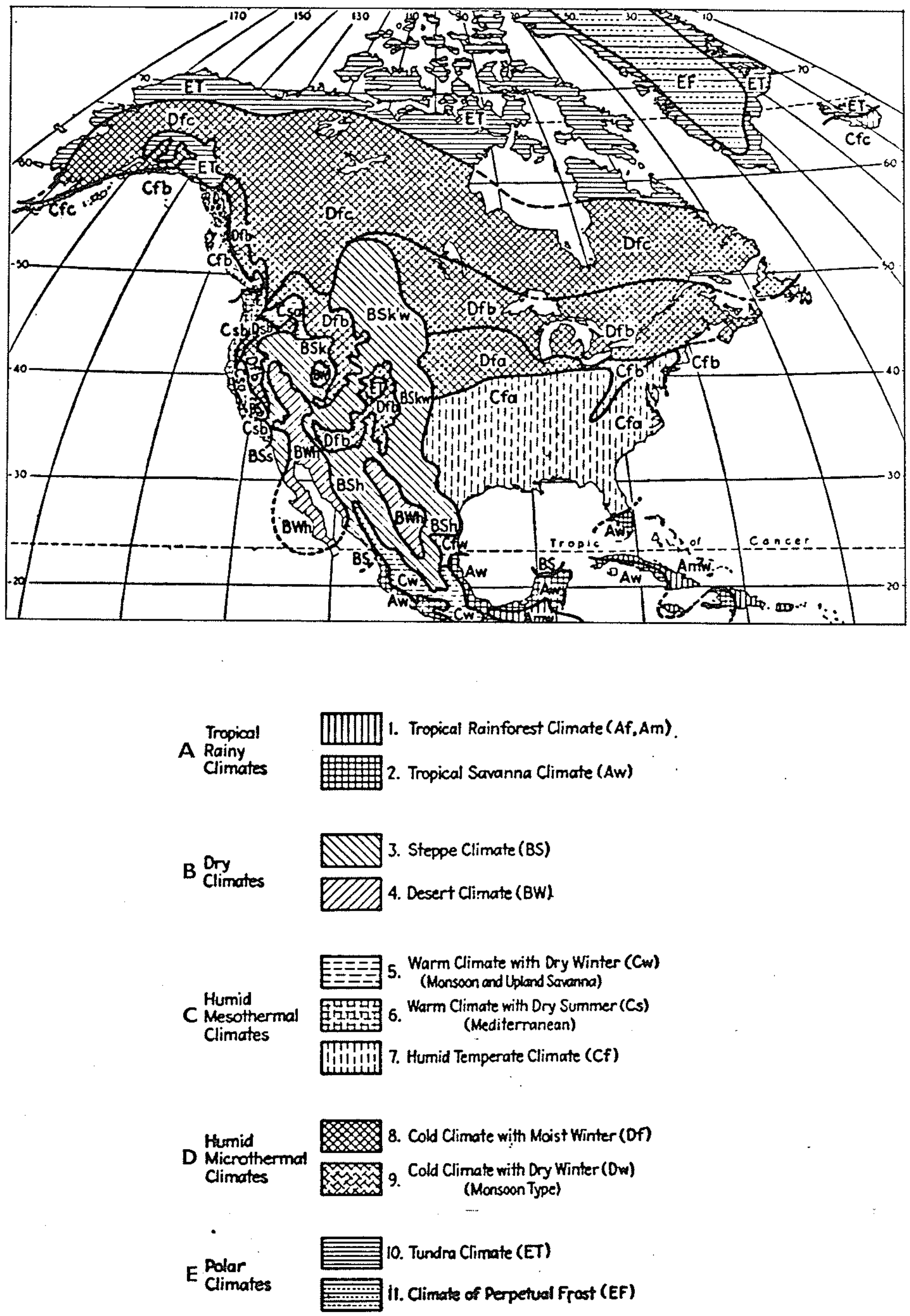

Figure 6.1: Climate of North America (by Glenn T. Trewartha: The scheme of classification is modified and simplified from Köppen.)

Records of first snowfall dates at some 27 locations in Manitoba were obtained from the Water Resources Division of the Manitoba Department of Mines, Resources and Environment. Records of first frost dates at a number of Manitoba meteorological stations were obtained from the Department of Transport's Monthly Meteorological Record. The final selection of the three stations to be used in this study was based on the following factors:

i) all three stations are within the same macro-scale climatic region;

ii) of all the possible choices among southern Manitoba meteorological stations these three have the most extensive records of both first frost and first snowfall dates; and

iii) all of these three meteorological stations are approximately the same distance apart as are Fort Albany and Moose Factory.

These three stations are situated in southern Manitoba between 96° and 100° west longitude and 49° and 50° north latitude. This area is shown in Figure 6.2. The three stations are listed in Table 6.1 together with the extent of their respective records of first frost and first snowfall dates. The extent of the modern dates of first frost from the Moose River estuary is also included in this table.

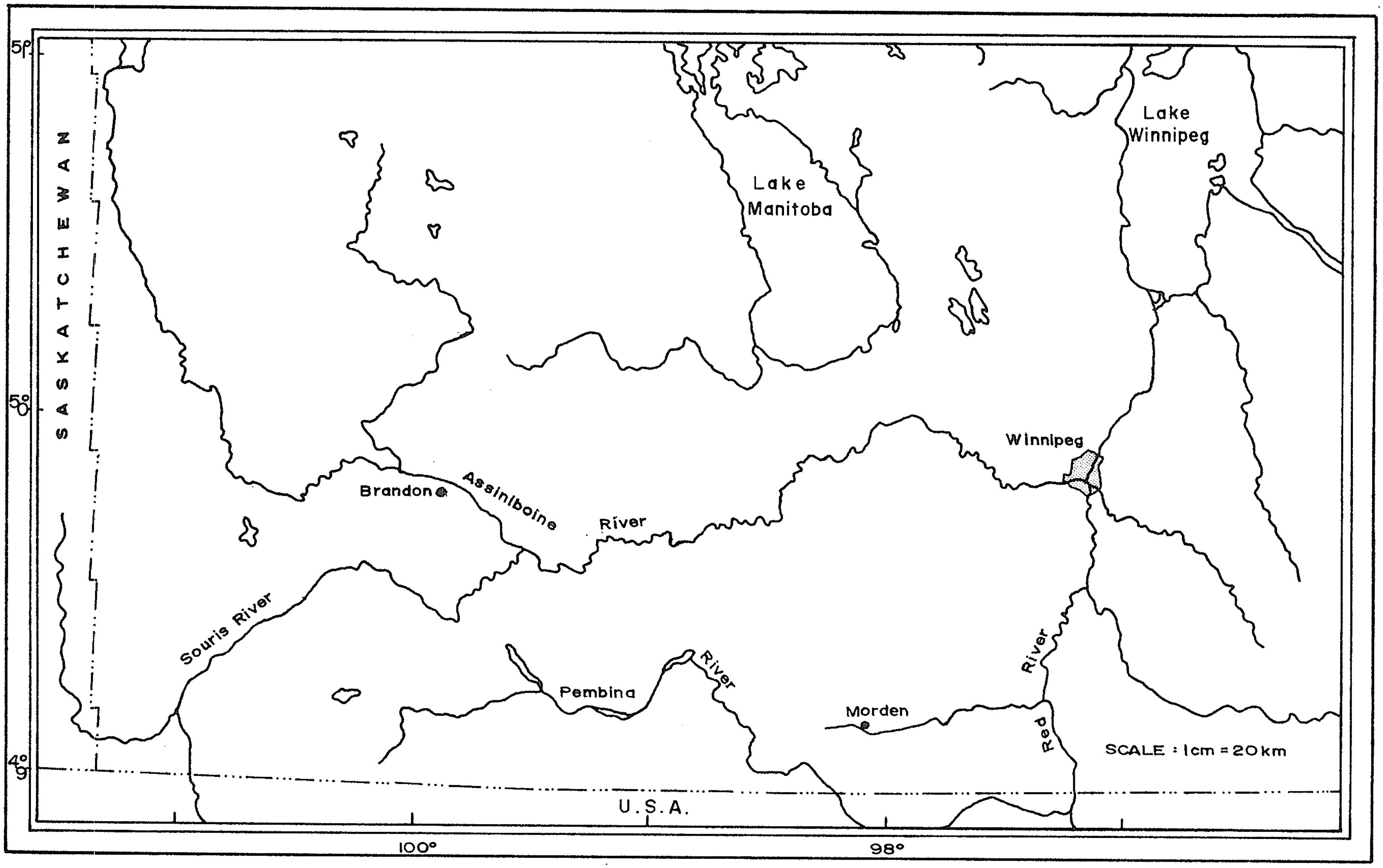

Figure 6.2: Location of modern meteorological stations used in this study.

TABLE 6.1: MODERN METEOROLOGICAL STATIONS

STATIONS	PERIOD OF RECORD	NUMBER OF YEARS WITH DATA
Winnipeg		
First frost dates	1922-1976	55
First snow dates	1872-1938	66
Brandon		
First frost dates	1922-1976	55
First snow dates	1890-1972	83
Morden		
First frost dates	1922-1976	55
First snow dates	1885-1961	61
Moose Factory-Moosonee		
First frost dates	1916-1976	58

C. Homogeneity Tests of Modern Dates

The use of the modern data to more readily determine the validity of the historical information involved a two-step process. Firstly, the southern Manitoba stations were compared with each other. The selection of these stations was based on the three previously mentioned factors so that the principle of spatial homogeneity testing could be realistically applied to their records of first frost and first snowfall dates. In the second step these results were then compared to those of similar tests performed on the Moose Factory and Fort Albany data in order to determine whether the degree of homogeneity between the historical dates is consistent with the homogeneity between pairs of modern stations.

To accommodate the need for numerical information in homogeneity testing, the modern dates of first snowfall and frost events were converted to numbers of days after July 31. Like the historical data, the earliest modern date considered is therefore August 1 (Day 1) and the latest is October 31 (Day 92).

The test for homogeneity performed on the modern instrumental data involved a simple correlation analysis. With their records of first snowfall events in the aforementioned numerical form, the southern Manitoba stations were paired off with each other and a correlation analysis was then calculated for each of the three sets of dates using equation (4). The same procedures were then applied to the modern dates of first frost. The results, shown in Tables 6.2 and 6.3, are accompanied by the outcomes of the same statistical test applied previously to the historical dates.

In terms of their dates of first snowfall the very low values of the correlation coefficients indicate that the modern stations in southern Manitoba are not any more spatially homogeneous than are Moose Factory and Fort Albany. However, although the correlation coefficients for the modern dates of first frost are low, they are all notably greater than that between Moose Factory and Fort Albany. This indicates that, on the basis of their dates of first frost, the modern stations are more homogeneous than the historical locations.

As was previously mentioned in Chapter V, occasional large differences between dates of occurrence may have a large negative impact on the values of the correlation coefficients calculated in these tests. Frequency distributions of differences between annual dates of first snowfall and annual dates of first frost were observed at the pairs of modern stations studied in order to test the frequency of occurrence of large differences (Figures 6.3 (a), (b) and (c) and 6.4 (a), (b) and (c)).

Figure 6.3 (c) indicates that there appears to be an inverse relationship between the frequency of occurrence and the magnitude of the difference between dates of first snowfall at Winnipeg and those dates at Morden. The greatest frequencies are associated with the smallest differences.

TABLE 6.2: CORRELATION COEFFICIENTS OF MODERN AND HISTORICAL DATES OF FIRST SNOWFALL

STATIONS	PERIOD OF COVERAGE	NUMBER OF PAIRED YEARS	CORRELATION COEFFICIENT	SIGNIFICANCE LEVEL
Modern				
Winnipeg-Brandon	1890-1937	48	0.42	99%
Winnipeg-Morden	1890-1934	40	0.36	98%
Brandon-Morden	1890-1961	57	0.17	95%
Historical				
Moose Factory-Fort Albany	1732-1866	111	0.32	99%

TABLE 6.3: CORRELATION COEFFICIENTS OF MODERN AND HISTORICAL DATES OF FIRST FROST

STATIONS	PERIOD OF COVERAGE	NUMBER OF PAIRED YEARS	CORRELATION COEFFICIENT	SIGNIFICANCE LEVEL
Modern				
Winnipeg-Brandon	1922-1976	55	0.25	*
Winnipeg-Morden	1922-1976	55	0.65	99.9%
Bradon-Morden	1922-1976	55	0.49	99.9%
Historical				
Moose Factory-Fort Albany	1732-1867	90	-0.01	*

* Not significant

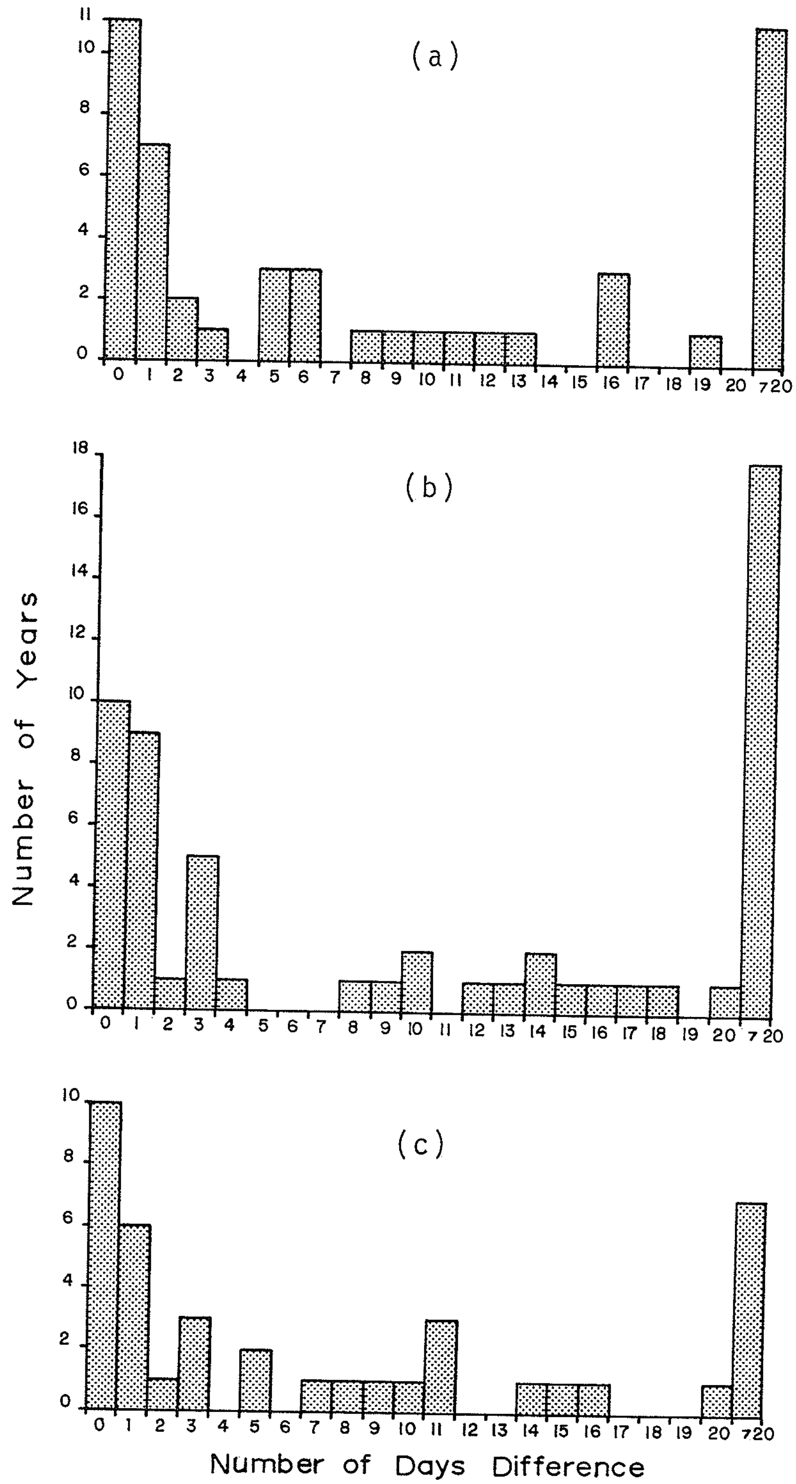

Figure 6.3: Frequency distribution of difference between dates of first snow: (a) at Winnipeg and at Brandon; (b) at Brandon and at Morden; (c) at Winnipeg and at Morden.

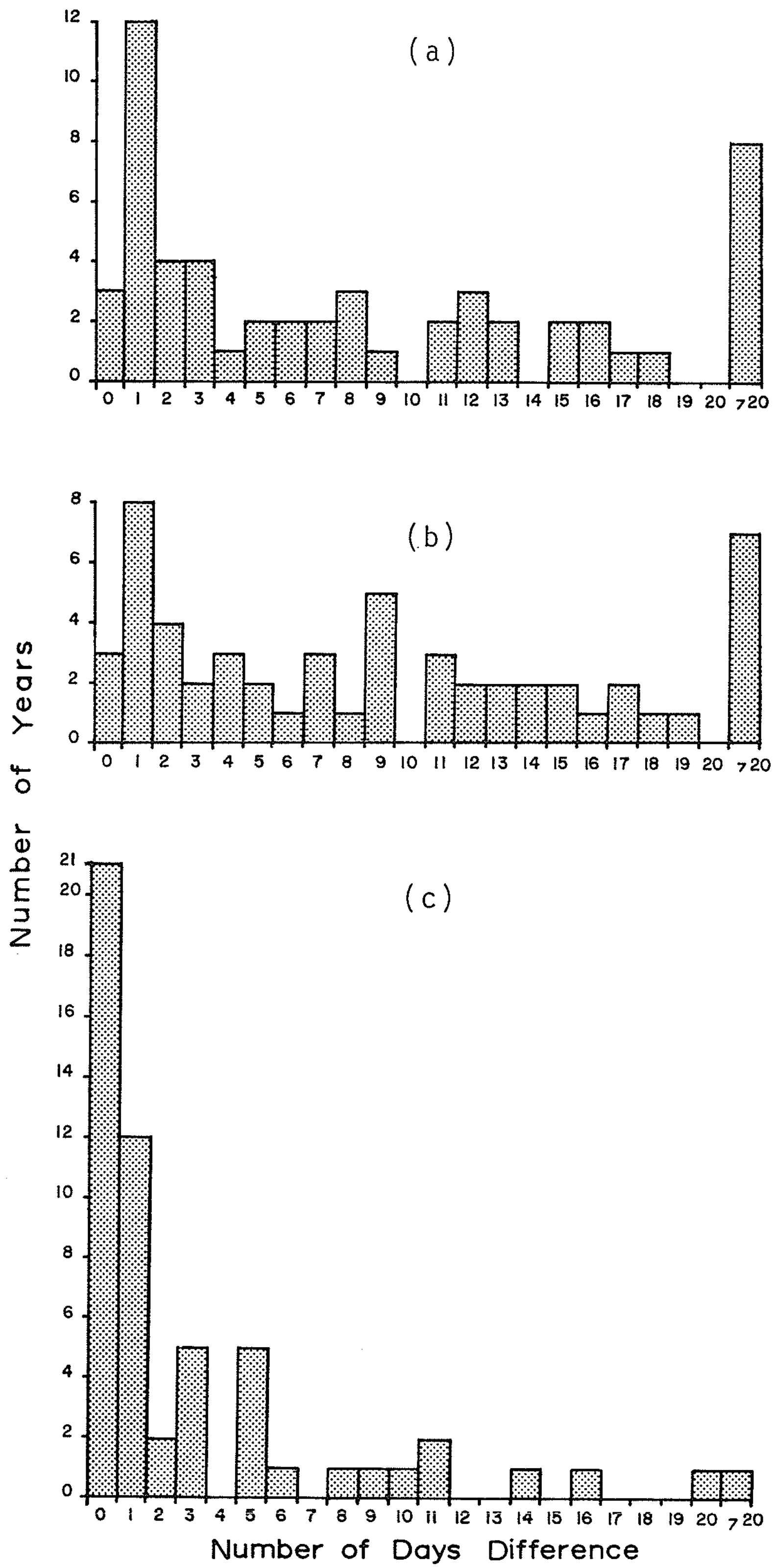

Figure 6.4: Frequency distribution of difference between dates of first forst: (a) at Winnipeg and at Brandon; (b) at Brandon and at Morden; (c) at Winnipeg and at Morden.

Figures 6.3 (a) and (b) show no such relationship. When compared to the same graphical analysis of the historical data (Figure 5.11) only Winnipeg and Morden (Figure 6.3 (c)) can be observed as having a greater degree of homogeneity than that between Moose Factory and Fort Albany on the basis of their dates of first snowfall.

Figures 6.4 (a), (b) and (c) all display an inverse relationship between the frequency of occurrence and the magnitude of the difference between dates of first frost at the modern paired stations. The strongest relationship is again observed to be between Winnipeg and Morden (Figure 6.4 (c)) although all three paired modern stations are considerably more homogeneous on the basis of their dates of first frost than are Moose Factory and Fort Albany (Figure 5.12).

The percentage frequency of differences exceeding 20 days was determined for both dates of first snow and dates of first frost from each of the paired modern stations and also from Moose Factory and Fort Albany (Tables 6.4 and 6.5). The results displayed in Table 6.4 indicate that Moose Factory and Fort Albany are no less homogeneous than the modern stations on the basis of dates of first snow. However, in terms of their dates of first frost Moose Factory and Fort Albany are far more inhomogeneous than are the modern stations (Table 6.5).

It seems evident, from the modern data, that the year-to-year fluctuations of first snowfall and first frost events vary considerably from place-to-place at the meso-

TABLE 6.4: PERCENTAGE FREQUENCY OF DIFFERENCES EXCEEDING 20 DAYS BETWEEN DATES OF FIRST SNOW

STATIONS	NUMBER OF PAIRED YEARS	% OF PAIRED YEARS HAVING MORE THAN 20 DAYS DIFFERENCE
Winnipeg-Brandon	48	22.9
Winnipeg-Morden	40	17.5
Brandon-Morden	57	31.6
Moose Factory-Fort Albany	111	22.3

TABLE 6.5: PERCENTAGE FREQUENCY OF DIFFERENCES EXCEEDING 20 DAYS BETWEEN DATES OF FIRST FROST

STATIONS	NUMBER OF PAIRED YEARS	% OF PAIRED YEARS HAVING MORE THAN 20 DAYS DIFFERENCE
Winnipeg-Brandon	55	14.6
Winnipeg-Morden	55	1.8
Brandon-Morden	55	12.7
Moose Factory-Fort Albany	90	38.9

scale. Thus, within areas of subdued topography in the humid microthermal climates in central Canada, significant mesoscale variations of the dates of first snowfall and dates of first frost occur and have real physical causes. This result implies that the lack of spatial homogeneity in the dates of first snowfall at Moose Factory and Fort Albany cannot be used as evidence to show that the data are invalid measures. However, these events do indicate that the historical dates of first frost are probably invalid measures since the degree of spatial inhomogeneity between Moose Factory and Fort Albany is greater than the degree of spatial inhomogeneity in southern Manitoba.

D. Comparison of Mean Dates

The final test applied to the modern data involved the calculation of mean dates of both first frost and first snowfall. This calculation utilized only those years for which records existed for all three modern stations. With regards to first snowfall, 48 years of coverage, extending from 1890 to 1938, were available whereas the records of first frost dates extended from 1922 to 1976 thereby providing 55 years of data.

Utilizing the previously mentioned system of numbering, the mean dates of first snowfall and first frost at the three southern Manitoba meteorological stations were calculated by the application of equation (1). The ensuing values are given in Tables 6.6 and 6.7. In order to more

TABLE 6.6: MODERN AND HISTORICAL MEAN DATES OF FIRST SNOW-FALL

STATIONS		MEAN DATE
Modern	(1890-1938)	
Winnipeg		October 25
Brandon		October 26
Morden		October 27
Historical	(1735-1864)	
Moose Factory		October 5
Fort Albany		October 2

TABLE 6.7: MODERN AND HISTORICAL MEAN DATES OF FIRST FROST

STATIONS		MEAN DATE
Modern	(1922-1976)	
Winnipeg		September 20
Brandon		September 11
Morden		September 21
	(1916-1976)	
Moose Factory-Moosonee		September 5
Historical	(1735-1864)	
Moose Factory		September 29
Fort Albany		September 28

easily accommodate comparative examinations, they are accompanied by the results of the same calculations previously performed on the historical dates.

An examination of Table 6.6 indicates that, with regards to first snowfall, the apparent extent of homogeneity between the modern stations is quite comparable to that between Moose Factory and Fort Albany.

At first glance the results displayed in Table 6.7 seem to indicate that, on the basis of a mesoscale comparison of first frost, the homogeneity between Moose Factory and Fort Albany compares favourably with that between the modern stations. However, it must be noted that the mean dates of first frost at both Moose Factory and Fort Albany are much later in the autumn season than the modern mean dates. In terms of a macroscale comparison, these results are inexplicable as the earlier mean dates of first frost, based on an extended period of record, would have been recorded in the more northerly, sub-Arctic climate of the James Bay region. Furthermore, the mean date of first frost calculated from modern records of the Moose River estuary, being earlier than the mean dates from southern Manitoba, is also more than 21 days earlier than the historical mean dates.

These results are further evidence that the historical dates of first snow may be valid measures whereas the historical dates of first frost are probably invalid. They also promote the possibility that this may be due to the fact that, as meteorological phenomena, frost events are generally much less visible than are snowfall events and therefore were recorded less accurately by the historical journalists.

CHAPTER VII

SUMMARY AND CONCLUSION

In the Introduction it was stated that the original objective of this study was to extend the climatic record of the James Bay area by as much as 150 years using historical references to snow and frost conditions contained in the journals of two Hudson's Bay Company posts. The information transcribed from the Moose Factory and Fort Albany journals comprised a great amount of heterogeneous descriptions of references to snow and frost phenomena. A previous, similar study had led to the development of a method of content analysis for the purposes of extracting dates of freezing and breaking of water bodies from these sources. The attempts made to apply this method of content analysis to derive dates of first snowfall and first frost were unsuccessful due to the narrow range of information contained in the transcriptions and because spatial components dealing with regular, local variations of snowfall and frost events are not apparent in the post journals.

The principle of spatial homogeneity was then applied to the historical dates of first snowfall and first frost in order to determine the degree of similarity between

Moose Factory and Fort Albany. It was assumed that if similar trends were detected this would indicate not only that the climatic conditions at the two locations are homogeneous, but also that the historical dates derived in this study are probably valid climatological measures.

With regards to dates of first snow, it was found that in certain time intervals there was a high degree of homogeneity between Moose Factory and Fort Albany, while in other time intervals the trends from the two stations were inhomogeneous. The tests revealed that the trends of dates of first frost at the two places were inhomogeneous throughout. The causes of this inhomogeneity were thought to be either physical in nature or somehow related to deficiencies in the data sources or in the method of interpretation of the data sources. Subsequent investigations indicated no inaccuracies in the transcribed information thus leaving real physical causes or deficiencies in the data sources as possible explanations for the differences in dates between Moose Factory and Fort Albany.

To determine which of these two explanations was the cause of the inhomogeneity between the two sets of historical dates, they were then compared to dates of first snowfall and first frost at similarly juxtaposed modern meteorological stations. As modern meteorological records are not available from the estuaries of the Moose and Albany Rivers, three meteorological stations in southern Manitoba were selected for this comparative examination. It was felt that the topographical similarities between southern Manitoba and the James Bay lowlands permitted the making of mesoscale comparisons.

The principle of spatial homogeneity was applied to the modern dates of first snowfall and first frost and the results were then compared to the trends found between Moose Factory and Fort Albany. With regards to dates of first snow it was found that the modern data are no more closely related than are the historical dates derived at Moose Factory and Fort Albany. Based on dates of first frost the modern stations were much more homogeneous than were Moose Factory and Fort Albany.

Although these comparative examinations cannot confirm the validity of the historical dates derived from the Moose Factory and Fort Albany journals, the results do not demonstrate that the historical dates of first snow must be considered invalid climatological measures. However, the results of these tests do indicate that the historical dates of first frost are invalid.

Climatological information derived from historical sources readily lends itself to computer coding and is increasingly used in attempts to catalogue or reconstruct climatic conditions of the past. This study has shown that historical information used in such endeavors may not be valid climatological measures and may therefore yield inaccurate or misleading results.

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