Climatic change in central Canada : a preliminary analysis of weather information from the Hudson's Bay Company Forts at York Factory and Churchill Factory, 1714-1850.

Ball, Timothy F.

CLIMATIC CHANGE IN CENTRAL CANADA: A Preliminary Analysis of Weather Information from the Hudson's Bay Company Forts at York Factory and Churchill Factory, 1714-1850.

by

Timothy F. Ball

A thesis
presented to the University of London
in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy
in
Queen Mary College

Winnipeg, Manitoba, 1983

I hereby declare that I am the sole author of this thesis.

I authorize the University of London to lend this thesis to other institutions or individuals for the purpose of scholarly research.

Timothy F. Ball

I further authorize the University of London to reproduce this thesis by photocopying or by other means, in total or in part, at the request of other institutions or individuals for the purpose of scholarly research.

Timothy F. Ball

The University of London requires the signatures of all persons using or photocopying this thesis. Please sign below, and give address and date.

ABSTRACT

A reconstruction of climate at the southern end of Hudson Bay has been developed for the period from 1714 to 1852 from diaries, weather journals and instrumental records maintained by employees of the Hudson's Bay Company. In order to cope with a variety of data, that can be generally classified as historical or secular, a coding technique for adaptation to a computer was developed that allowed for the integration of the two distinctly different types of material. Two sites at York Factory and Churchill Factory located approximately 100 miles apart on the southwest shore of Hudson Bay were studied. In this way homogeneity could be checked because changes at one site would be reflected in changes at the other unless they were caused by local variations. The study provides a long term record of climate change in a region that has received very little attention and yet is very significant to the general pattern of climates in the northern hemisphere.

Analysis of temperature, wind, precipitation, thunder and lightning, frost, and phenologic events indicate trends similar to those found in other parts of the northern hemisphere, but attempts at comparison of individual years with those experienced in Europe proved fruitless. The weather was more severe than at present in the first half of the 18th Century with colder temperatures, more days with snowfall and a higher percentage of northerly winds. From ap-

proximately 1780 to 1815 there appears to have been a great deal of variablility in the weather particularly in the number of days with precipitation. A critical change seems to have occurred in 1760. Prior to that date the two sites experienced very similar weather but after that date the variations are similar but the intensities and frequencies of events are quite different. This appears to indicate a change in the mean position of the Arctic Front so that York Factory, which had previously experienced Tundra type weather similar to Churchill Factory, after that date had weather symptomatic of the Boreal forest region.

PREFACE

There is also some danger at the present stage of developing, at considerable expense, the theory (and elegantly mathematically complete theroretical models) of climate without adequate knowledge of the observable behaviour of climate, and of the processes involved in climatic changes, over the last 300 to 3000 years. The soundness of the theoretical constructions, and of forecast advice given on the basis of them, is needlessly jeoparized as long as this observational base of the subject is neglected.

(H.H. LAMB, 1977, p. 17)

ACKNOWLEDGEMENTS

I wish to thank my advisor, Dr. B.W. Atkinson, for his kindly and thoughtful counsel during the preparation of this thesis. I would also like to thank the academic officers of the University of Winnipeg for their patience while this thesis was being drafted. I wish also to thank Dr. Roger Kingsley for his assistance with some of the mathematical and computational aspects of this work, and Miss Doree Sabourin for her care and accuracy in the typing of this manuscript. Finally, I would like to thank Mrs. Joyce Chernichan for the original work of entering over 160,000 records of data into our computer system, so that these analyses could be carried out.

DEDICATION

I dedicate this thesis to my loving wife, Marty, without whose encouragement and patience it would not have been completed.

CONTENTS

Appendix page

LIST OF TABLES

LIST OF FIGURES

Chapter I

INTRODUCTION AND OBJECTIVES

The interest in climatic change has received a boost in the last few years that has resulted in a growing awareness among all segments of society. This boost is probably attributable to the dramatic changes and fluctuations in weather that have begun to occur throughout the world Certainly people in Buffalo, New York were conscious in 1978, of the impact of snowfalls and low temperatures beyond all previously measured. Similarly, Great Britain will not forget too quickly the summer of 1976 with its extreme heat waves and drought, or the summer of 1977 with its excesses of rainfall.

The evidence of climatic fluctuation of varying wavelength and amplitude is defined as more and more information becomes available from a variety of sources. Climatic change is now widely recognized as a reality. Furthermore, researchers and politicians are increasingly aware of the significance of these changes on the human condition. As Hare and Thomas comment

> Today, however, the study of climatic change involves more professions than most interdisciplinary studies-physical scientists, geographers, biologists, historians, economists, archaeologists, and anthropol ogists are all interested in climatic change as it affects their discipline.
> (Hare and Thomas, 1980, p.86)

This awareness is being further accentuated by the increasing world population, and the demands this is placing on world food supplies. It is significant that in the past few years there has been an increase in the number of world conferences on matters that had previously been of concern only at the national or at most the continental level. World conferences on population in Bucharest in 1974 and food supply in Rome 1976 are examples of this concern that has brought together nations from the extremes of ideology. Much of the increased concern about shortages of food was a result of the extremes of climate that caused major crop failures throughout the world. The extremes of climate were themselves variable, in some areas drought, in others excesses of moisture, while in still others frosts or extremes of heat all served to diminish yields. The extent to which these climatically caused problems affected the world are perhaps best exemplified by the number of articles appearing in newspapers, by books being published, and by government reports presented on the possible results. In his book The Cooling, Lowell Ponte writes

> It is cold fact: the global cooling presents humankind with the most important social, political, and adaptive challenge we have had to deal with for ten thousand years."
>
> (Ponte, 1976, p. xvi)

Writing in the preface to the same book Reid Bryson says that,

> "My own opinion is intermediate-that climates change by relatively abrupt small steps; that these small steps are important, for they can be disruptive to stressed ecosystems such as ours is now; and that man can prepare somewhat for their occurence.
>
> (Ponte, 1976, p. xii)

Of course it is not just food supply that is of concern. Gradual cooling in northern cities, the Northeastern United States for example, would create increased heating costs, fuel supply problems and transportation problems. There is little agreement on the nature of climatic change. In the Canadian context F. Kenneth Hare writes,

> The concept of climatic change is not an easy one for Canadians to grasp, especially since our spectacular day-to-day weather changes are of greater magnitude than any due to climatic change. ...to reveal the fact of climatic change it is necessary to filter out these natural variations, which are part of our ordinary climates. Climatic change, that is to say, is a subtle process.
> (Hare, 1951, p. 9)

Geologists were among the first to observe that the northern regions of the world had experienced extensive continental glaciation. They also realized that the major geological eras were delineated by significantly different climatic periods.

The geological time scale might have been both an advantage and a disadvantage to early acceptance of climate change. The concept that temperatures could change gradually over millions of years would be acceptable to scientists of the uniformitarian school and to a public who would view short term fluctuations as cataclysmic and disquieting. Conversely these factors tended to retard acceptance of significant climatic changes on a much shorter time scale. The degree of fluctuation of climate and the time scale over which it can occur are still at the core of most research.

The longest obvious measure of time scale that the general populace can relate to is the human lifespan. If the temperature changes over a period of two or three million years it is easy to accept as a fact but extremely difficult to relate to over a total human lifetime. However within that lifetime we do have an ability to recall with suprising accuracy extreme seasons that have occurred. A study of the weather memories of senior citizens in Indiana showed, "...that many elderly persons do have a good recollection of past weather conditons. This shows up particularly well in relation to specific events. Given the time that has lapsed since many of the events occurred, the specifity is remarkable." (Oliver, 1975, p. 171)

Despite this recall ability and a general awareness that, "Winters were colder when I was young," or statements of that type, scientific interest was not aroused. A great deal of the problem for science lay in the fact that there was little evidence.

During the last 100 years there has been the development of world wide weather stations and improved meteorologcal instrumentation. However, even here there is the nagging problem that the 70 per cent of the world that is ocean has virtually no weather recording stations, and vast stretches of land, the polar regions, mountains and deserts, are in a similar situation. Automatic weather stations and satellites are starting to provide more complete coverage, but this is a slow and expensive process. Further they cannot provide data of past weather with the result that the world climatic picture, both temporal and spatial, remains barely an outline sketch.

It is therefore not surprising that we know little of the detail of the world weather picture. It is even less surprising that we have been unaware of climatic changes through time. As Lamb(1977, p.1) puts it, "Not so very long ago-between the wars in fact-climate was widely considered as something static, except on the geological time scale..." Thanks in part to Lamb's efforts much progress has been made, and yet we are still in dire need of data.

One of the features of Lamb's contribution to our growing awareness and understanding of climatic change has been his constant theme that the necessary data come from a variety of diverse sources and fall across the boundaries of many disciplines and thus encompass many methodologies. Others have recognized and tackled these problems in a variety of ways. One approach proposed by Craddock (1973, p.217) outlined a plan of action to collect weather data for the period from 1493-1860 in a uniform manner that can be adapted to the computer. He chose the beginning date because, "...before that time, direct evidence of weather situations over the American sector of the northern hemisphere does not exist."

The extent and nature of settlement patterns coupled with the large size of the North American continent will never allow us to obtain data for the whole "American sector" comparable to the data available in Europe for the historic period. Catchpole and Moodie (1978, p.124) note for Canada, "In comparison with Japan and Britain, the documentary evidence from Canada spans a brief period, but it is nonetheless important and is exceptionally rich in some of its characteristics."

It is relevant at this point to examine why North America has received so little attention with regard to its climate through the period since the arrival of Europeans. Researchers in North America, and Canada in particular, have only recently begun to examine some of the documentary evidence available. There appear to be several reasons for this tardiness. First, because of the view already mentionned by Lamb that climate change did not occur except on the geological time scale. Kenneth Hare correctly points out that "There are no historical documents, let alone instrumental meteorological records, concerning Canadian weather and climate until late in the sixteenth century." But he then goes on to comment that, "From the reports and diaries of early explorers, missionaries and garrison soldiers, we know that the weather of the seventeenth and eighteenth centuries was not essentially different from that experienced today." (Hare, 1980, p.85) a statement that seems to suggest that climate is still considered as something static. Second, because of a consuming interest in the climatic phenomena of the Pleistocene, and third the lack of knowledge that the documentary evidence referred to by Catchpole and Moodie existed. This last point was due to some extent to the fact that many of the documents were stored in European depositories.

Modern studies all indicate that the geography of the continent has a very significant impact upon the weather patterns of the northern hemisphere, particularly in the zone of the westerlies. From the historical climate perspective any information that can help to fill the current gap will be beneficial. This study attempts to pursue Craddock's concept of computerized data in central Canada.

1.1 OBJECTIVES

In light of the preceding introductory comments this thesis makes use of diaries and journals of climatic information maintained in central North America with a view to expanding significantly our knowledge of the past climate of North America. In order to make maximum use of these sources a methodology has been developed that will hopefully serve as a model for scientific use of historical documents. Major objectives can be outlined as follows;

1. To establish a broad flexible coding system that will allow for subjective written and proxy historical data to be adapted to computerizaton.
2. To establish a system that will allow for the integration of historical climatic information and instrumental meteorological records.
3. To provide a pioneer study of approximately 200 years in length by establishing long term records for the Hudson's Bay[1] Company posts at Churchill, Manitoba and York Factory, Manitoba, representing an important but neglected region of the northern hemisphere. The selection of these two locations will be explained later in this chapter. In the future other Hudson's

---

[1] The large saltwater bay extending from the Arctic Ocean south into Central Canada is called Hudson Bay, but the company that was granted rights to all the area being drained by rivers flowing into Hudson Bay is called The Hudson's Bay Company.

Bay Company journals at other locations will be examined to provide a spatial dimension to this primarily temporal study.

4. To provide information on yearly weather patterns and extreme weather anomalies that will assist historians and other social scientists in their attempts to document causes and effects of climate upon historic events.
5. To attempt to fill a small part of the large observational gap of climatic data in North America and particularly central Canada thus adding to the general knowledge about climate and climatic change in the Northern Hemisphere.
6. To attempt to examine the relationship, if any, between the sequence of climatic events in Europe and central Canada.

Two sites were chosen for the study, one at York Factory and the other at Churchill, both in the province of Manitoba, Canada. Although there were numerous sites that could have been selected (a complete list is given in Appendix B) these two were chosen because they satisfied a great many of the requirements needed to fulfill the objectives. York Factory has the most complete and longest record of any of the sites. It also was the administrative centre for the Hudson's Bay Company and as such had better qualified officers and they possibly therefore maintained the best records. It was also chosen because it was close to the site at Churchill where the record was almost comparable in length. Churchill had a further advantage because a modern instrumental record is maintained there, thus comparisons of historic climatic events could be carried out. Finally the sites are close enough for comparison and similar enough in environment to allow for comparison of climatic sequences. In this way actual climatic changes, rather than those caused by changes such as the erection of buildings, would be seen at both stations. This would provide for a check on the relative homogeneity of climatic events in the two records.

These objectives are directed at methodologies for dealing with vast quanitities of historical data in a rigorous manner. The thesis also attempts a preliminary examination of the actual climatic information generated by the study in order to extend westward the work of others in the North Atlantic and European sectors.

Chapter II

PREVIOUS WORK ON CLIMATIC CHANGE IN CENTRAL CANADA

For several reasons most of the work on proxy and instrumental evidence of climatic change has been carried out in Europe. The extensive network of long term recording stations combined with the historic impetus of scientific research and the impetus of meteorological knowledge demanded by the world wars is partly responsible. Conversely the lack of stations and the paucity of early records has hampered research in North America. While instrumental climate records are very limited in North America compared to Europe, historical sources of climate information are even more scarce thus creating a greater disparity between the two continents. Despite the vast array of historical documentation in Europe it is only recently, and principally through the work of H.H. Lamb, that the potential for using these proxy sources has been explored. The lack of documentation coupled with the lack of long term instrumental records has combined with the vastness of North America to inhibit research.

This review of previous literature acknowledges the pioneering work of Lamb, Manley and others of the European sector; however it is felt that analysis of the work in that region is not particularly relevant at this point. The principal reason for this position rests upon the geographical fact that central North America is a long way from Europe and as a result any correlations between the two regions are a relatively small portion of this essentially methodological and preliminary study of a valuable new source of data.

One of the ultimate objectives of the data generated by this study is to help to fill in the map. As a result there is a brief discussion of the extension westward of the European work, particularly that of Lamb and Johnson (1966) on pressure patterns of the North Atlantic and European work during the historic period the reader is referred to the encyclopedic work of H.H. Lamb (1977). Studies carried out on the east coast of North America will be discussed later, unfortunately there are very few studies done in the region between the eastern seaboard and the southern regions of Hudson Bay, a distance of approximately 1500 kilometres.

At present there are many large gaps in the climatological literature of North America. These gaps are both temporal and spatial and until they are at least partially filled only a vague picure and therefore a vague analysis of climatic change and its causes can be drawn.

In this review of previous literature the division between the secular period and the historical period will be considered as defined by the World Meteorological Organization in Technical Note No. 79. As the committee notes in the report these periods are loosely defined because the periods of quantitative meteorological observations and the period of extant chronicles, "...differ from place to place and from element to element." (W.M.O. 1966, p. 30). The secular period in North America reflects this variability with eastern regions generally having longer histories of settlement and therefore longer periods of instrumental record. Western and northern regions have at most 100 to 120 years of relatively continuous record. Meteorological journals maintained at Hudson's Bay Company posts will help to push this time back in some locations. The earliest instrumental meteorological record in the Hudson's Bay Company records was kept at Churchill Factory in 1769, followed by a continuous four year record maintained at York Factory from 1771 through 1774. These journals are valuable as datum points in a sea of proxy data from a vast area, but they cannot be considered as accurate or long enough to extend the secular period much beyond 150 years.

To provide a general context for this study a brief examination of evidence for hemispheric and continental climatic change is necessary. Recently several studies of the climatic history of different regions of North America have been published using early instrumental records and some proxy data (Mitchell, 1961; Roden, 1966; Pfaller, 1967; Wahl and Lawson, 1970; Eichenlaub, 1976; Mock and Hybler, 1976; Rosenberg, 1978; Skaggs, 1978; Travis, 1978). None of these studies include the region of central Canada within their purview.

It is unfortunate for historical climatologists that the beginning of the instrumental period, which progressed surprisingly quickly from the construction of the first instruments in the seventeenth century to the establishment of recording stations in North America by 1738, should be coincident with the end of the Little Ice Age. As a result clear delineation of the end of this critical period will have to be determined in North America from proxy and historical records. At present there appears to be a debate in the literature as to when this period ended. Evidence from many sources and regions clearly establishes that the entire northern hemisphere experienced a distinctly cooler period with "...low values of the long-term mean temperature at all seasons of the year by comparison with recent normals in most parts of the world" (Lamb, 1977, p.465). Obviously different regions, with their unique local conditions that can delay or advance the onset of climate changes, experienced the effects of the hemispheric cooling at different times and with different intensities. The author defers to the general position taken by Lamb that for the onset of the Little Ice Age "It is reasonable to regard the time from about 1550 to 1700 as the main phase for most parts of the world..." (Lamb, 1977, p.463). It is interesting to note that there does not appear to be as much variation in the date of onset of the Little Ice Age as there is in the date of the termination. It is important, however, that we do clearly establish the dates of these transitions because a difference of 50 years would be the average lifespan of a man of that time and is therefore very important from an historical point of view.

Instrumental evidence for North America in the 18th and 19th century is almost exclusively restricted to the eastern seaboard, with the earliest known systematic records beginning at Charleston, South Carolina in 1738. Four of these were maintained at stations in in the eastern United States.

The most detailed analytical use of early instrumental records are found in the work of Wahl (1968), and later Wahl and Lawson (1970). The results generally indicate that the 1830s and 1840s were markedly cooler than the period from 1931-60. They attribute this difference to an increase in frequency and persistence of influxes of polar air, which can possibly be interpreted as an increase in meridional flow.

Lamb and Johnson (1959), in their study of historical pressure data for the northern hemisphere, showed that during the 19th century the longitude of the western Atlantic surface trough in the region of 45 degrees north moved steadily eastward. As Bradley points out "The more westerly position of the western Atlantic trough in the early to mid-nineteenth century might thus be interpreted as a period of shorter wavelength of the stationary long-wave pattern, with a stronger trough over eastern North America (i.e., more meridional conditions) with reduced zonal flow in the upper westerlies" (Bradley, 1976, p. 4). This would result in an increased flow of polar air into eastern North America, a situation that Bradley argues is supported by temperature studies of various periods in the 20th century.

A subsequent study by Bradley appears to be less enamoured of the work of Wahl and Lawson.

> However, generalizations made by Wahl and Lawson for the western United States are based on a few widely scattered observations, most of which were kept for less than five years within the 20-year period. In fact, many states had almost no records for this period.
>
> (Bradley, 1976, p. 502)

Despite this difficulty Bradley only comments on it as it affects the precipitation patterns of the western United States for the 1850s and 1860s. It is valid criticism, but perhaps the key word is "generalization". When examining short time periods, that is from one to five years, the criticism is valid. When a longer time period is examined, that is greater than ten years, the criticism is less valid.

In a later study Lamb and Johnson (1966) found that

> "...despite the differences between the circulation patterns prevailing in the cold 1690s and in the warmth of the 1730s there were some features in common between them which distinguish a regime unlike the present century. The most obvious example of this is the extent to which Europe was apparently covered by anticyclonic (high pressure) patterns in every decade between 1680 and 1750. A concomitant of that (which unfortunately lies in the less guaranteeable edge region of our maps) is the low latitude of the main cyclonic (low pressure) over the western Atlantic."
>
> (Lamb and Johnson, 1966, p. 37)

Variations in latitudinal and longitudinal positions of the western Atlantic trough are obviously related to variations in the quasi stationary long wave pattern. Lamb and Johnson (1959, 1966) extended historical trends of general pressure patterns as far west of the prime meridian as their data would allow, and showed that the zones of wind circulation shift latitudinally on a long-term basis, (several decades) by as much as one to two degrees of latitude. During the period from the late eighteenth century and the early part of the twentieth century there was a one and one-half to three degrees northward shift of the 40-year mean position of the Iceland low.

Evidence for the 19th and early 20th century from western North America is scarce, and problematical. For example Baker (1960) indicates that minimum temperatures for the period from 1819 to 1950 in St. Paul, Minnesota, were experienced in the 1850s. In contradiction Wahl and Lawson (1970), using fragmentary records from military camps, concluded that temperatures in the 1850s and 1860s were warmer than the current climatic normal (1931-1960). (This period is used by Wahl and Lawson, although the W.M.O. now accept the period 1941-1970) This apparent contradiction is probably explained by one or both of the following factors.

1. The higher temperature region was centred to the west of Minnesota or
2. The records were too fragmentary to yield an accurate picture.

The former contention is probably the most reasonable because Minnesota would be influenced more by the outbreaks of cold Arctic air that would tend to block the penetration of warm Pacific air.

There are very few studies of climate changes in Canada using instrumental records and there are none available for the Hudson Bay region. The most significant national study appears to be the work of Thomas (1974). Regional studies that infringe upon the Hudson Bay region include Currie (1954), Thomas (1968), Longley (1972) and Bradley (1976).

Thomas (1968) concludes from a summary of the longest available records in Ontario that there has been a trend towards a warmer climate in Canada since 1880, with the major increase in temperature occurring in the 1890-1900 decade after an unusually cold spell from 1880-1890. In northern Ontario, which includes the shores of Hudson's Bay immediately to the east of York Factory, Chapman and Thomas (1968, p. 2) state that "...there has been no apparent trend towards warmer or colder temperatures since about 1910." A climate study of the prairie region, by Longley (1972) which includes that portion of Hudson's Bay where the two sites of this study are located, includes a plot of the ten-year moving average of mean temperature for the prairies south of fifty-five degrees north. Unfortunately the sites are both north of this line, but the trends are worth noting. Temperatures rose between approximately 1897 and 1910 to remain fairly constant between 1920 and 1950 during which time the annual mean stayed between 2.7 degrees Celsius and 3.3 degrees Celsius. The warmest decade was between 1925 and 1934. Between 1945 and 1960 it was generally cold, although the mean did not approach the values recorded prior to 1905.

2.1 NON-INSTRUMENTAL AND DOCUMENTARY HISTORICAL EVIDENCE

An excellent study of the existing and potential historical evidence for climatic change in western and northern Canada is set out by Catchpole (1978 p. 17-60). In this work he delineates the extent of the available Canadian historical evidence. "A deficiency of the historical evidence is the comparative brevity of its time span and this is most apparent in the communication evidence...Canadian sources are limited to three centuries, barely one per cent of the interval since 20,000 B.P." (Catchpole, 1978, p. 20) Later in this article Catchpole notes that "by virtue of their broad distribution in time and space, and their frequent climatic commentary, the post journals comprise the richest source of climatic evidence in the Hudson's Bay Company's Archives."(Catchpole, 1978, p. 33) It is the opinion of Catchpole, and this author that the post journals and the meteorological journals maintained through this time and in this region represent an almost unparalled source comparable to any records located to date.

Until recently knowledge of the potential for historical climatology using these records was restricted to one or two isolated and cursory studies. An example of this type of work was published by A. Burnett Lowe under the title "Canada's First Weatherman" (Lowe, 1961, p. 4). Unfortunately Lowe did not continue his work and it remains on file at the Department of Atmospheric Service's weather office in Winnipeg. Although trained as a meteorologist Lowe provides average temperatures with no explanation of how these were obtained, or any awareness of the great dangers inherent in temperatures taken with mercury thermometers that freeze when temperatures reach -38.8 degrees Celsius (-37.9 degrees Fahrenheit), as they frequently do in the regions round Hudson Bay. It should be noted that Lowe obviously intended to continue these studies and if there had been a greater awareness of the significance of these records and a greater awareness of the significance of climatic change at that time, he might even have been allowed to pursue them as part of his regular job.

In 1965 a study was carried out by MacKay and MacKay (1965) in order to determine the dates of freeze-up on the Churchill and Hayes Rivers. The work made use of the post journals for Churchill and York Factory supplemented by information from records of the Department of Transport and the Geological Survey of Canada (Mackay and Mackay, 1965, p. 7). The paper attempted to estimate temperatures for the period prior to instrumental records and concluded that the time of harbour closing at Churchill could be estimated on the basis of temperature alone. The study found that "...neither river shows in its records a trend toward earlier freeze-up or later break-up" (MacKay and MacKay, 1965, p.7) which seems to suggest that temperature has not varied significantly over the period of record.

A subsequent, and much more detailed study carried out by Moodie and Catchpole (1975) applied rigorous testing to the technique of content analysis in order to ensure a systematic and objective method of establishing the annual dates of freeze-up and break-up. The significance of these results was elucidatd in a subsequent paper and serve as a base for both the techniques developed and the trends observed. It is difficult, however, specifically to classify this work as being indicative of local weather for as the authors themselves note, "the climatological similarities between York and Churchill are not paralleled by equivalent hydrological similarities" (Moodie and Catchpole, 1975, p. 101) An interesting point to make is that freeze-up does tend to reflect local conditions whereas break-up is much more a function of melting and runoff conditions over the whole drainage basin. A distinction that is observed in the results of MacKay and MacKay as well as Moodie and Catchpole who both found that the dates of freeze-up vary more than the dates of break-up.

One of only two truly climotological studies based upon the Hudson's Bay Company Archives was a study of air mass frequencies over Rupert's Land carried out by R. Minns (1970). Using a method developed by Bryson (1966), of determining air mass frequencies by identifying certain diagnostic features, namely wind direction and temperature, the author extracted information from four post journals. He reached the conclusion that outbreaks and existence of Arctic air in western and central Canada were more frequent in the late 19th century than at the present time. This could probably be equated with the modern interpretation of a transition from zonal to meridional conditions.

The most recent contribution, and the second truly climatological study is the work of T.R. Allsopp. This work is an attempt to determine "a chronological sequence of agricultural weather for the Red River basin from 1800 to 1871..." by the use of "...select viable scenarios based on the premise that what has occurred before can occur again" (Allsopp, 1977, p. 1). This is an interesting empirical approach in light of the current poor predictive techniques for weather forecasting beyond three or four days or even thirty days. The strength of the paper lies in its synthesis of material from a variety of sources as diverse as dendrochronology, journals, diaries and recorded lake levels.

2.2 OTHER SOURCES OF EVIDENCE OF CLIMATE CHANGE

The discussion to this point has involved only historical sources of climatic evidence for the region around Hudson Bay. There are however, several excellent studies that examine evidence of climate change from a variety of other indicators. Most of these are insufficiently sensitive to detect other than relatively long term changes. It is more precise to characterize them as indicators of environmental change and generally they can be classified into four sub categories.

1. Glaciological and geological studies (primarily geomorphological).
2. Paleosol, vegetational and biological studies (primarily palynological).
3. Cultural evidence.
4. Dendrochronology.

2.3 GLACIOLOGICAL AND GEOLOGICAL STUDIES

The first category includes a study by C.W. Locke and W.W. Locke III that used air photographs to determine those areas that showed reduced lichen cover on north-central Baffin Island in the North West Territories of Canada (Locke and Locke, 1977). It was determined that "...a limited amount of lichenometrical measurements indicated that the lichen-free areas probably represent a period of more extensive snow cover approximately synchronous with the Little Ice Age" (Locke and Locke, 1977, p. 291).

A study that would be in the same group but which relied upon glaciological evidence attempted to relate past and present glaciological responses to climate. The hypothesis was of course the traditional Lyell approach that the present is the key to the past. A second assumption made was that favourable conditions for glacierization would require "...some combination of snowy winters and cool summers" (Brinkmann and Barry, 1972, p. 79). In their effort to determine present conditions that would create an ice centre in the Keewatin District of northern Canada Brinkmann and Barry reached several conclusions concerning the results obtained from analysis of weather anomalies at the surface and 700 mbar level, as well as displacements of the mean 700 mbar trough over eastern Canada. They found that high winter precipitation may occur simultaneously on both sides of Hudson Bay on a monthly basis, even though daily circulation patterns are quite different. The monthly pattern reflected a slight westward displacement of the 700 mbar trough which is hemispherically related to a general low index type of circulation. When the trough was deep over eastern Hudson Bay cool summer spells occurred in both regions but the weather was generally dry in Keewatin and wet in Labrador-Ungava. With the trough in either a western or normal location in winter Keewatin and the northern part of Labrador received above average precipitation, while the area between Hudson Bay and Ungava Bay was average or below. Western and normal positions of the trough result in Keewatin being drier than average and Labrador-Ungava wetter than average. (Brinkmann and Barry, 1972, pp. 88-89)

These changes are obviously related to changes in the flow components associated with the various positions of the

700 mbar trough. Some positions and intensities result in flow patterns that transport increased moisture to the area. They suggest that this supports, or at least is not in contradiction with the palynological evidence. It is important that the study does not notice any significant temperature differences between the west and east sides of Hudson Bay, Keewatin on the west side of Hudson Bay and Labrador-Ungava on the east side, regardless of the position of the trough.

As part of research project begun in 1977, the National Museums of Canada are attempting to determine "climatic change in Canada for the last 20,000 years" (Harington, 1980). One of the articles published after one year of work was "a review of paleobotanical studies dealing with the last 20,000 years; Alaska, Canada and Greenland". (Hills and Sangster, 1978, p. 73) A map from this article is shown in Figure 1 and is included to illustrate the paucity of paleobotanical information generally throughout Canada, but specifically in the region of Hudson Bay. Very few of the paleobotanical studies extend into the recent time period and fewer still attempt to examine the climatic implications of their results. One part of this research project includes reference by Catchpole (1978, p. 25) to work in progress at the University of Manitoba that will use ships logs of the Hudson's Bay Company to extract references to sea-ice and weather. A masters thesis completed in the spring of 1981 provides a detailed examination of contacts with ice in Davis Straits over the period of record. (Catchpole, pers. comm.) (Faurer, 1981)

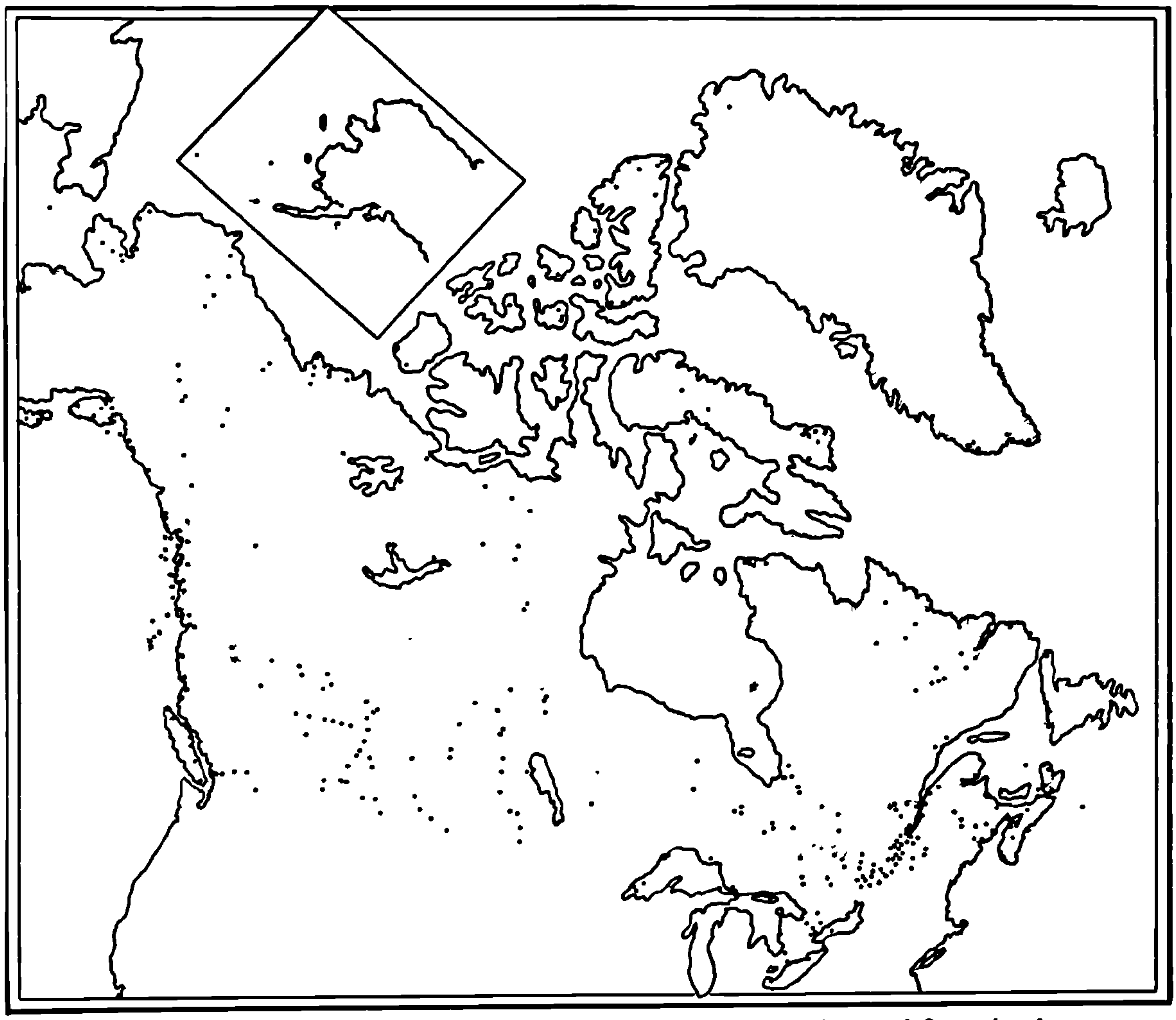


FIGURE 1 **Sites of Paleobotanical Studies for Canada, Alaska, and Greenland**

SOURCE. Hills, L.V. and Sangster, E.V., SYLLOGEUS, No. 26. National Museum of Natural Sciences 1980; Ottawa, Canada

Figure 1: Location of palynological sites in Alaska, Canada and Greenland

2.4 PALEOSOL, VEGETATIONAL AND BIOLOGICAL STUDIES

Three studies can be used as examples of the second group. These are the work by Ritchie and Hare (1971), which attempted to examine the relationships between the tree-line and climate in the late quaternary, and the extensive work of Nichols in the Ennadai, Keewatin, and Lynn Lake regions of central Canada (Nichols, 1967b). After this initial work Nichols published a more complete analysis of these regions. The latter study is the most valuable as a potential link between the natural indicators of climatic change and the historical records of this study (Nichols, 1970). Nichols estimates the mean summer temperature of the Keewatin district to have been about one degree Celsius above modern values during the medieval warm epoch. This was followed by a return to colder conditions which culminated in the colder conditions of the Little Ice Age. Again the broad scope of these techniques lacks the sensitivity to determine other than general climatic change such as the Little Ice Age. This is valuable, however, because it does indicate that this event did occur in the study region and would therefore give credence to studies that indicate the end of that event.

2.5 CULTURAL EVIDENCE

In the third category, namely cultural, there are some interesting transitions occurring that suggest environmental change. These changes are also apparently coincident with the Little Ice Age. Three factors are identified by Barry et al (1975) that seem to point to a cooling trend. There was; a continued expansion of hunting of ringed seal among Eskimo cultures; an increasing spread and adaptation of the quarmat[2] as a form of housing; and finally a tendency toward communal housing (Barry et al., 1975). As the authors note in their conclusion

> The precise nature of the climatic influence, where it seems to have been critical in effecting cultural change is hard to assess." (Barry et al., 1975, p. 206)

Geographers are all too aware of the dangers and implications of environmental determinism, but it is also generally acknowledged that cultural responses to environmental change are much more direct in earlier societies.

2.6 DENDROCHRONOLOGY

The third study bases climatic reconstruction upon statistical analysis of dendroclimatic evidence. The most complete study of this type, which is of value to this study, is the work of Blasing and Fritts (1976). Using ten different types of tree-growth anomaly patterns identified in Alaska and northwestern Canada for the period from 1800 to 1939, the authors inferred climatic conditions and correlated these with circulation anomalies over the region, reconstructed from arid site trees in the southwestern United States. Instrumental records for the period from 1899 to 1966 were used to calibrate tree ring data from 49 sites located in southern Canada, the western United States and northern Mexico. Pressure data from the instrumental records was subjected to reduction techniques that identified

---

[2] Quarmat - a skin-roofed sod/stone, snow block or ice block structure.

five distinctive pressure types in western North America and the north Pacific sector. Blasing and Fritts conclude "...from the coincidence of growth anomalies in Arctic and sub- Arctic regions with certain anomalies in the pressure patterns that the pressure reconstructions do provide some valid information on past climate in those regions" (Blasing and Fritts, 1976, p. 57). But most importantly they note that "the overall reconstructions imply a more meridional circulation in the 19th century than in the first half of the 20th" (Blasing and Fritts, 1976, p. 58).

In the work of Brinkmann and Barry (1972) discussed earlier there is an attempt to clarify the climatic differences between the west and east sides of Hudson Bay. Because they studied locations of the Arctic Front, which Bryson (1966) places along the southern shore of Hudson Bay, they avoided the complexities of a transitional zone. Their region of study falls totally within the tundra zone which is well to the north of even the summer position of the Arctic Front and the northern forest limit. Both locations being examined in this study are very close to this northern forest limit, Churchill lying just to the north and York Factory just to the south. As Lamb points out, the fact that the two phenomena of the tree line and the mean summer position of the Arctic front are also related in Eurasia indicates that "It is probably a two-way relationship, with the vegetation distribution a natural response to the temperature and radiation conditions associated with the air masses on either side of the Arctic Front but the differences of surface roughness, albedo and moisture helping to maintain the general positon of the Front" (Lamb, 1977, p. 228). It will be seen later that there is evidence that the tree line in the vicinity of Churchill has been artificially shifted southward by the deforesting activities of man.

2.7 THIS STUDY IN THE CONTEXT OF PREVIOUS WORK

Because this study covers a relatively long period of time and because it spans the transition from subjective written documents and other proxy sources of climatic information into the era of instrumentation it is difficult to classify it within the context of the works discussed in this section. Climatologists tend to study either the historical or the secular portion of the records, partly due to methodological differences. In some areas, such as central England, it has been possible to find secular records that cross over the boundary into the historical period. However this is extremely rare and does not occur in sufficient locations to aid in smooth transition of climatic records. Until now the central Canada region has had no instrumental record that transcends this boundary. It has the added problem of lacking historical documents and records not to mention the paucity of proxy data generated by human activities and cultural patterns. Many regions have the benefit of climatic evidence from organic sources. Dendrochronology is an example of this type of evidence and is particularly suitable because the scale of time, that is annual or semi annual, comes close to the time scale of the historical record. To a great extent it appears to be this precision of measurement and length of time about which one can accurately make a climatic statement that is the inhibiting factor in keeping researchers in their specific areas. A dendrochronologist is extremely satisfied if a seasonal pattern of climate can be established from one year to the next. In order for an instrumental record to achieve the same information a large amount of information has to be discarded to the dismay of the researcher. Unfortunately climate is continuous and therefore ultimately the methods of research must be brought together to provide a continuous climatic record. Determinists might argue that the onset of the Little Ice Age triggered an attempt to measure scientifically its effects thus leading to the invention of meteorological instruments; others would say that it was a natural evolution of cultural advance. Regardless of the cause the result was that the Little Ice Age straddles the transition from historical to secular periods with the result that people measuring with different scales find different dates for its commencement and its decline.

Catchpole (1978) makes a distinction between inferential historical evidence and communicated historical evidence, which may or may not be actual weather diaries. Under the heading of inferential historical evidence he identifies behavioural elements, such as settlement, cultivation and migration, that can be altered if the climate of a region should change. They are cultural elements that are responsive to changes of climate and therefore can be used as indicators of those changes. Again the implications of environmental, or more specifically climatic, determinism are implied.

Communicated historical evidence is the category to which Catchpole assigns historical sources that "...contain direct references to the weather and related environmental conditions (Catchpole, 1978, p. 18). Sources of this type range from those of Claudius Ptolemaeus kept at Alexandria in the second century A.D. to similar diaries maintained from 1621 to 1650 by the Landgrave Hermann IV of Hessen. As Lamb notes other diaries that have been subjected to scientific study are:

1. William Mede 1337-1344, Lincolnshire England
2. E. Haller 1546-1576, Zurich, Switzerland
3. Tych. Brahe 1582-1597, Hven, Denmark

He comments that many other weather diaries are extant, but very few have been studied in even a cursory manner (Lamb, 1977, p. 30).

Much work has been done on sources that identify extreme events such as droughts, floods or great frosts or snows. As would be expected most of these comments are related to their impact on the human condition, and Lamb correctly warns of the inherent dangers of the difference between our need to know not only the extremes that these studies represent but also normal range of climate of earlier times. An example of this problem can be seen in farming in western Canada. For wheat the best conditions for optimum yields and worry-free farming occur when conditions are close to drought. A dry spring allows early seeding and easy working of the fields. Adequate rain, nominally 76mm to 100mm in the month of June followed by dry conditions will ensure excellent yields. Climatologically it would have been a very dry year. Agricultually and economically it would have been a year unworthy of comment or at best, if yields are well above average, a passing comment on good yields.

In summarizing this review of previous work in the Hudson Bay region some difficulties for the climatologist are both inherent and insurmountable. These might be listed as follows:

1. The lack of modern records, and the continuing existence of large regions with no recording stations, seriously hampers synoptic analysis. The region of North America defined as ET climate according to the Koppen system there are only 16 stations with meteorological data spanning more than 25 years in an area, including the Arctic archipelago, equal to Europe.
2. The lack of modern weather stations reduces the possibilities for comparison of historically derived data with that occurring at present or even the immediate past. It is ironic to note that if climatic interpretation of the Hudson's Bay Company records by the computer method outlined in this study can be achieved the area of central and certainly northern Canada will have a more complete network of climatic information sources for the historical period than for the twentieth century.
3. Even in those locations where modern meteorological records are being kept there are none that are of sufficient length or continuity to provide a 30 year span.

Recently some of the problems of collecting data in the Arctic regions of Canada have been resolved by the establishment of scientific research stations, although these tend to concentrate on or around the ice fields of Baffin Island. Remote automatic weather stations are providing additional information, although these tend to be concentrated in the Beaufort Sea in conjunction with the oil explorations in that region. Finally, the ubiquitous satellites are gathering large volumes of data that will help to provide continuous and complete coverage of these remote regions.

Chapter III

THE FORT SITES

It is a quirk of geography that the early invasion of Canada by the English, and in particular the Hudson's Bay Company should be through north central Canada; an area that today is struggling even to exist let alone to expand. The search for the Northwest passage coupled with the practice of latitude sailing and efforts to avoid the North Atlantic Drift resulted in early explorers to Canada arriving via the Davis Straits and Hudson Straits into Hudson Bay. As a result the earliest trading posts were established on the shores of the Bay. The principal sites were at York Factory, Fort Albany, Moose Factory and Fort Churchill, and therefore these locations provide the longest period of record for this study (see Fig. 2).

The Hudson Bay Company's primary interest was the fur trade, a commerce that required relative ease of movement to the interior. Therefore these early Forts were all located on the estuaries of relatively large rivers. The sites of the stations used in this study are shown on Fig. 3a & 3b.

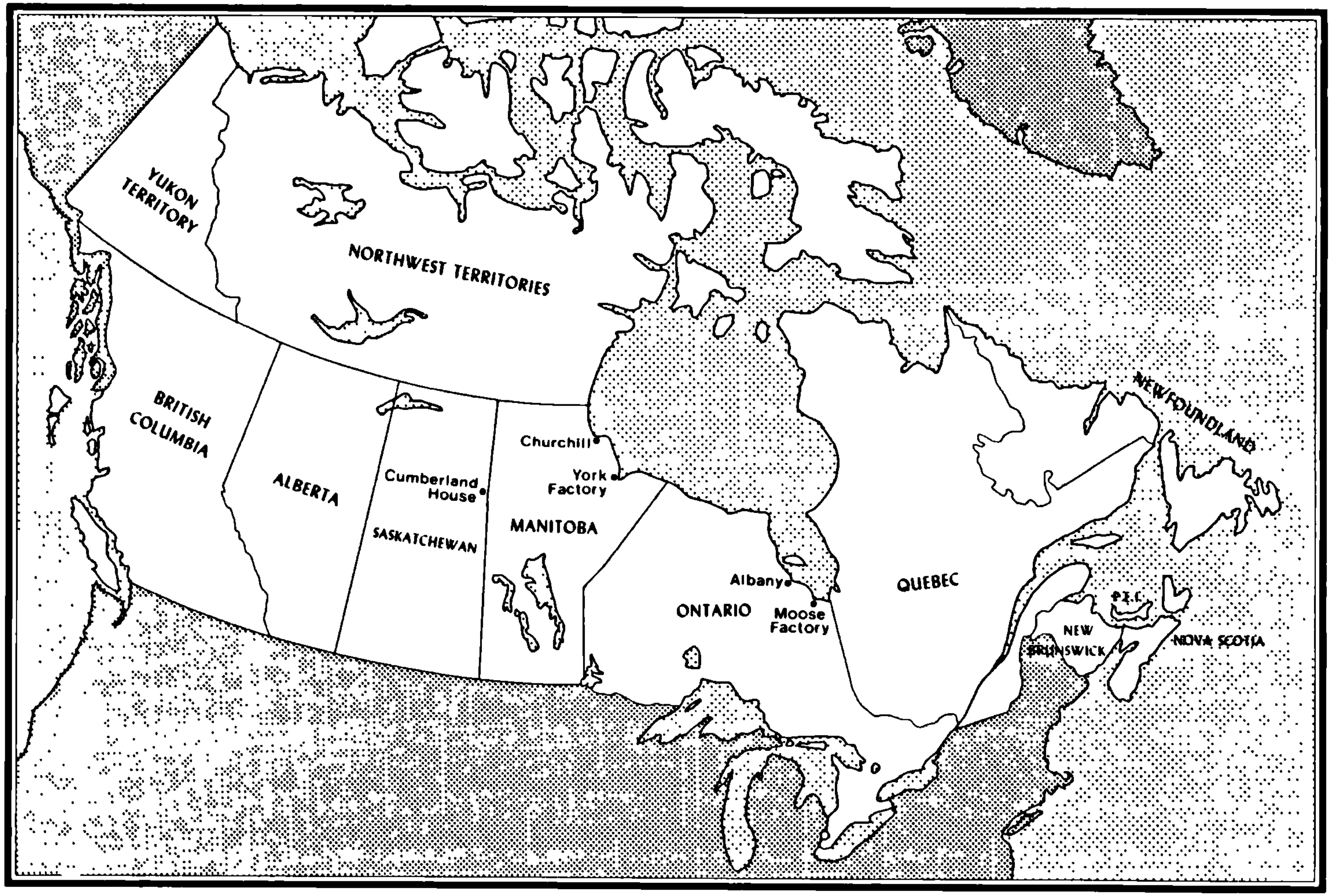
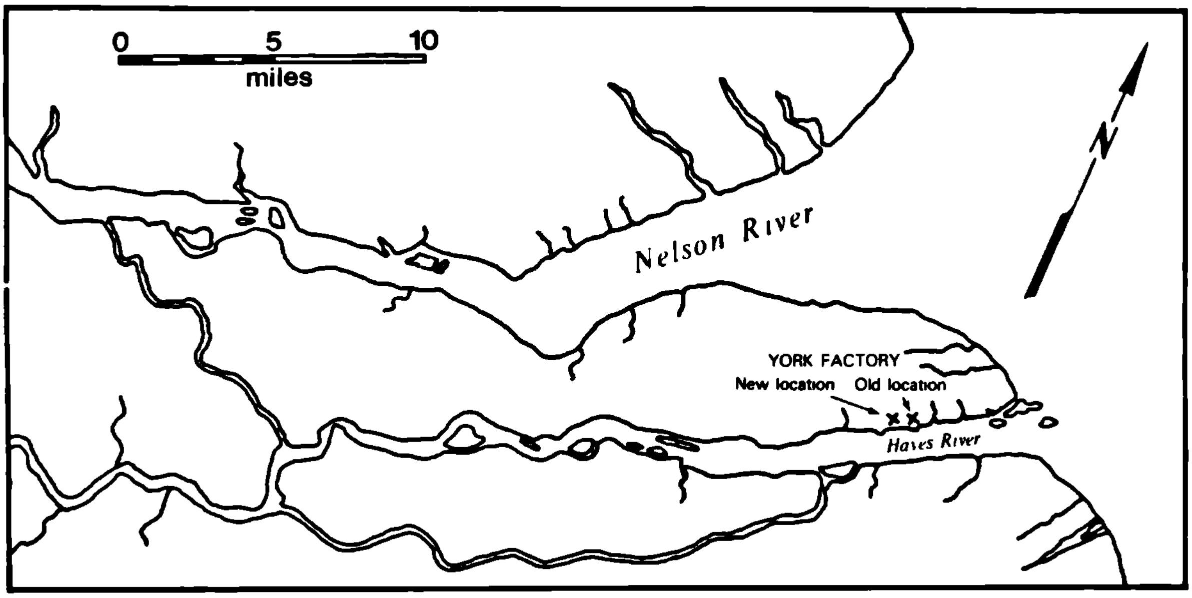


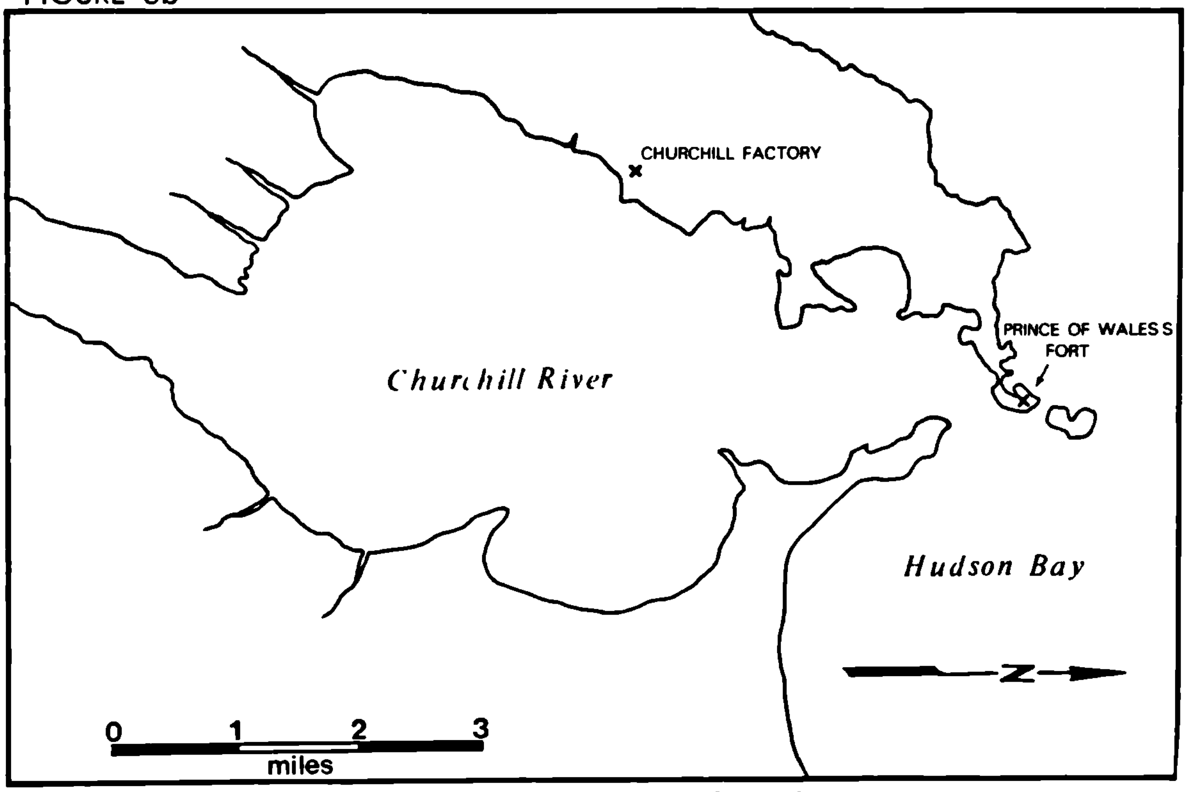
Fig. 2 Location of Study Sites

FIGURE 3a



Locations of York Factory

FIGURE 3b



Location of Churchill Factory and Prince of Wales's Fort

3.1 YORK FACTORY

The settlement at York Factory is one of the oldest in North America, having been established in 1682 under the name Fort Nelson. Unfortunately there is little or no record of this early period. The site was occupied alternately by the French and the British between 1682 and 1697 and by the French from 1698 to 1713. Following the treaty of Utrecht the British returned in 1714 and occupied the Fort almost continuously until 1952. Throughout this period the Fort occupied two sites. The first is shown at point A on map Fig. 3a, and was in existence from 1714 to 1790. This change of location is extremely important insofar as the continuity of a climatological record is concerned; it is examined in more detail when the consistency of the data is considered. The second post was located at point B on Fig. 3a, and was in existence from 1791 to 1953 as a trading centre for the Hudson's Bay Company. The main building of this second site is still in remarkably good condition as can be seen in Figures 4 to 13. Churchill Factory is no longer in existence, but the walls of Fort Prince of Wales still stand as shown in Figure 14.

3.1.1 Site 1

Thomas Hutchins, surgeon and scientist, maintained a meteorological journal at this location in 1771 and 1772 (H.B.C Arch. B239/a/67). In the introduction to his journal he provides a very adequate description of the locale, particularly with regard to its climatic location. The location is approximately fifty-seven degrees north, ninetythree degrees west on the ribbon of land that separates the Hayes and Nelson Rivers. The buildings are approximately 100 yards from the edge of the Hayes river and 5 miles from marsh point that marks the estuary on Hudson Bay.

Hutchins notes that the "The shore rises gradually from the point of the marsh and at this place is ten or twelve feet above high water mark" (H.B.C Arch. B239/a/67 p.1) Due to isostatic rebound in this area Hudson Bay has been rising since disappearance of ice during the last retreat of the Wisconsin ice. The result is that there is an extensive low marine plain surrounding the ever shrinking Hudson Bay. Both sites 1 and 2 are now further above sea level than they were at the time that Hutchins made his observations. It is not thought that these changes are significant enough to create any measurable climatic variations at the sites over the period of record.

Generally the site can be described as wide, open, and as unencumbered from physical features as is possible. The only major interference that requires discussion are the woods that surround the Fort. Hutchins notes that

> ...it is five miles from the sea and defended from the cold bleak winds from the northward and westward by the woods which surround it, at about a quarter of a mile distance, except the south-east side which is open to the river
> (H.B.C Arch. B239/a/67 p. 1)

Fortunately wind directions were recorded as follows.

> The direction of wind is observed by the vane on a flag-staff about fifty feet high...
> (H.B.C Arch. B239/a/67 p.2)

Because this location is so close to the tree line where tree height is low, usually less than 2.5 m, (see Fig. 4) the fifty foot staff would provide adequate clearance above the tree canopy. Also it is important to note that the one quarter mile clearing is well within the standards acceptable for modern 'forest' climatic stations.

The World Meteorological Organization (W.M.O. Tech. Note# 79. 1966) warns that wind exposures may be affected through time by trees growing up in an area. At York we could expect a northward movement of the tree-line and more favourable growing conditions if there was an amelioration of the climate in the post Little Ice Age period. The result would be an increase in the quantity and size of the trees surrounding the Fort as the climate became milder. Any attempt to observe this by examining the trees themselves is hampered by an early example in North America of man using up the most immediate energy source. By 1820 the demand for firewood coupled with the extremely slow replacement rate of the trees was taking its toll. A fascinating book written in retrospect and subtitled "Some observations on the state of the Canadian northwest in 1811 with a view to providing the intending settler with an intimate knowledge of that country", by Eric Ross (1970) summarizes the impact of these demands at York and Churchill. At York Factory he writes that "...the line of trees over the years has been retreating even further from York and the other bayside Factories, under the relentless demand for fire-wood and timber" (Ross, 1970, p. 101)

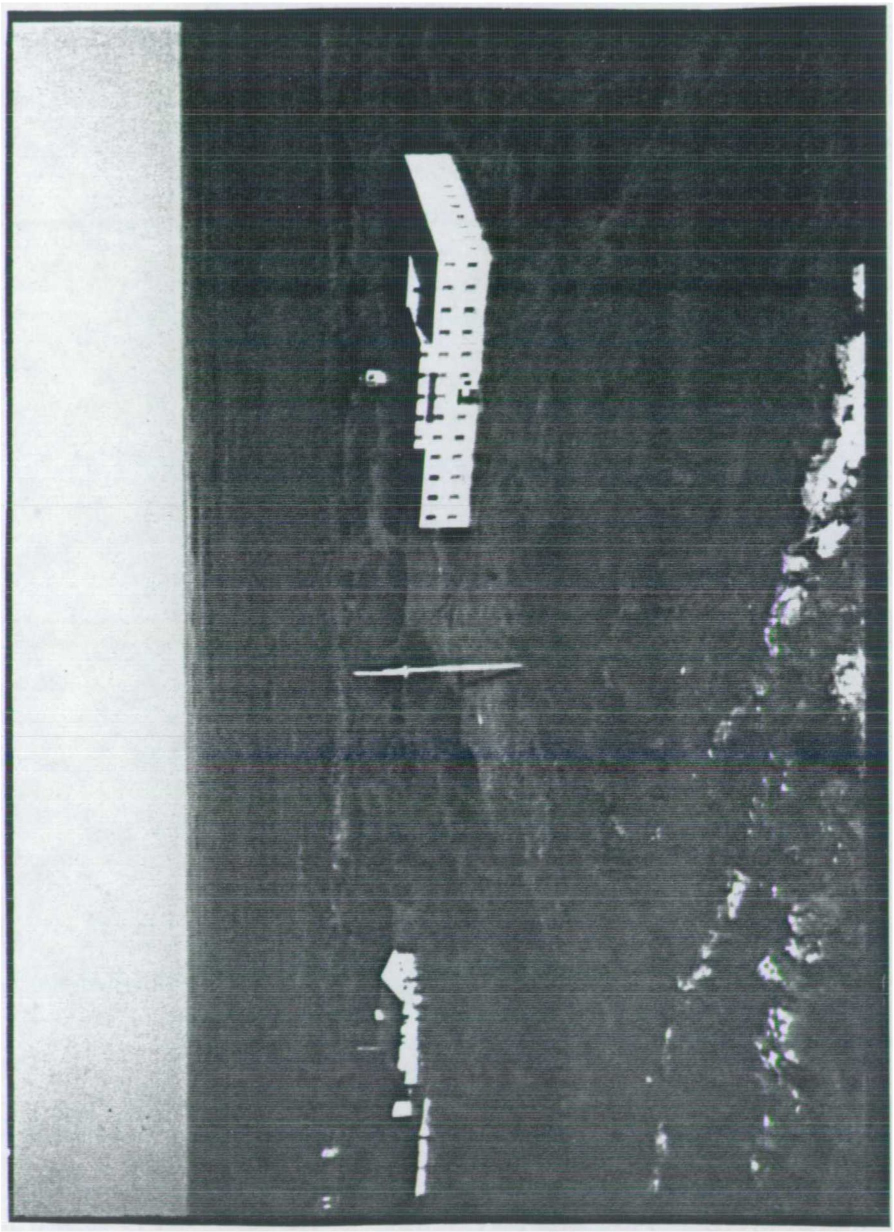


FIGURE 4 Aerial view of York Factory looking north-west. Note the height of the bank and the clumps of trees in the distance.

Figure 4: View of York Factory looking Northwest

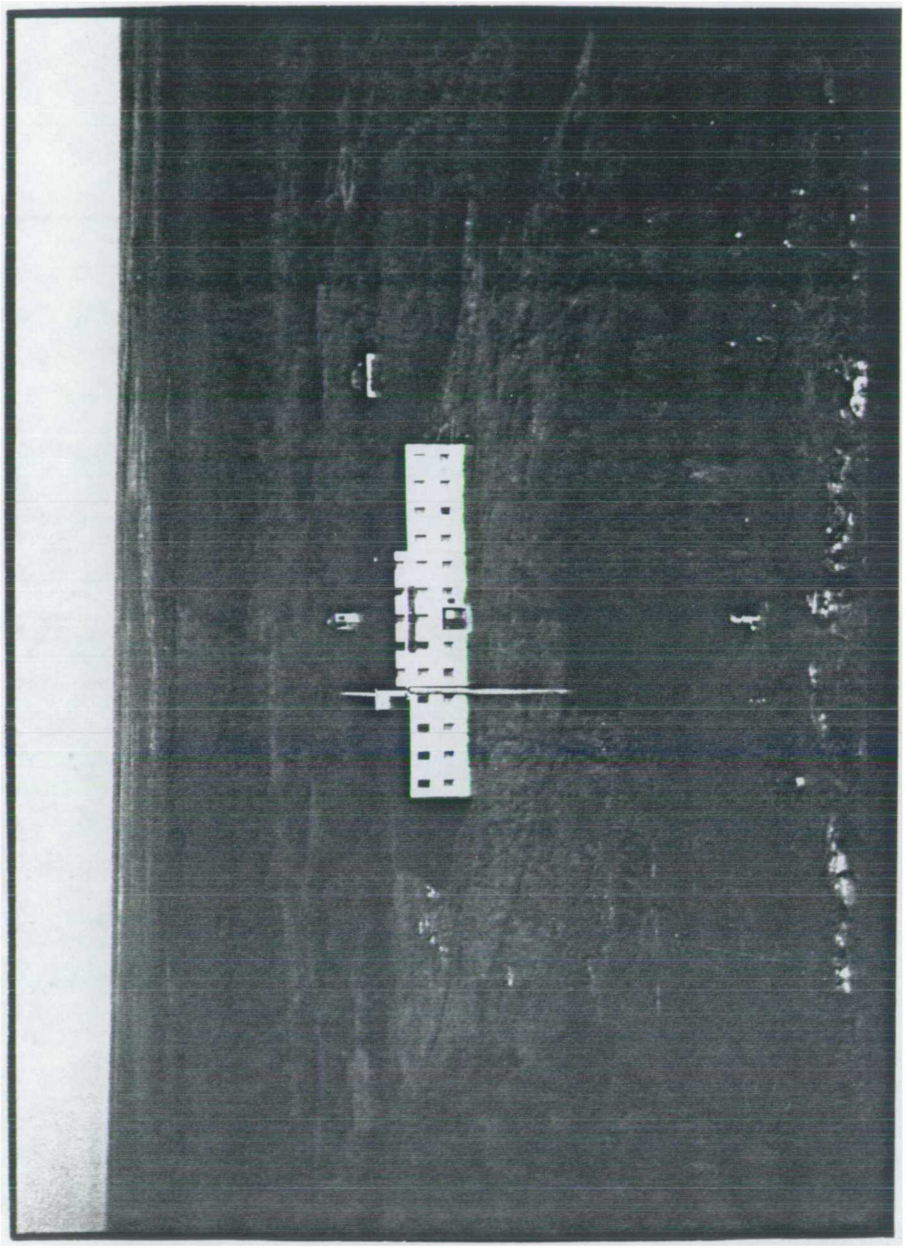


FIGURE 5 View of York Factory looking north. Notice the height of the bush relative to the man.

Figure 5: View of York Factory looking North.

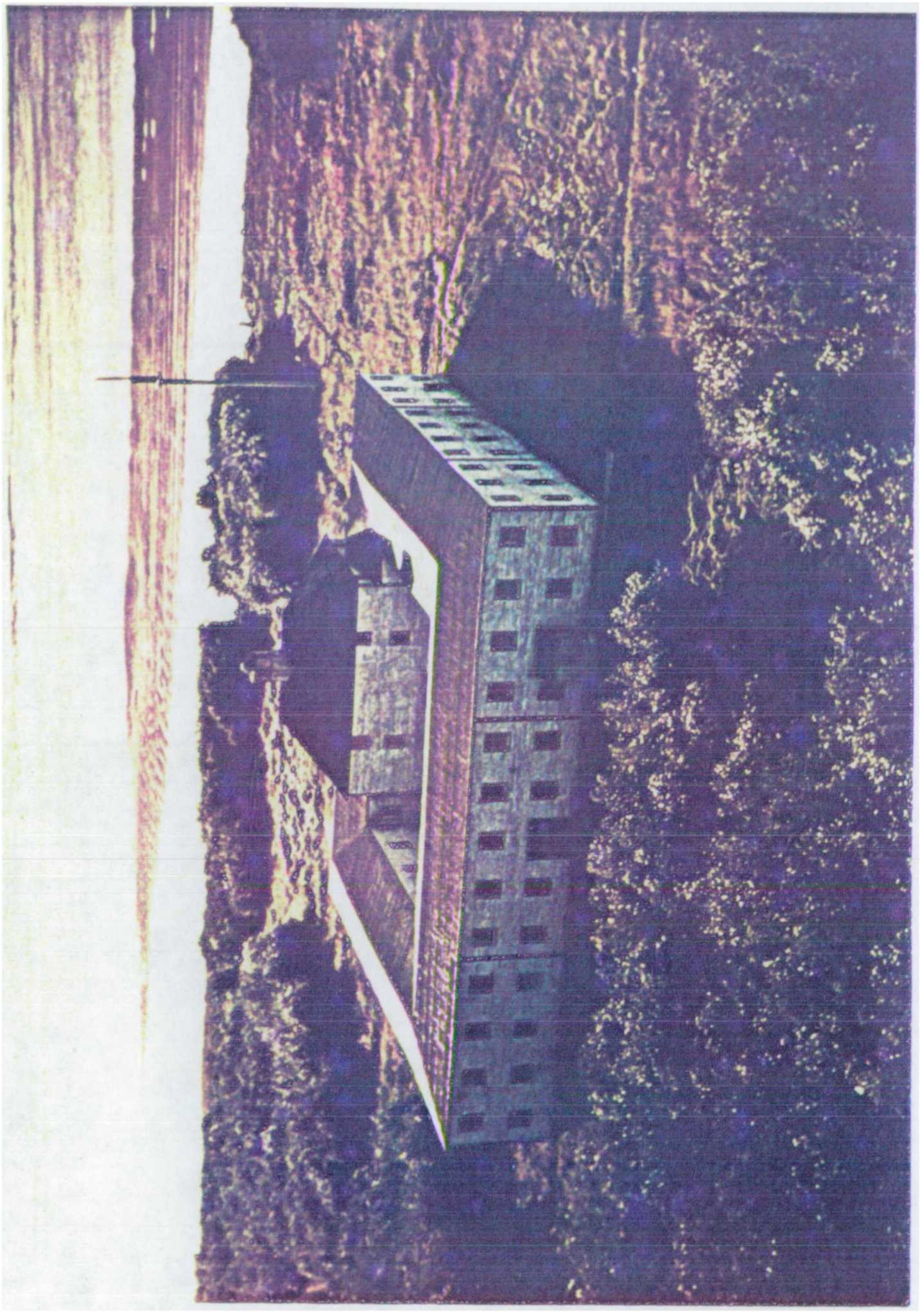


Figure 6: View of York Factory looking south toward the Hayes River.

Figure 7: View from the main building lookıng southeast across Hayes River

Figure 8: Ground View of York Factory looking Northwest

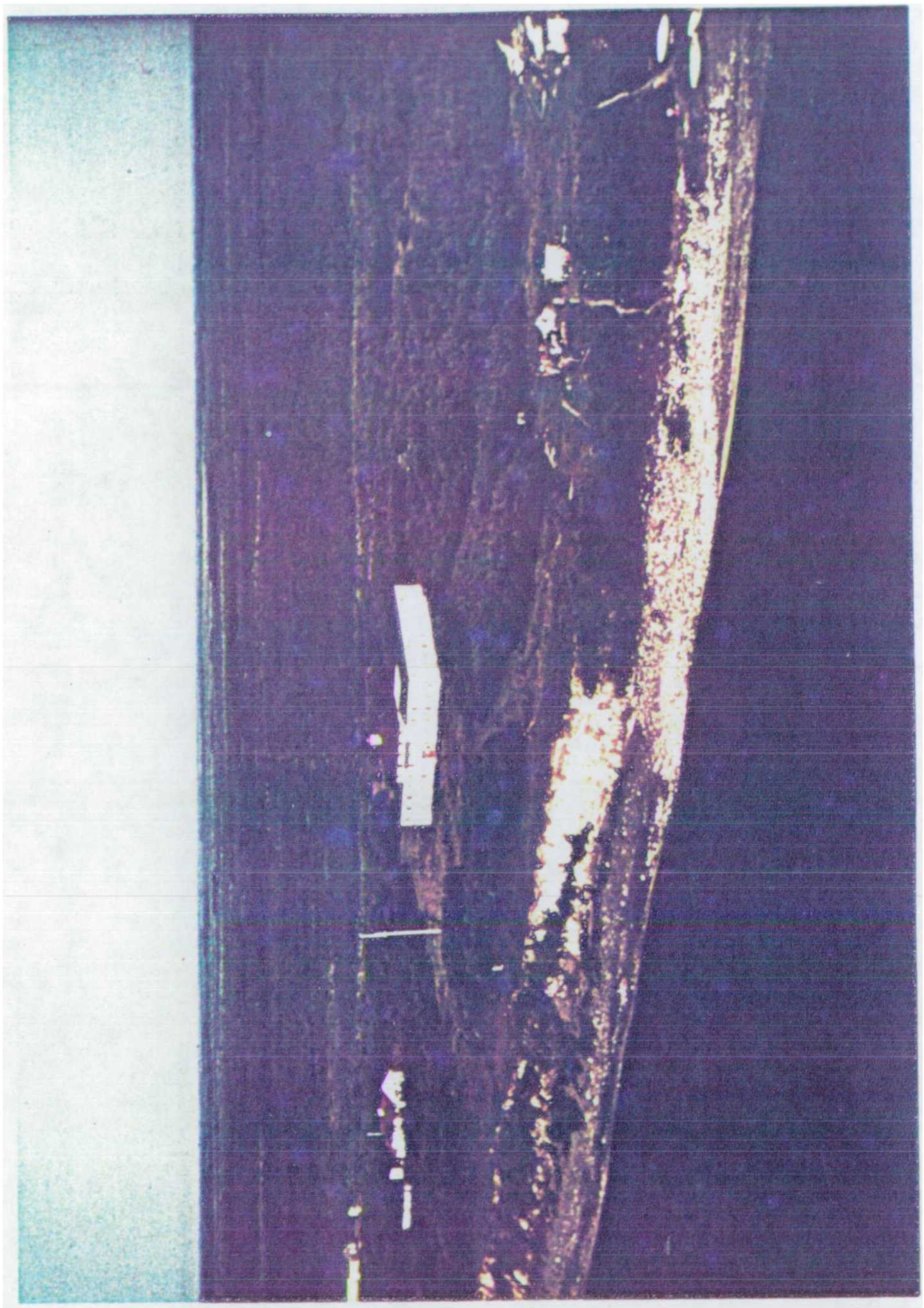


Figure 9: Aerial View of York Factory looking Northwest

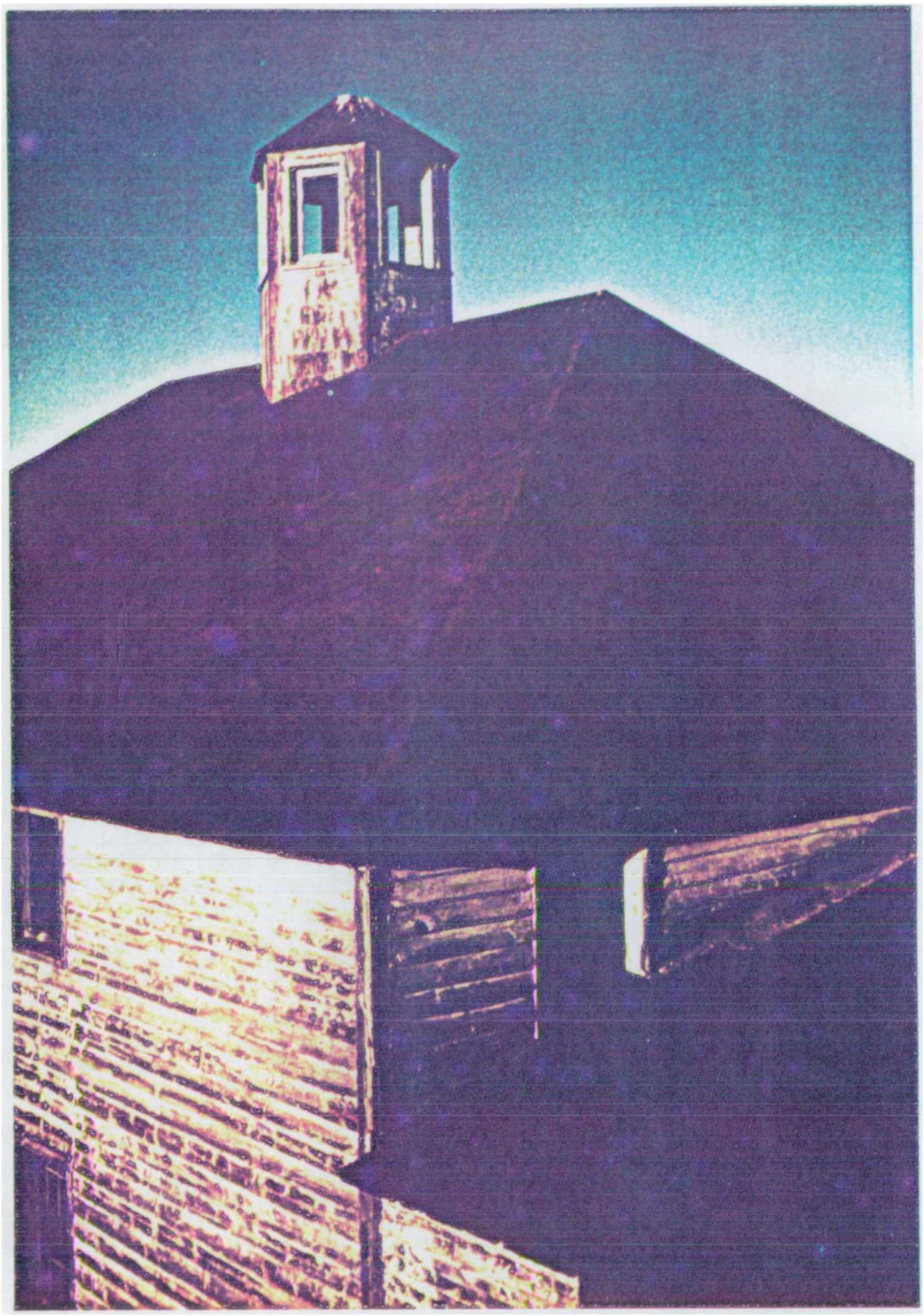


Figure 10: Main building at York Factory with Cupola or lookout

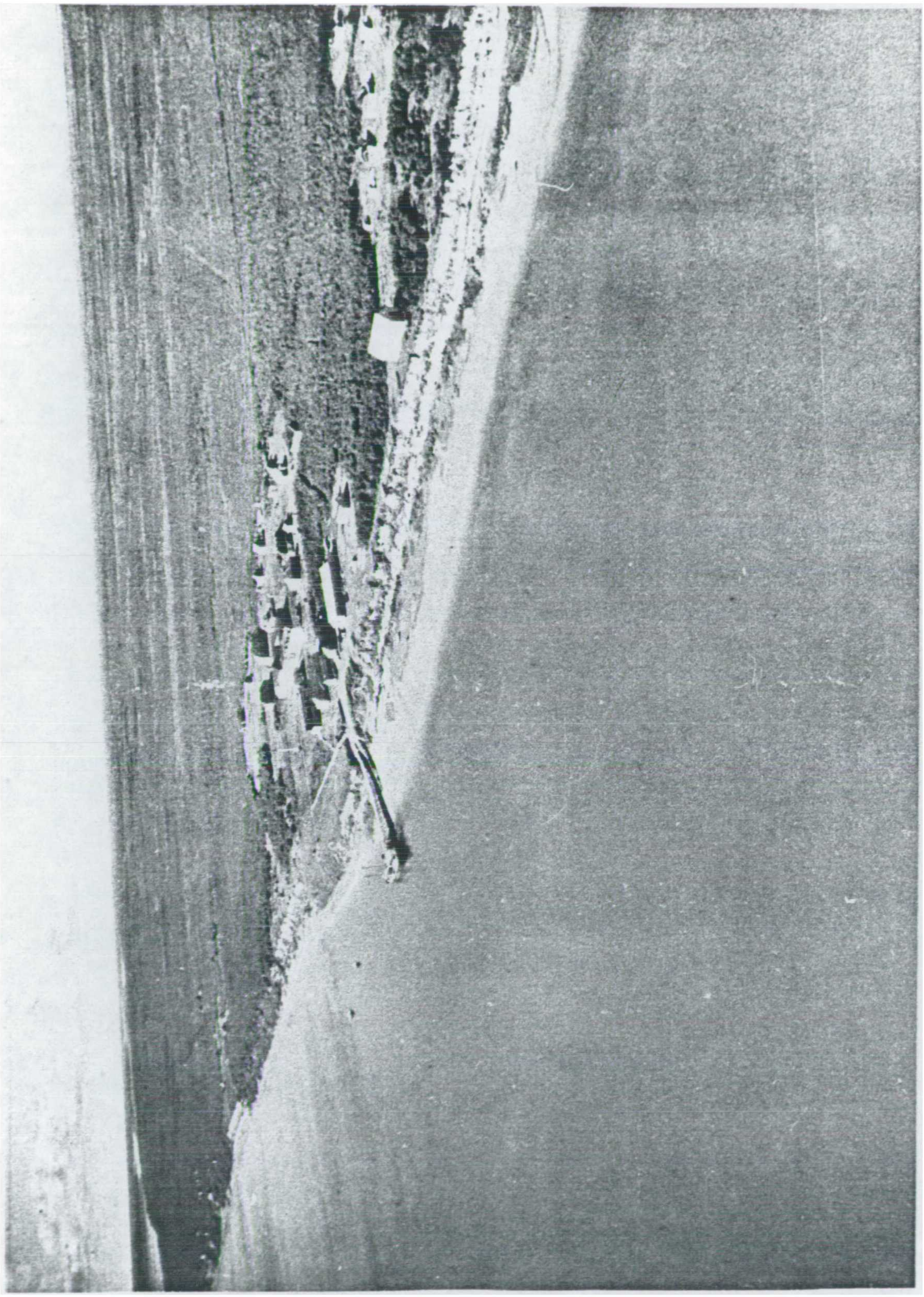


FIGURE 11 Oblique aerial view of York Factory looking north-west.(taken in 1932)

Figure 11: Oblique aerial view of York Factory looking NW. (1932)

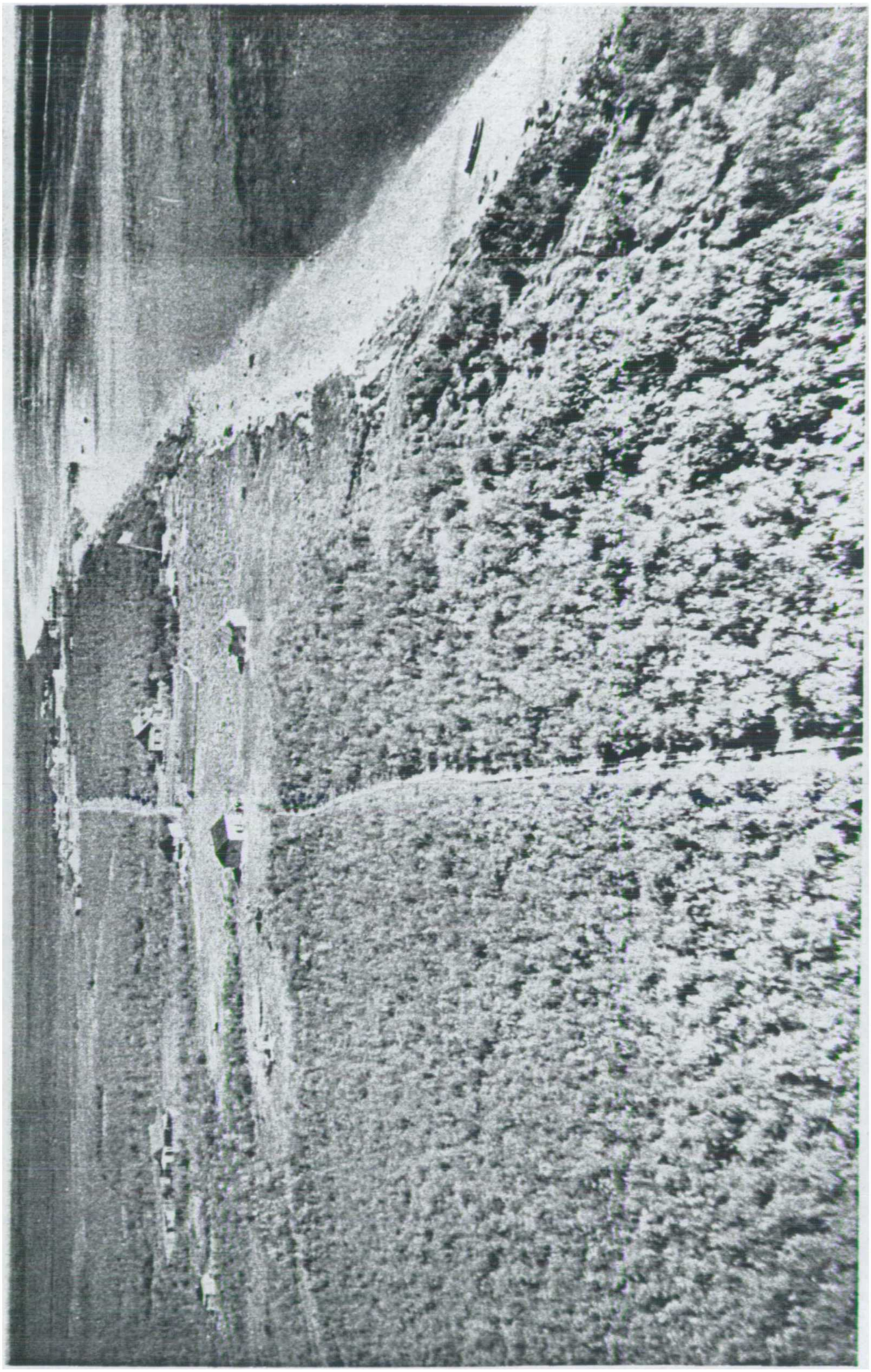


FIGURE 12 Oblique close up of York Factory looking east. Note the height of the bush relative to the men in the right foreground.

Figure 12: Oblique aerial view of York Factory looking East. (1932)

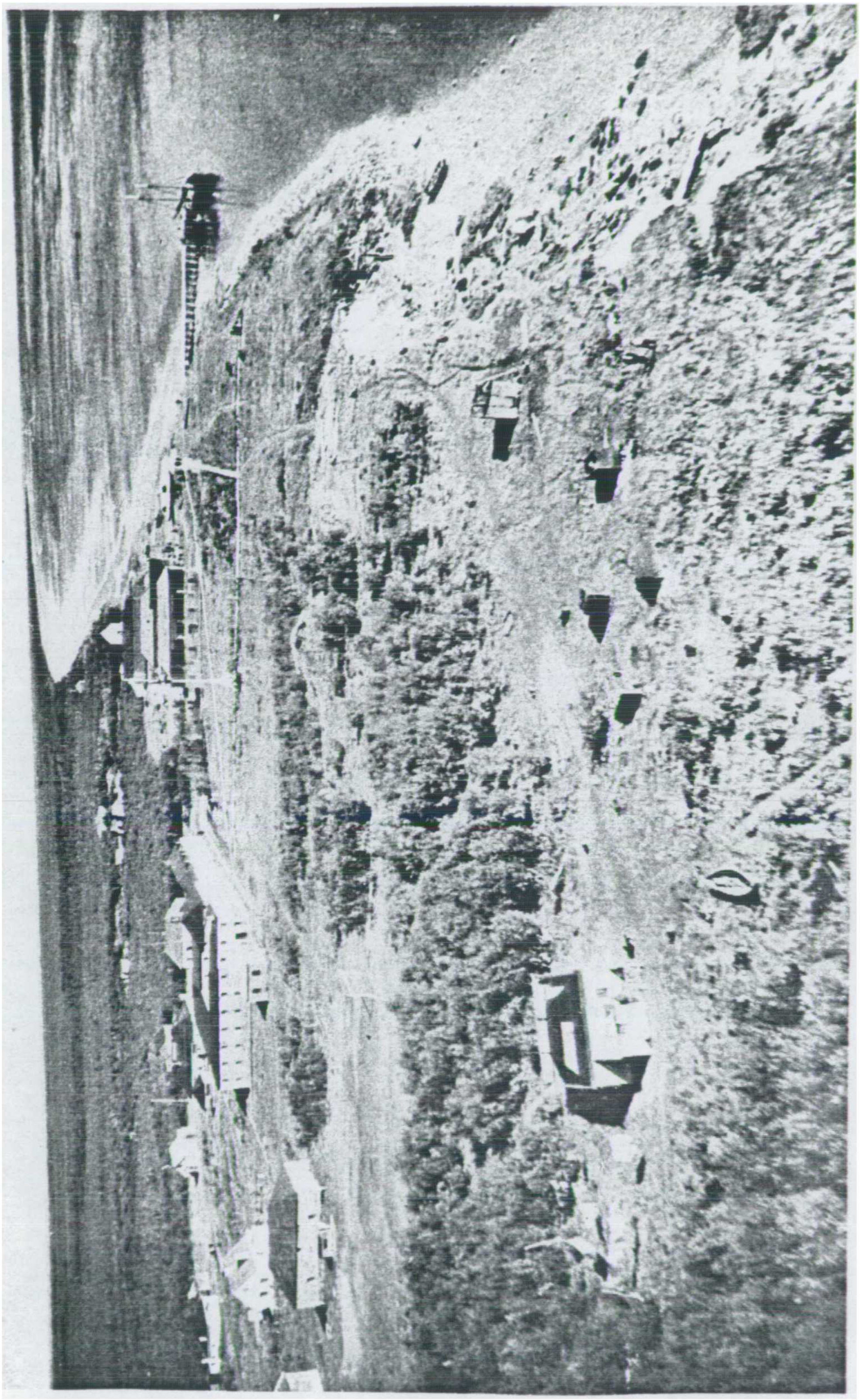


FIGURE 13 Oblique close up of York Factory looking east.

Figure 13: Oblique closeup of York Factory looking East. (1932)

3.1.2 Site 2

The second York Factory was built because of the danger of flooding at the original location. The motivation to move was further precipitated by the destruction of the first Fort by the French Admiral La Perouse in 1782. J.B. Tyrrell visited the York Factory region in 1912 and noted that "...the old Fort could be clearly identified by Robson's plan, and was about half a mile north of (ie. downstream from) York Factory" (Douglas and Wallace, 1926, p. 12). The sites are so close and the topography so similar it is reasonable to assume that there will be little or no variation in the climate as measured at the two stations.

3.2 CHURCHILL FACTORY

It is rather ironic that today Churchill still flourishes as a major port while York Factory is virtually abandoned because throughout the period since the arrival of Europeans the latter was the most important. Churchill provides a further irony in that the first location was abandoned in favour of Fort Prince of Wales, only to see the Company return to the old Fort location in 1782. Samuel Hearne had been governor of Churchill that year and had suffered the loss of the Fort to the French. When he returned he re-established at the old location 5 miles up river from Fort Prince of Wales.

It is difficult to determine the height above sea level of either the old Fort or Fort Prince of Wales. An indication of the elevation of the latter is provided by Ross.

> The point is too small - just large enough to accommodate the Factory and its palisades, but no more. It is also too high and too steep for easy communication with the water, and yet it is too low for safety... "Fresh water comes from a cask sunk in a swamp about three hundred yards from the Factory. Unfortunately it is on the same level as the high tides...
>
> (Ross, 1970, p. 103)

Even today neither site, both of which have been subjected to the effects of isostatic rebound, is more than 15 feet above high water mark. It is reasonably safe to assume that both sites were even closer to sea level over the period of record. Sloop Cove, which was used for wintering the Forts' vessels, is now dry under any tidal conditions, and has been used as a clear indication of the amount of isostatic rebound in the region (Fuller, 1963, p.44).

Trees at Churchill are even less of a potential interference to climatic observations than they are at York. Today the tree line runs just to the south of the port of Churchill. It is possible that the southward limit of the tree-line is a reflection of human interference rather than climatic conditions. Rate of growth is extremely slow in this region so that trees removed in the eighteenth and nineteenth centuries would only now begin to show significant replacement. Ross observes that "...by the middle of the eighteenth century, the scattered trees along the banks of the Churchill had been cleared to a distance of some 80 miles from its mouth" (Ross, 1970, p. 101). More important, he notes that observers of the time wrote that at Churchill the trees were smaller and further from the Factory than at other Company locations.

The flatness of the terrain and the open exposed sites that have seen little or no change during the period of record leave them unencumbered with the usual changes that occur to weather recording stations. The uniformity of conditions over a wide area at both York Factory and Churchill Factory tends to negate any differences in climate that may be a result of minor changes in the location of observations. These changes in location are even less significant for the continuity of the record than is normally the case because they occurred during the historical period, that is prior to the commencement of instrumental records. As a result it would appear that the sites have changed very little, and certainly in no way that would be detrimental to a long term climatic record, and therefore are probably representative of a much larger area and are important as an analysis of climatic change in central Canada.

3.3 THE LOCATIONS ON A LARGER SCALE

Both stations are located on the southwest shore of Hudson Bay and at approximately the same latitude, Churchill at 58 degrees 45 minutes north and York Factory at 57 degrees 10 minutes north. Hare and Thomas (1979) have divided Canada into seven arbitrary climatic regions with most of the country classified under the Arctic and Boreal. Churchill and York Factory are located on the boundary between the Arctic and Boreal regions. This boundary separates the treeless Arctic region from "...the climate that supports, and is interlocked with, the Boreal forest formation that stretches from Alaska to Newfoundland..." (Hare and Thomas, 1979, p. 129).

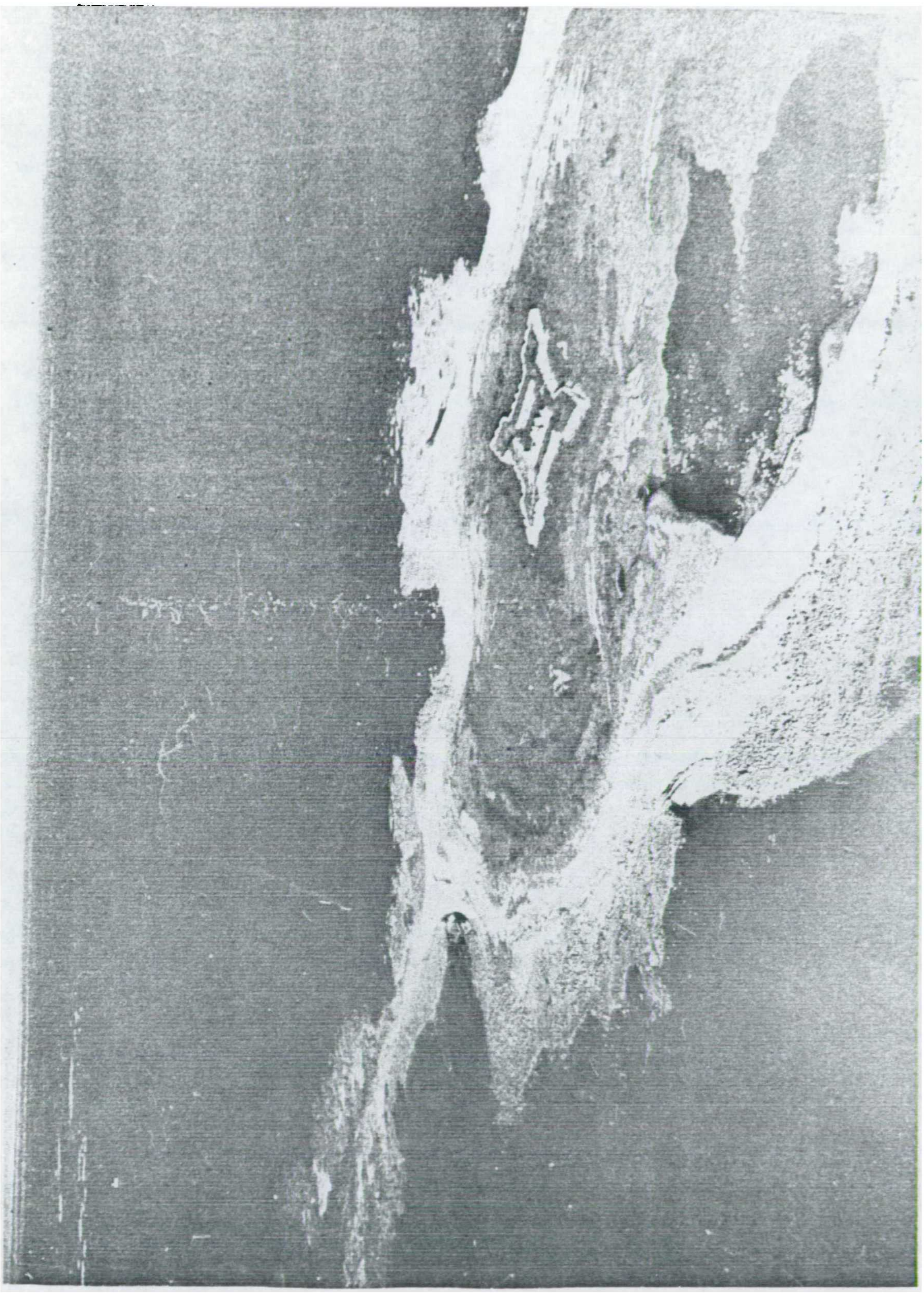


FIGURE 14 Oblique aerial view of Prince of Wales fort looking south.

Figure 14: Oblique aerial view of Prince of Wale's Fort, south. (1932)

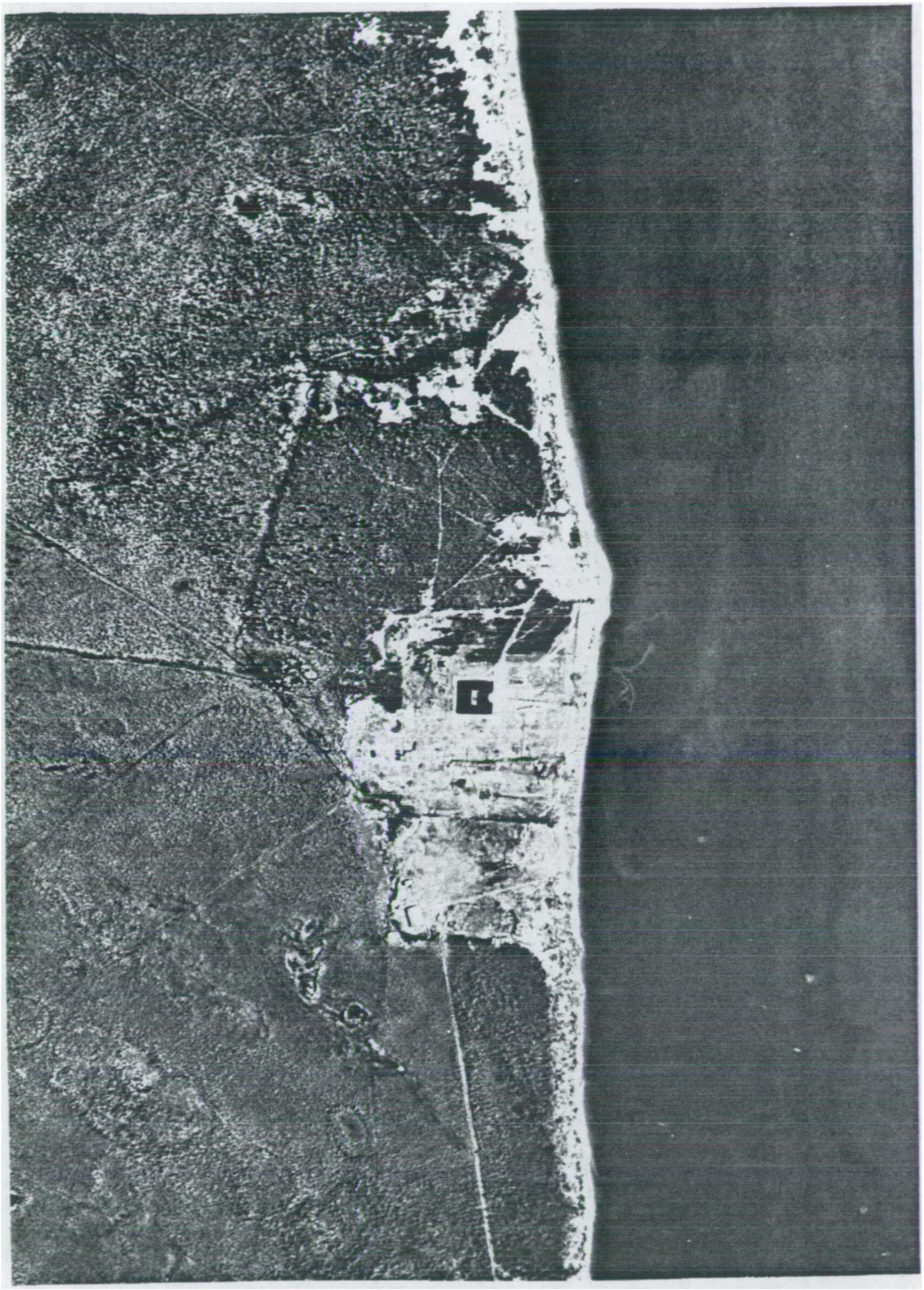


FIGURE 15 Vertical view of York Factory taken in 1964.
Note the number of buildings that have been removed.

Figure 15: Vertical view of York Factory taken in 1964.

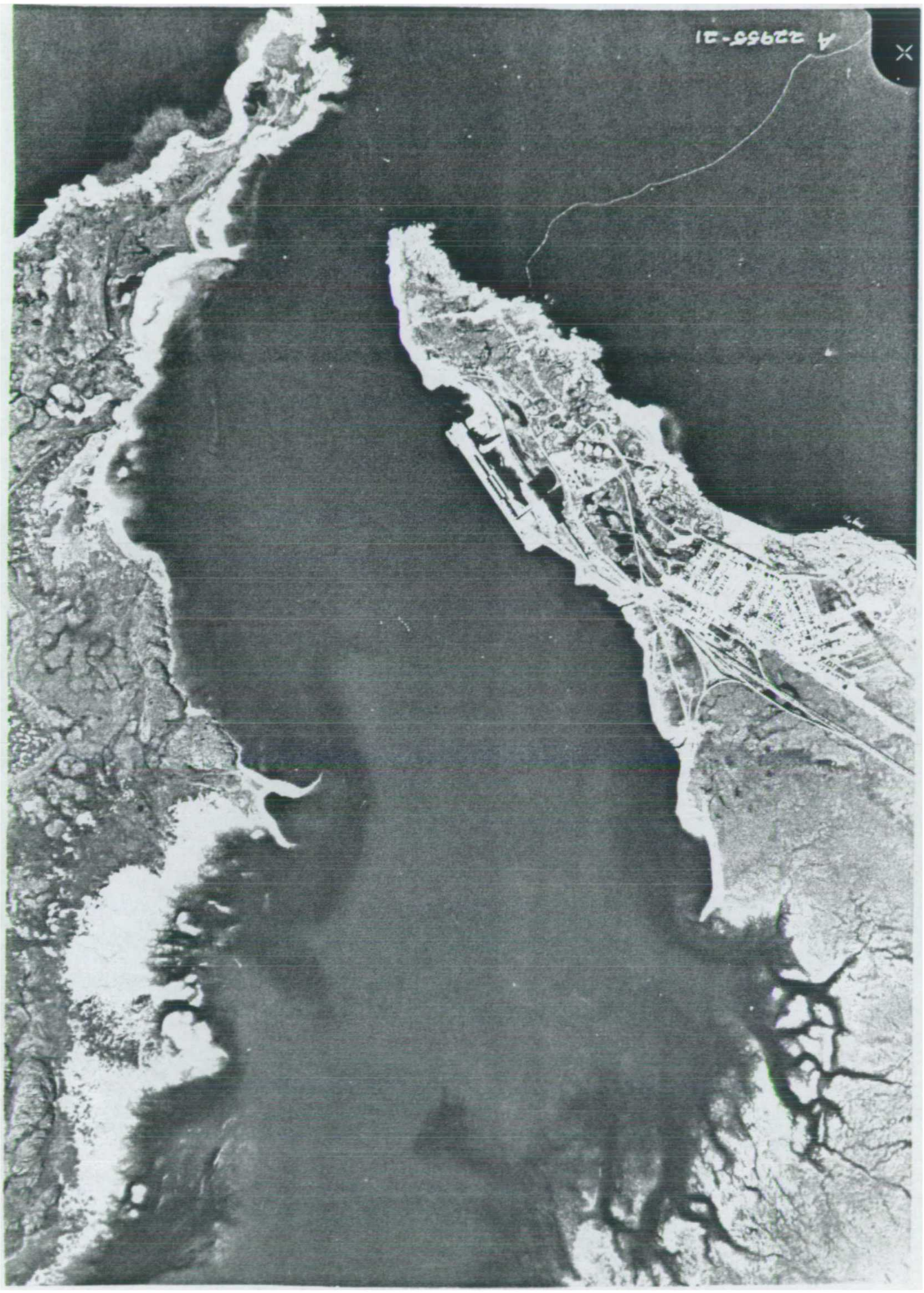


**FIGURE 16 Vertical view of the Churchill region taken in 1960.
Compare the map in Figure 3b with this photo.**

Figure 16: Vertical view of the Churchill Region

Hare and Thomas show Churchill and York Factory in the Boreal region, but Bryson and Barry suggest that they are within a region they categorize as Arctic.(Bryson 1966, Barry 1967) Regardless of the outcome of this disagreement we are left with an awareness that this portion of Hudson Bay and its coincidence with the treeline is a very important zone as far as climate is concerned. The treeline represents a very distinctive response to a climatic boundary and is coincident with the mean summer position of the Arctic Front. A change in climate should be reflected in a change in location of the mean annual position of the Arctic Front and if these changes occur over sufficiently long periods should result in changes in the position of the Arctic Front. Because the rate of growth of trees in this region is so slow the change would have to be for a long period of time, certainly in excess of the time covered by this study. Similarly the southern limit of continuous permafrost appears to be a reflection of a region of climatic transition because of the apparent causal relationship between this boundary and the mean summer position of the Arctic Front. Again shifts in this limit would require long periods of time. However, the coincidence of these two distinctive physiographic features indicate a regiom that represents a distinctive climatic boundary. Because York Factory and Churchill straddle this boundary they should reflect in their climatic histories any changes in the position of this boundary. As will be seen in the conclusions it would appear that Churchill is constantly on the Arctic side of the boundary, while York Factory is variously on the Arctic or

Boreal side for different periods of time. That is the mean summer position of the Arctic Front, during the period of record of this study is always south of Churchill, but moves north and south of York Factory for various periods of time.

Unfortunately there has been no weather observation programme at York Factory since October 1914. Official government of Canada records were maintained from October 1874 to June 1883; from September 1885 to July 1889; and from September 1898 to October 1914. These records were not maintained on a 24 hour basis and record only temperature, precipitation and a synoptic report. In fact at the present time (July, 1981) Churchill and the climatological station at Gillam which opened in 1965 are the only observing stations for the whole southwest portion of Hudson Bay. It is rather ironic that there were more climatological observers in this region in the 18th and 19th centuries than there are in the 20th century.

Longley does not see this as a problem for in the official Government publication on the Climate of the Prairie Provinces he writes "Churchill is the only station on the Hudson Bay lowlands. Its record may be interpreted as giving a good picture of the climate of this coastal area" (Longley, 1972, p. 10). In this publication the climatological data for Churchill are as shown in Table 1.

TABLE 1

General Climatic Information for Churchill 1956-67

Mean Ann.		Temperature Daily Means			
		Max		Min	
19.1 F		F	C	F	C
-7.2 C	Jan	-10.6	(-23.7)	-24.4	(-31.3)
	Apr	20.6	(-6.3)	4.7	(-15.2)
	Jul	62.7	(17.1)	44.5	(6.9)
	Oct	35.1	(1.7)	25.1	(-3.8)
	Extremes	91.0	(32.7)	-49.0	(-45.0)

Elevation: 39 Metres

Mean dates of frost:	Last in spring	June 21
	First in Fall	Sept. 14

Mean annual precip. Total:	15.99" (406.1mm)
Mean annual snowfall:	69.1" (175.5mm)

Note that temperatures are given in Fahrenheit in the original table. Celsius has been added.

Source. The Climate of the Prairie Provinces. Richmond W. Longley. Climatological Studies Number 13. Environment Canada, Toronto, 1972.

3.4 THE CLIMATE OF HUDSON BAY

Hudson Bay is an extremely large inland sea occupying a geological basin in central North America. The size and location of this body of water has a marked influence upon the weather characteristics of North America. Modification of temperatures by the presence of open relatively warm water in early winter and the existence of ice well into summer greatly affect the zonal characteristics of the climate pattern. Further, it is located in the path of the planetary wave influenced by the barrier of the Rocky Mountains. The principal climatic features at the surface are; the intense outbreaks of cold Arctic air during most of the winter and on frequent occasions in the summer; the seasonal movement of the Arctic Front; the seasonal variation of cyclonic activity as the cold Arctic air advances and retreats.

The Arctic is the land of treeless open tundra, of ice caps, and of permanently frozen ground (permafrost), though the latter extends well outside the Arctic. Hudson Bay, Foxe Basin, Fairs Strait, Baffin Bay, and the channels of the Arctic Archipelago are largely enclosed seas with an Arctic climate (Hare and Thomas, 1979, p. 129).

There is tacit agreement with this definition in Bryson's article on the relationship between air masses and the tree-line (Bryson, 1966). It is essential to note, however, that on the scales at which climatic zones are usually determined a very large transition zone can be converted to a simple line. A precise definition of trees is difficult in this region of stunted growth therefore a clear definition of the tree-line is of equal vagueness. For stations that are located at the edge of the tree-line climatic zones have little meaning. This is particularly true in this case because there is considerable evidence that the extensive cropping of trees for firewood and construction pushed the tree-line considerable distances away from the settlements. The extent of this clearing is discussed in greater detail in a later chapter.

The primary controls of the climate are the annual variation of the radiation balance and the resultant circulation patterns of the atmosphere. In the upper air circulation the dominant pattern is created by the low-pressure centre over northern Baffin Island. This centre expands and contracts seasonally and is connected to the expansion, contraction and movement of the Icelandic Low. The net result of these features is a dominance of north and northwesterly flows of air across Hudson Bay, in winter these bring frequent and intense outbreaks of cold Arctic air. In summer the track of cyclonic activity is displaced northward so that it brings cloud and precipitation from the west or south west across Hudson Bay. Despite an increase in the frequency of southerly winds the cold waters of the Bay remain the dominant factor for air temperatures.

To generalize at this point it can be said that two basic weather types affect the climatic conditions at our two sites.

1. Cold Arctic air masses push south across the Bay during all seasons of the year, but their frequency decreases in the summer.
2. Cyclonic activity bringing inclement weather occurs during all seasons with the frequency increasing noticeably during the summer months.

It is important to note that the foregoing discussion applies to the whole of the Hudson Bay region and therefore conditions at Churchill and York Factory differ due to their location at the southwest corner of the Bay. Obviously length of day and net radiation values are higher for these southern locations. Because this is the zone of the Westerlies much of the weather originates over the interior plains and tundra regions between the Bay and the Rocky Mountains. This region provides few significant physical barriers and in fact the region immediately surrounding the Bay is known as the Hudson Bay Lowlands and extends some 80 to 160 kilometres inland from both Churchill and York.

The most important physical feature that influences the local climate of our stations is the ice that covers the Bay for the greater part of the year. Low summer temperatures are a direct result of a body of water that is extensively covered with ice well into July. Even after the ice has gone the water temperature rarely exceeds 7.2 degrees Celsius (45 degrees Fahrenheit) in the southern portion of the Bay, while northern sections remain close to the freezing temperatures. Open leads in the ice occur throughout the winter resulting in steam fog or Arctic sea smoke, although the uniformity of tundra snow cover and sea ice with snow cover means very little contrast in surfaces compared with the summer land/water condition.

Both stations must be classified as coastal because of their locations but they are more representative of land conditions with regard to their climatological classification. There are two main reasons for this statement. First because of the ice cover over the Bay for almost eight months of the year there would seem to be no apparent distinction between the surfaces of the land or water. The sea ice with its snow cover would appear to have the same surface albedo as the land however the depth of the snow and the existence of vegetation creates a considerably different regime. King, et al. (1964) found that five inches (12.7 cm) of snow depth or less resulted in a varying albedo that was a function of depth. Above that depth albedo remains relatively constant. Also vegetation was able to support only a limited quantity of snow on its branches and this rarely exceeds the critical five inch depth. Snow depth over the ice would not be critical as ice albedos are comparable to those of snow. In the summer the cold waters of the Bay would contrast sharply with the surrounding land surfaces.

Secondly, the prevailing wind directions are from the northwest throughout the winter months with an increase in southerly winds in the summer months. Further the influx of air masses is predominantly from the northwest and west. The result is that virtually all of the weather influences for both stations originate over land surfaces.

In summary the sites of both York Factory and Churchill Factory appear to be ideally suited as locations representative of large scale climate and indicators for long term climatic change. The uniformity of the terrain, the general lack of vegetation or at most low brush, and the lack of any high ground are all conducive to consistent climatic variables and therefore changes are more likely to reflect atmospheric changes. The historic evidence indicates that from the very beginning of the record the area immediately around each site was cleared of trees. The rate of growth of trees is extremely slow, approximately 300 years to achieve 15-20 cm diameter; therefore it is reasonably safe to say that once the sites had been cleared they would remain clear well into the 20th century even if they had been abandoned. As was noted earlier in this chapter both Factories were relocated during the period of record, a procedure that is of grave concern to the climatologist, but as will be seen there is no evidence of these shifts affecting the data. Changes in location occurring while a proxy record is being maintained would not appear to be as critical as those made while a long term instrumental record is being kept. Most qualititative measures of climate, such as whether it rained or not, are normally too crude to reflect other than catastrophic changes. Instrumental records are a different matter but fortunately the sites did not change while those records were being maintained.

Remote areas have all sorts of problems and handicaps for the historical climatologist, such as lack of data, and lack of coverage, but they do have the advantage that there is no interference to the site due to being encompassed by urban areas. This is true of these sites.

Chapter IV

POST JOURNALS

Any observational study is only as valid as the data on which it is based so it is essential that the nature and source of those data be clearly explained. The purpose of this chapter is to scrutinize the documents in order to determine their validity as a source of climatic information. The first part discusses the general nature of the records maintained by the Hudson's Bay Company. This is followed by a more specific examination of the daily journals which include most of the references to weather, and therefore are the major source of data. After sections that scrutinize the journals at York Factory and Churchill Factory there is a detailed discussion of the actual meteorological records maintained by employees of the Company.

The methodology developed in a later section is designed to extract the maximum amount of information available in the journals. Although the types of information are very wide ranging, something which is both a strength and a weakness of proxy data, it is essential to acknowledge that there are limits to the amount of methodological licence that can be taken. These limits are directly related to the quality and quantity of those things observed and recorded by the journalists. The contents of these journals are fixed by the fact that they record only those factors that were of interest to the journalists or his employer. It is fortunate that the Company imposed a considerable degree of uniformity upon the record. This was achieved by specifying those things that they considered essential to their decision making. Consider the difficulties of running a Company of the size of the Hudson's Bay Company and then complicate that by adding the distances. But the most difficult problem of all was the frequency of communication between the Governors in London and the central post at York Factory and the individual posts throughout North America. The length of sailing time from London around the north of Scotland through Davis Straits and into the Bay with all of its dangers of icebergs, sea ice and the severe weather of that part of the world meant that only one sailing a year was possible.

> Each year the Company dispatched a small fleet, which sailed directly from the Orkneys to Hudson Bay. These ships penetrated Hudson Strait in mid-summer when the strait was still congested with drift ice. On entering Hudson Bay the ships separated, one being destined for James Bay and the other for the west coast at York Factory or Churchill. The ships returned in September by which time Hudson Strait was relatively ice free.
> (Catchpole 1978, p. 25)

Obviously with only one opportunity per year to receive and transmit information it was essential that accuracy, consistency and detail be paramount.

The amount and extent of the material that has been accumulated by the Hudson's Bay Company during the 300 years of its existence must be almost without parallel. Certainly there can be few commercial companies that can boast of such a complete and extended documentation of its history, commerce, and influence. Recently these materials were transferred from the Hudson's Bay Archives in London to their new home in the Provincial Archives Building of the Province of Manitoba. The quantity of material measures in the tons and serves as a source of data for research by such disparate disciplines as anthropology, mathematics and biology.

Most of the material has been classified by the Archives into two sections. Section A is material that concerns the Company as a whole, for example minute books, servants' commissions, grand ledgers, and bills payable book. Section B includes material that relates to the activities and affairs of individual trading posts. This section has been further subdivided into records of the various activities, for example accounts books, lists of servants and post journals. There are five other major divisions labelled C, D, E, F, and G. These include material that should prove important for future historical climate studies. Most important will probably be the ship's logs, but there are maps and private journals that should also yield valuable information.

Other documents that are of extreme interest to the historical climatologist are those submitted to the Royal Society. The Archives of the Society contain twenty-four volumes of meteorological observations made on Hudson Bay between 1771 and 1807. The individual who must be credited with having these records maintained and deposited with the Royal Society is Samuel Wegg esquire. As a member of the Society and as a Governor of the Hudson's Bay Company Wegg used his position to further his and the Society's interest in the world around them.

The Royal Society council minutes for 23 December 1773 read,

> It was moved and ordered by ballot, that two barometers, four thermometers and two barometers be puchased at the expense of the Society, and sent as an acknowledgement to the Hudson Bay Company, for their considerable and repeated benefactions; with a view that they be conveyed to some of their officers at their settlements to make observations of the state of the weather and send them from time to time to the Society...
> (Hudson's Bay Company Archives)

Most of the manuscripts forwarded to the Royal Society were copies of journals that are still retained in the Company Archives. The copies are laid out very carefully and in most cases in beautiful script. It is not clear whether these were transcribed in North America or in London before they were forwarded. That Wegg was the driving force is clearly shown in the title page of many of the documents. For example,

> A meteorological journal kept at York Fort in Hudson Bay in the year 1775 and 6 for Sam'l Wegg esq.
> (Royal Society Archives)

It must be noted that some of the manuscripts are composites of several records. In some cases the journal has been maintained by more than one observer, in other cases there are records from two or more recording sites in one journal. The records are a mixture of records from both coastal Forts, such as York and Albany and from inland posts such as Cumberland House. One of the most interesting records, and one of the earliest instrumental records in northern North America was maintained at York Fort in Pitts Harbour in Labrador for the period beginning in October 1766 to June 1767.

A precise record of the periods of record are given in Tables 11, 12, 13, and 14. The general periods of record are as follows; Non-instrumental, Churchill from 1718 to 81852, York Factory from 1714 to 1858w|; Instrumental records, Churchill infrequently from 1768 to the present, Y¬ork Factory from 1771 to approximately 1926. A more detailed examination of these instrumental records will be found later in the chapter but first it is necessary to examine the previously mentioned post journals. As will be seen these provide the majority of the information that forms the basis of this study. The journals were maintained on a daily basis by the Factor who was responsible for the running of the Fort. In the early records the Factor wrote the journal out himself, but in many later cases his words were transcribed by a writer. It was the practice to keep a rough copy of the journals and then to write a finished copy that was subsequently forwarded to the Company headquarters in London England. There are some instances where both the rough and finished copies of the daily journal have been preserved. Similarly there are instances where the finished copy is missing and the rough copy is extant. This is fortunate because it allowed for a comparison of the rough and finished copies to ensure that transcription was accurate. There are evidences of editing of many of the rough copy comments but there is no evidence of climatic comments being edited or altered in any way.

Each day the Factor was required, by the Company, to make certain entries that related to the well being of the Fort. These included; the daily weather; the provisions given out to the men, and the Indians; the provisions obtained by the hunters and in trade from the Indians; the duties being performed by each man; and any other data such as disciplinary action or trading activities that would be of interest to the Governors. Needless to say the men were occasionally remiss in their duties and were reminded of the importance of maintaining daily entries. Sometimes the directions were very specific as in the following:

> Among the circumstances, which are always to be noticed in the journals, is...the date of the freezing of the lakes & river, the chief falls of snow & their depths, the greatest thickness of the ice, the commencement of thaw, the breaking up and draining away of the ice. These observations are not to be considered as a matter of idle curiosity; but may be of very essential use...
> (Hudson's Bay Company Archives, a 6/18, pp. 211-13)

It is interesting to speculate on why the Factors were required to record the daily weather. The reports could have been of little value to the Governors in their early deliberations, although they did have a desire to reduce costs, as is the want of any Company executive. One of the major objectives of the Governors was to increase the food supply at the Factories, supplies that were termed 'country provisions' in the post journals and other documents. As self sufficiency was increased dependancy upon expensive provisions sent from England could be reduced. The struggle for self sufficiency revolved around attempts at growing English produce in gardens at each Fort, and by animal husbandry. Obviously climatic information would be of some value in determining those species most suitable to the conditions.

A second reason for maintaining the daily weather records was the inherent interest in the natural environment displayed by many of the Company employees. Not the least of these was Andrew Graham who spent twenty-five years in the Company service on the shores of Hudson Bay and in its environs between 1767 and 1791. During this twenty-five years he compiled an enormous inventory of material on all aspects of the region from Indians and Eskimos to minerals and birds. It is noted in the preface to the edited edition of his observations that:

> The Archives of the Hudson's Bay Company contain ten manuscript volumes of the 'observations', running to more than two thousand pages and written over a period of twenty-five years.

Part of these 'observations' include general comments on the weather, for example

> On the south side of Hudson Bay where the Company have their settlements the air is commonly sweet and severe, and the weather very warm during the months of June and July, but in the winter months extremely cold. And it appears by observation at York Fort and Severn River the mercury on Fahrenheits's standard thermometer was often times at 63 degrees below the cypher and in summer it rose to 98 degrees above the cypher.(Note: The cypher was set at zero.)

The observations referred to will be discussed later in the section on instrumental records. However, it must be mentioned at this point that the instruments used in taking of these records were provided by a Mr. William Wales, an astronomer of the Royal Society. He and a companion Mr. Dymond also of the Society, travelled to Churchill Factory in the years 1768-1769 in order to observe the transit of Venus across the sun. While there they recorded scientific data of various types including several climatic variables with the aid of instruments. There can be little doubt that their activities were quite significant in encouraging further weather observations.

Another weather observer of note was Peter Fidler, renowned for his abilities as a surveyor and a map maker. Fidler also maintained a daily weather record that includes, for the most part, temperatures recorded at least three times a day. This journal and his interest in the weather seems to evolve from a basic curiosity about the world around him that is a hallmark of his life. One journal maintained by this remarkable man begins with the following,

> Meteorological observations made by Peter Fidler at York Factory Hudson's Bay (sic) by a Dollands 10 inch Fahrenheit's thermometer until July 12th 1794-5 after that with an 8 inch Carey's all spirits ones (sic)-
> (Hudson's Bay Company Archives, E/3, p. 2)

This particular record covers the period from Oct. 12, 1793 to Sept. 2, 1795 at which time Fidler was sent to Cumberland House. His record was continued at York Factory by Charles Isham and is one of the manuscripts in the Royal Society Archives. It is not known how Fidler came by two thermometers but one was presented by the committee as a reward for services.

A third reason for maintaining daily weather records probably can be found in the fact that it is just that, a daily event. Most diaries or daily journals have some reference to the weather and for men whose lives were so controlled and dependent upon the weather it is not difficult to understand their interest. Further most of these men were trained as mariners and in the maintenance of ship's logs which require keen and careful observation of the weather and in particular the wind.

This study will make no attempt to analyse those weather references that could generally be referred to as subjective, although they have been coded for future use. Obviously phrases or terms such as thick, mild, fine, moderate, are all qualitative comments of each individual observer and present different problems of interpretation than the more specific narrowly defined phrases, such as wind direction or the occurrence of a precipitation event. When climatic data are so scarce it is important that nothing is left unused. Ultimately the subjective commentary will serve two necessary functions. First it can provide supporting information for the more precise information. For example if there is a precipitation event did it occur when the general conditions were thick or mild? Its use in conjunction with other information should provide a more accurate picture of the observer's understanding and use of the term. This leads to the second function because once the parameters of the observer use of the terms have been established they can be used where no other information is available.

In a larger sense the classification of these subjective terms is far less problematical than would first appear; it is simply a matter of limiting the number of groups. The records yield nine terms that have been classified as general weather comments. These are pleasant; fine; mild; moderate; stormy; heavy, close or thick; fair; sultry; and variable. They can be grouped as follows:

1. Pleasant, fine, mild, moderate and fair.
2. Heavy, close or thick.
3. Sultry.
4. Stormy.
5. Variable.

Sultry was distinguished from Heavy because it was only used in conjunction with hot weather, while Heavy was used regardless of the temperature but most frequently with cooler temperatures.

Within each group it is very difficult to separate the climatic conditions represented by each term, however as a group they tend to encompass a fairly clearly defined set of conditions. On the other hand each group is very clearly different from the other and provides, on a day to day basis, a relative picture of the weather pattern.

4.1 NON-INSTRUMENTAL JOURNALS

The first journal maintained at York Factory following the return of the British in 1714 was recorded by James Knight, while those at Churchill were recorded by Richard Stanton beginning in 1718. The following comments are applicable to both sites because the procedure was consistent with Company regulations and in many cases the observers had worked at York Factory and Churchill. There is a possibility that earlier data than the Hudson's Bay Company records may be extant. The Compagnie du Nord for example, through their servant Jeremie, who was born at Quebec in 1669 and spent several years at York Factory, may have maintained records that could be stored in Quebec or in France. No reference to this material has been found in any work carried out to date and there is no record of any formal search having been carried out. Journal entries begin on the 5th September 1714 and the first weather entry occurs on the following day. It is very brief "very thick & foggy weather." The next day while apparently exploring the area Knight records the first storm in the record.

> Weather proving so bad we had like to have been lost and were in very great danger in being in ye same condition there being so violent storm we struck several times by the sea running so high and the weather so thick.
> (Hudson's Bay Company Archives, B239/a/1, p. 1)

Knight was to remain at York for five years until in 1719 he was moved to Churchill to establish that Factory. His successors continued the journal each in his own style but each recording basic weather elements. The reference to individual styles needs comment because any variations in the record would tend to reduce the homogeneity of the data. Style in this context means that the order of presentation varies, not that the content varies. For example one observer would put the weather comments at the beginning of the daily entry while others would put them in the middle or at the end. Similarly the order of presenting the variables would vary. Some would present the wind first followed by precipitation events, others would use a different order.

The continuity and nature of this record, that is whether it is a daily journal or a meteorological record, is listed in Tables 11-14. The reader will also find in this list the names of the men keeping the record whenever it is known.

Types of entries vary slightly from one journal keeper to another, but there is a surprising consistency in the form and content of each. This is best illustrated by the following sample of entries recorded directly from the journals.

20 September 1714
Wind NNW a moderate gale and cloudy weather.

12 April 1715
Fair weather thaw'd much today wind very strong NW.

28 December 1719
A very hard storm SW all night with drift this morning it prov'd moderate warm weather till noon then shifted to NW a violent storm with snow and drift.

21 February 1725
NE a fresh gale with a continued snow.

27 July 1731
N to ENE fresh gales with showers of rain.

17 December 1759
Wind south and more moderate. At 12 veered to west with snow.

5 June 1762
Hard gale NW with rain all day.

25 July 1767
NE cloudy weather afternoon thunder and

lightning and heavy rain.

2 February 1773
NW morning foggy latter. Clear very cold.

18 March 1787
Stiff breezes west and variable with brisk gale NW A.M. Cloudy middle clear-later snow. More snow in 2 days than all winter.

1 February 1800
Thick weather with light snow wind NE fresh breeze.

17 February 1800
Fine breezes west and north clear weather. Indeed this winter is very remarkable for its fineness of weather, scarce a day but a person might have walked any where without equiping him much in his winter dress.

Note that these entries are not footnoted but are presented in chronological sequence and may be found in the journal for the appropriate year.

The weather variables that appear most consistently are wind direction, qualitative wind speed, precipitation, cloud cover, and general weather comments. These are given in the order of frequency of occurrence as indicated by the computer count of coded data. Naturally they form the backbone upon which all other data are presented.

In most journals the references to weather are made as the first part of the daily entry, in others it occurs at the end, while occasionally some had references in the middle of a days entry. This last type of entry usually occurred when there was a comment on long term, seasonal, or anomalous weather.

Sample entries of this type are as follows:

> 11 may 1730
> Extreme cold for season NE fresh gale cloudy....
> water not rising suggesting cold is extensive.
>
> 3 April 1732
> NNW fresh gale with continued snow...here has
> fallen as much snow since last Thursday night as
> has fallen the whole winter.

It is difficult to determine exactly when during the day the journal entry was made, a problem that is complicated by the time of entry varying from one journal keeper to the next. In most cases it would seem reasonable to assume that the entry was made in the evening after the day's work had been completed. There are some entries that add credence to this argument. For example, the entry for the 14 April 1723 reads, "ESE hard gale, this evening it rain'd hard with thunder and lightning being rare at this time of year." However there are some that raise doubts about the consistency of the time of observation. Generally it can be stated that the entries were made in the evening and changes that occurred were duly noted. It is reasonably safe to say that the specific hour of record is of little importance when dealing with proxy data.

The pattern of work day adds further problems because it changed from season to season. Andrew Graham writes.

> The servants are rung out and in to duty by a bell. they work from 6 to 6 in summer, and from 9 to 2 in winter, being allowed an hour to breakfast, and the same time to dinner.

Obviously the amount of working time was controlled by the hours of daylight. Whether the hours of journal keeping were subject to the same controls would be purely a matter of conjecture. The significance of the argument for climatic observations lies in the need to ensure that there is a consistency in the time of the observation.

Another question of importance is in the nature of the entry for each day, it could be either the weather at the time of the entry or the weather the last time the writer was outside, or his general impression of the whole day It would appear from the evidence of the approximately 200 years of daily journal entries that the author read for both Forts, that if there was a significant change in the weather this was noted by a double entry as follows:

17 July 1727

"S'ly forenoon hot weather came to NE afternoon heavy shower of rain with thunder and lightning."

Similarly if there was any distinctive or extreme weather in the evening or at nighttime this normally received comment.

12 aug. 1718

Rain'd and blow'd very hard all night wind west at

> day it held up but very hazy. Evening continuing a storm of wind northerly squales of rain and very raw cold weather.

During the coding process the time of the entry was recorded when available. If the terms morning or afternoon were used then the reading was allotted to 10 or 14 respectively. The following table indicates the number of observations per hour. Note that 24 indicates that there was only one reading for the day with no indication of the time when the observation was made.

Overall the pattern then is for the daily weather to be recorded as a single entry unless there is a change or event of sufficient magnitude to warrant comment. Obviously not all observers were as zealous as they might have been, nonetheless the record shows that these men have left a legacy of climatic data that have yielded an excellent source for understanding climates of the past.

The names of the observers and the dates that they were responsible for are shown in Tables 11, 12, 13, and 14. Table 11 and 12 indicate the names of the Factors who wrote, or had written by the scribes, each of the post journals. Table 13 and 14 list the names of the recorders of the instrumental records, or as they are labelled in the frontispiece of each, the meteorological journals. In many instances the names are different than those of the post journal writer simply because the instruments were maintained and recorded by employees other than the Factor. Us-

TABLE 2

Frequency of Observations for each hour at York and Churchill

Code	Frequency York	Frequency Churchill	Percentage York	Percentage Churchill
1	152	74	0.2	0.1
2	52	3	0.1	0.0
3	12	8	0.0	0.0
4	1500	25	1.5	0.0
5	445	44	0.4	0.1
6	12464	3507	12.4	5.7
7	3925	386	3.9	0.6
8	4819	5119	4.8	8.3
9	2235	48	2.2	0.1
10	2310	2873	2.3	4.7
11	60	5	0.1	0.0
12	13135	5268	13.0	8.6
13	463	297	0.5	0.5
14	7216	281	7.2	0.5
15	2147	13	2.1	0.0
16	2380	3614	2.4	5.9
17	120	51	0.1	0.1
18	9675	3490	9.6	5.7
19	139	257	0.1	0.4
20	4795	4046	4.8	6.6
21	5504	170	5.5	0.3
22	233	22	0.2	0.0
23	196	27	0.2	0.0
24	26721	31821	26.5	51.8
Total	100698	61449	100.0	100.0

ually this was the surgeon who tended to be a universal man of science and invariably the only other literate member of the Fort, particularly in the early records.

4.2 INSTRUMENTAL JOURNALS

As far as can be determined, none of the instruments used by employees of the Hudson's Bay Company can be located today. This is not to say that they do not exist, but rather that none have been preserved or retained in the Company's possession. It is possible that some remain in the custody of descendants of such ardent early Canadian meteorologists as Peter Fidler, Andrew Graham, and Thomas Hutchins.

Despite this lack of the original instruments we do have some record of the instruments being used. We also know that the impetus for the observations and most of the instruments originated from the Royal Society. The originator of the world wide weather observation network that was to occupy the Royal Society for many years to come was Doctor James Jurin.

> The system of observations organized by the Royal Society in London from 1724 to 1735 was of great scientific value. the secretary of the Society at that time was J. Jurin, a physicist and Doctor who had been a student of Newton. In 1723 Jurin invited scientists of various countries to carry out meteorological observations, and he gave detailed instructions as to the form of the data records.
> (Khrgian, 1970, p. 71)

The influence of Jurin continued for a considerable time particularly with regard to the format that the record of observations should take. Hutchins notes at the beginning of his 1771-1772 record that in observing the wind he followed the method proposed by Dr. Jurin in the Philosophical Transactions (Jurin, 1722, p. 84). He also obviously followed the order in which the data were to be presented column by column.

Despite the diligence with which the observers followed the bookkeeping instructions of Jurin, they were not as fortunate with the instruments. Early instruments provided to the Society were the products of Francis Hawksbee, the younger. Jurin had suggested that all instruments should be from his shops in order to allow uniformity and ultimately comparison of the results (Middleton, 1969, p. 58). Most of the research done on the accuracy and reliability of early instruments shows that Hawksbee's thermometers were not even approximately accurate. Thomas Hutchins indicates in the preface to his 1771-1772 journal that it was not Hawksbee's instruments that were being used, presumably because they were found to have been unreliable.

> The instruments used in taking these observations are a barometer and thermometer of Nairne's construction, and we have great reason to think them both very good as Mr. Wales the astronomer (who remarked the last transit of Venus at Churchill) was commissioned to send them. The thermometer is that termed the standard with Fahrenheit's scale; the freezing point is at the thirty-second degree above the cypher.
> (Hudson's Bay Company Archives, B239/a/67 p. 1)

In 1773 the Royal Society provided several instruments to the Hudson's Bay Company including four thermometers. The difficulty is that these instruments appear to have been in use for some time by various officers of the Company; however the Society established a research committee on calibration only in 1777. Thus any records prior to that year must have been kept with uncalibrated instruments. Henry Cavendish submitted a paper on the problems of calibration in 1776 and as a result he was appointed chairman of a committee on the calibration and use of thermometers. Unfortunately the major concern was with the upper fixed point and whether this should be determined by placing the thermometer in the boiling water or in the steam immediately above. This is unfortunate as this upper end of the scale was of little significance in the sub-Arctic climates of Hudson Bay.

Usually the most important thing to determine with early temperature readings is whether the thermometer was protected from exposure to the direct rays of the sun. Generally it can be said that the observers of the Hudson's Bay Company were well aware of the need to shade the thermometer. It is interesting, and important to note, that although there was obviously no knowledge of electromagnetic radiation and the solar spectrum there was an empirical awareness of the differences between snow that was melting due to above freezing ambient air temperatures and snow that was melting in direct sunlight. This is best illustrated in the various comments made about the thawing of snow, which shows the powers of observations as well as the different conditions that can occur. The comments are as follows: thaw, thaw at noon; thaw all day; thaw in lee; thaw in sun; and thaw out of wind.

The transit of Venus was an event of great significance for

astronomers but as with so many things it led to the provision of secondary information of almost equal value. In this case the astronomers, Wales and Dymond, were forced to spend a full year, from September 1768 to September 1769, because of the limited sailing connections in order to observe an event that lasted approximately seven minutes. As good men of science they used the time to observe and record as many natural phenomena as possible, including an accurate record of daily climatic information. Their records include acknowledgment that the thermometers were located in shaded locations (Dymond and Wales, 1770).

The instruments Wales and Dymond used were sent to York Factory rather than back to England where they were put to good use by surgeon Thomas Hutchins. Hutchins states quite clearly in the preface to his meteorological journal that the thermometer was placed on a north facing wall away from direct sunlight (Hudson's Bay Company Archives, B239/a/67, p. 1). Assuming that the wall was built of unpainted logs we can probably then also say that there was little reflected sunlight either.

The last commentary available on the collection of temperatures is found in the journal kept by Doctor John Rae during his year long stay at York Factory investigating the loss of the Franklin expedition. Like Wales and Dymond he also put time to good scientific use by keeping an accurate meteorological journal. A direct quote from this journal for 1845-1846 shows that precision of measurement had progressed.

> The thermometers were suspended within a couple of inches of each other, under a tunnel like covering of stout canvas, facing north and protected as much as possible from the sun's rays at the same time quite detached from any building. Height of thermometers from the ground, four feet six inches.
> (Hudson's Bay Company Archives, B239/2/164, p. 1)

Between 1769 and 1846 there are several meteorological journals at both York Factory and Churchill Factory. It does appear that one of the thermometers was in an exposed location because in 1791, W. Jefferson records a temperature of 108 degrees Fahrenheit (42 degrees Celsius). If Jefferson's thermometer was placed in an exposed location we have reassurance of an awareness of the problem in the memoranda for a meteorological journal maintained by Thomas Topping from 1811 to 1813.

> The thermometer should be kept where the direct and reflected rays of the sun cannot affect it..." (Hudson's Bay Company Archives, B42/a/139a, p. 1)

Many of the problems of early temperature readings can be offset by various mathematical adjustments, but there is one problem that cannot be overcome and that occurs because mercury freezes. This was something that the Royal Society committee on calibration were not concerned with, although they should have been aware of the problem based on the reports of Wales and Dymond. Mercury freezes at -37.9 degrees Fahrenheit (-38.8 degrees Celsius) but, it becomes increasingly less malleable as that temperature is approached, thus any readings approaching this temperature, and certainly any after it, are of little value.

The observers did not consider this a problem although they were obviously fascinated by the phenomenon. Frequent experiments were carried out but little is resolved except possibly to allow the modern researchers to determine that the ambient air temperature was at least -37.9 degrees Fahrenheit (-38.8 degrees Celsius). For example on the 23rd of January in 1821 the journal notes; "Extremely cold quicksilver frozen like a piece of lead" (Hudson's Bay Company Archives, B239/a/133). The same author wrote in 1816, "Weather more intensely cold than ever I knew before in Hudson's Bay (sic) during a period of 25 years having tried the freezing of mercury...". (Hudson's Bay Company Archives, B239/a/128) It would appear safe to assume that the author is in fact well aware of the freezing point of mercury because the word 'tried' implies experimentation. January 1822 he records,

> Some quick silver that had been put out some time ago for trying the cold was observed to be frozen while the thermometer was only 36 below zero which proves the weather to have been six degrees colder than per the thermometer.
> (Hudson's Bay Company Archives, B239/a/134)

Apparently the observer considered the temperature at which mercury became solid to be -42 degrees Fahrenheit, because mercury actually freezes at -37.9 degrees Fahrenheit (-38.8 degrees Celsius) it would appear that the thermometer was quite close to being correct. Fortunately we are later informed that the observers continued to record the readings without correction. On the 19th of January 1836 there is a discussion in the daily journal entry concerning the freezing point of quicksilver and the accuracy of thermometer which ends with an expression of doubt as to the correctness of the records as kept for the past five years using one of those "Gilbert, London" thermometers (Hudson's Bay Company Archives, B239/a/149). Two years later in 1838 the observer has either noted an increase in the error factor or has forgotten his original estimate for he writes "-35 degree by the incorrect one presently in use here, which when rectified may be registered at -44 degree full"(Hudson's Bay Company Archives, B239/a/151).

The final difficulty with the freezing of mercury lies in the use of the word solid to determine a temperature of -37.9 degrees Fahrenheit (-38.8 degrees Celsius). W. Jefferson provides examples to illustrate this problem. In January 1790 he notes that "1/2 oz quicksilver exposed last night to the weather was frozen as to bear to pressed flat with my finger" (Hudson's Bay Company Archives, B42/a/114). Then exactly a year later he writes, "th. -36 degrees three oz of quicksilver exposed to the weather last night in a marble mortar this morning was so much frozen as to bear to be pressed with my finger and cut with a knife" (Hudson's Bay Company Archives, B42/a/116).

Some of the questions raised by these comments can only be answered by attempts to recreate the original conditions through experimentation. It was impossible to be rigorous about the methodology employed because the original experiments were imprecisely carried out and imprecisely reported. Artificial temperatures were created by the author in a laboratory environment in which 1/2 ounce and 3 ounces of mercury were tested in an attempt to recreate those conditions reported by Jefferson. In addition the following questions were tested with the results as indicated.

1. What is the range of malleability compared to the range of temperature? There was no measurable difference observed in the reaction of 1/2 ounce and 3 ounces of mercury. Both began to exhibit a degree of rigidity at approximately -34 degrees Celsius (-29.2 degrees Fahrenheit) and became solid at approximately -39 degrees Celsius (-38.2 degrees Fahrenheit). The mercury could be pressed flat with a finger, in the manner described by Jefferson, at a temperature of approximately -37 degrees Celsius (-34.6 degrees Fahrenheit).

2. Would the heat of the observer's finger, presumably applied to mercury that had been taken indoors, create its own malleability? Obviously body heat and pressure would ultimately combine to melt solidly frozen mercury however it was found that it was physically impossible to maintain contact with the frozen mercury without freezing the finger. Therefore it must be assumed that the temperature was somewhere between -34 degrees Celsius and -39 degrees Celsius when Jefferson pressed it with his finger.
3. Did the use of a marble mortar have any effect? Similar experiments as outlined above were carried out using a marble mortar, however there were no differences in the results obtained.

The experiments seem to indicate that under these conditions mercury is malleable over a relatively narrow range of temperatures. Also it suggests that the thermometers being used by Jefferson were reasonably accurate. One important question remains unanswered; when the observer records that the mercury was solid had he tested it or was it merely a visual observation. This can never be positively answered, however it seems reasonable that if mercury was placed outside for the purpose of determining its malleability a test with finger pressure is the most natural thing to do.

Nonetheless, the temperature measurements and the observations are still of extreme value because they are all that is available for the period and for those locations. Unique problems do not normally affect the accuracy of the readings but they are frustrating both to the observer and to the historical climatologist. Two examples of this type of problem are found in the York Factory journals. In one instance the thermometer was broken by Indian children and although the surgeon attempted to repair it with gum arabic he had no success. The second example involves the removal of mercury from a thermometer for use as a medicine.

The time at which the observation was made is of much greater concern when instrumental records are being studied. Fortunately there is a high correlation between the precision of the instrumental readings and the awareness by the observer that a regular schedule is required. As a result there is only one record in which the time of observation is not recorded. This is the record maintained by Peter Fidler. All other records have the time of observation noted, although those times are not consistent from record to record. Generally there are three readings each day with a noon reading being the one most persistently observed.

The value of these instrumental records cannot be overstressed as they will probably provide absolute measures for comparison with modern records and also serve as calibration points for the proxy data. Preliminary analysis is provided. However more detailed studies have not been carried out as this would be a thesis in itself. Daily, monthly and annual mean temperatures have been calculated and tentatively compared with the modern record for Churchill.

Chapter V

METHODOLOGY

5.1 INTRODUCTION

This thesis involves two distinct sections. The first relates to the problems of dealing with historical data and therefore requires an historical methodology. The second relates to the scientific method as it is applied to historical data. Others have worked with these methodologies, but few have attempted to combine the two into one continuous study. Ladurie (1971) discusses this point at some length in the introduction to his excellent work, Times of Feast, Times of Famine. The problem lies in the difficulty of creating a continuous measure of climatic data despite the change in source and nature of the material.

The approach chosen in this study is a function of five concerns.

1. The non-quantitative material that occurs through most of the record.
2. The occurrence of instrumental records that increase in numbers towards the modern era.
3. The volume of material to be dealt with, (200 years X 365 days X an average of 3 or 4 pieces of information daily.)
4. The need to establish uniformity throughout the length of the record to enable comparison with other records and other times.

5. The need to establish meaningful measures of variables from which prevailing atmospheric conditions can be inferred.

It was decided that because of the volume of data involved some form of computer data set was necessaray. The total number of observations, comprising a group of climatic variables recorded for a specific time, is 162,147 for both locations. Each observation had an average of five recordable details, with the result that there are approximately 810,735 specific pieces of climatic information. When the coding method is included it results in a total computer data bank of approximately 3 million digits or bytes of information. The whole process of transcribing from daily diaries and coding took approximately 4 years of work. Keypunching of the coded data was carried out principally by one operator and took approximately one year. This facilitated manipulation of the data, ease of analysis, and provided for easier access and hopefully will provide for integration by other researchers. The requirement for computer stored data sets has been discussed at length by J.N. Craddock (1970), but little discussion centres on the problem of creating computer data sets that combine subjective weather journals with actual instrumental records.

The instrumental records present problems of interpretation and accuracy but obviously lend themselves to easy computerization. A more complex problem lies in establishing a scientifically acceptable method of adapting diary entries and proxy data for the computer and ultimately for statistical analysis. Implicit here is a need for a rigorous method that allows for testing and comparison with the instrumental data. As Moodie and Catchpole put it,

> "...the use of historical documents is thrust upon the environmental investigator by the lack of scientific data throughout much of historical time," therefore "the analyst must recognize that he is attempting to extract scientific information from ostensibly unscientific sources."
> (Moodie and Catchpole, 1975, p. 4)

In their work on freeze-up and break-up of rivers in the regions of Hudson Bay the authors apply the technique of content analysis. The quality of their work clearly indicates that the subjective historical journal can be adapted to the rigours of a scientific method. The results of their investigation correlate with variations in the climatic elements that would influence the freeze-up and break-up events. This thesis provides a history of some of those elements and will help reinforce the variations in those events.

If we accept the efficacy of this method, and the preface comments of Kenneth Hare would seem to support such a position, then a conversion of written data to a numerical format that entails less subjectivity should be equally acceptable (Moodie and Catchpole, 1975, p. vii). As a result it was decided that once a complete survey of the range of climatological terminology had been established a simple numerical code for the various conditions could be constructed. The daily post journals for York Factory, and Churchill were read through from beginning to end and lists of meteorological comments were culled into notebooks. The objective of the system of transcription was to extract all relevant information in a manner that would facilitate the coding of this information for computer storage and analysis. Following the completion of the initial stage, that is, the transcription of the York Factory journals, it was assumed that the resultant chronological list of comments contained a comprehensive sample of types of references to weather and the environment that occur in the Hudson's Bay Company post journals.

After this was completed a list and grouping into obvious climatic variables was attempted. This process determined that the following weather elements were mentioned to a greater or lesser extent throughout the record. Temperature; wind direction; wind speed (verbal only), barometric pressure; precipitation events (no measurements); cloud cover; thunder and lightning; general weather comments; thawing; frost; and drift.

The results obtained were noteworthy in the consistency of terminology and the method of recording used.

The only unusual variables

were due to the presence of Hudson Bay which created such local phenomena as ice fog or Arctic sea smoke which was referred to as sea roak. A second reading of the journals confirmed this uniformity and as a result the initial groupings remained unchanged and no additional categories of climatic phenomena were added. A completed list of variables was created and within each the various categories that occurred throughout the journals was given a numerical code. It was decided that a numerical code rather than an alphabetical or alpha-numeric system was the simplest, most flexible, and most easily adapted to the computer. On a wider scale the format of modern climatological records is achieved through the use of a numerical system.

Notice that the list of variables includes those that would be found only in an instrumental record, for example temperature and barometric pressure. This was done because there are a few instrumental records maintained by the Company's men that are a mixture of instrument readings and weather diaries. Also one of the major objectives of this study was to integrate historical and instrumental records and these journals provided an excellent opportunity for the method.

5.2 CATEGORIES OF CLIMATIC PHENOMENA

A brief discussion of each category follows.

5.2.1 Location

Although only two locations were used in this study it is hoped that other journals will be analysed therefore allowance was made for up to 99 location numbers.

5.2.2 Date

The date was recorded as day, month. For example 0511 indicates the 5th of November. In 1752 the Gregorian Calendar reform was introduced and was implemented by the Hudson's Bay Company on the prescribed date. The coding procedure recorded the dates exactly as they were given in the journals. Correction by the addition of 11 days to all dates before the change was achieved once the data were stored in the computer.

5.2.3 Year

Because the data span three centuries it was necessary to record the complete number eg. 1797. The total number of records at York Factory is 100,698. These are distinctly defined

weather observations ranging from one per day to eight per day. The annual count of observations begins in September of 1714.

The record at Churchill is not quite as extensive as that for York partly because it does not commence until September 1718, nonetheless there is a total of 61,449 observations.

5.2.4 Time

A twenty four hour clock was used, but certain arbitrary times were established. If the record merely said the weather was morning, afternoon, or evening then the times of 10, 14 and 18 respectively were assigned. These times were chosen because they were the most appropriate to define morning, afternoon, and evening. They were also the observation times most frequently referred to when a record was made during those periods. Similarly if there was only one record for the day and no indication of the time of recording then the time 24 was assigned.

5.2.5 Temperature. Instrumental records

All entries in this section were obtained from instruments, but since one of the objectives of the method is to integrate secular and historical information provision was made in the coding system for temperature and barometric pressure readings. A prefix was used, with 1 indicating above zero and 2 indicating below zero. All temperatures were recorded in Fahrenheit with conversions to Celsius being done subsequently by the computer. Temperature was occasionally recorded to half a degree but a computer check indicated that the number of records of this type was less than 1% at both stations. Consequently it was assumed that a degree of accuracy of plus or minus one degree Fahrenheit (0.6 degrees Celsius) was a minimum reliable level. There are a total of 63,230 individual records of temperature at York Factory and 22,601 at Churchill Factory. The specific periods covered by the instrumental records are shown in Tables 13 & 14.

5.2.6 Barometric Pressure

In most cases wherever temperatures were being recorded barometric pressure was also being observed. All of the records are noted in inches of mercury to one hundredths of an inch except for John Rae who somehow managed to read the scale to one thousandths of an inch. Although these observations will be useful in more detailed studies of changes in longterm weather patterns, they were coded and stored but not analysed in this thesis.

5.2.7 Wind Direction

It is interesting to note that wind was recorded to 32 points of the compass, and therefore the coding system allowed for each direction. However, as will be seen in the analysis a grouping of directions was performed. It is unlikely that even these observers, who were trained mariners and therefore used to recording wind directions to a fine degree could have made these observations from a flag unaided by the immediate presence of a compass, as would be the case on board a ship. Conrad and Pollak suggest that

> Generally one can be content with eight directions; if 16 directions are given in the original data, it is usual to reduce these to eight. The frequencies of the intermediate directions are allotted half to each of the two nearest main directions.
>
> (Conrad and Pollak, 1950, p. 180)

In addition to the 32 standard compass directions beginning with 01 as north through to 32 as north by north north west. A 33rd category was necessary because there were occasions when the observer was unable to establish a specific direction and used the term variable to indicate this condition. It is quite clear that the term is used to refer to direction of the wind and not the speed.

5.2.8 Wind Strength and Wind Type

There is no record of actual measurement of wind speed anywhere in the journals. Numerical values are sometimes used but they are not related to measurements but are values related to some observable natural event such as leaves trembling on the trees. The first values of this type used are those recommended by James Jurin in his advice to observers published in 1722. A later record uses the Beaufort scale but generally only subjective wind terminology is used. There is a consistency to the use of the terms and although they reflect terms that are similar to those used by the Royal Navy it is very difficult to apply any absolute values as to the strength of the wind.

The observers noted the strength of the wind, for example, smart, stiff, strong; and the type of wind, for example, calm, breeze and gale. Because of this distinction two variables, one for strength and one for type, were established. In the original documents the observers tended to combine the concepts of strength and type, for example stiff breeze or strong gale, therefore a two variable system would allow for achieving any combination necessary.

5.2.9 Precipitation Events

One factor that becomes apparent as one reads the daily journals is the extent to which climate affects the lives of these early Canadian settlers. It is equally evident that the indigenous population were more affected because of their total dependence upon the food supply provided from natural sources. The European settlers had the advantage of being able to store food, primarily in salted form, and also to supplement their rations with provisions brought from England. Generally it can be stated that variations in temperature had little effect upon the pattern of life or the availability of natural food supply. Variations in precipitation appear to be much more critical and this seems to be reflected in the number of different categories necessary for all seasons of the year.

Three major divisions were established with a prefix of 100 representing any rain event, 200 any snow event, and 300 any miscellaneous moisture event. The second and third position allowed for 8 different forms of precipitation in each of the divisions. A final point to be noted is that there are two types of entries in each division. The first defines the actual type of precipitation, for example heavy rain. The second defines the length or time of occurrence of the event, for example snow last night.

Some categories could possibly have been incorporated with others in the original coding system, but it was felt that combining could be performed by the computer in any subsequent study if necessary. Two categories unique to these records and this region are, mizzling and rime. The former refers to precipitation between mist and drizzle. The latter refers to a heavy rime icing that is variously mentioned as rime, roak, sea roak and sea smoke, and is normally associated with moisture being transported from open leads in the ice by east or northeast winds. Unlike fog it seems to be moisture in a supercooled state as a heavy rime ice is deposited on anything with which it comes in contact.

Significant precipitation elements are recorded as shown in Table 3. Not all of the categories are listed hence the total recorded events do not tally with those shown.

TABLE 3

Total Frequency of Precipitation Observations 1715-1852

	York Factory Frequency		Churchill Factory Frequency	
Element	Absolute	Rel.(%)	Absolute	Rel.(%)
Rain	2296	2.3	1551	2.5
Showers	1146	1.1	715	1.2
Heavy Rain	664	0.7	502	0.8
Continous Rain	531	0.5	231	0.4
Snow	5047	5.0	3156	5.1
Showers	453	0.4	447	0.7
Heavy Snow	846	0.8	742	1.2
Rime	1349	1.4	169	0.3
Hail	51	0.1	13	0.0
Fog	1660	1.6	915	1.5

Precipitation events of any type are recorded in 21,833 (21.7%) of the individual observations at York Factory and 13,505 (22%) at Churchill Factory. These percentages,and the relative percent figures shown in Table 3, are calculated as percentages of the total number of observations including those times when no precipitation occurred. The barometric pressure was recorded in inches to the nearest on hundredth of an inch in all records except one. This was the record maintained for one year at York Factory by John Rae, the noted scientist and explorer, in 1846. For all practical purposes his measurements to one thousandth of an inch by use of a vernier scale is of little consequence; therefore the values were rounded off. From 1715 to 1852 a total of 35,400 readings were taken at York Factory and at Churchill Factory. At York the readings range from 28.00 inches to 31.00 inches with greatest number of readings being 1051 at 29.80 inches. At Churchill the range is 28.83 inches to 31.13 inches with the greatest number, 253, being at 30.00 inches.

5.2.10 Cloud Cover

Seven types of cloud coveras listed in Table 4, were identified although it was not possible to determine proportions of sky cover from the terms used. Possibly further research might distinguish the subtle differences between part clear; part cloudy; and part clear, part cloudy. It is probably safe to assume that all three could be combined into one category that implies the sky is approximately 50 percent clear. Fundamentally the only distinction that can be categorically stated is that the sky was either clear or there was cloud whose percentage varied anywhere from one-tenth to ten-tenths cover. The term overcast was used approximately 8 percent of the time in both records but it is not apparent that it was always accurately applied. A more detailed discussion of the relative merits of these categories occurs in the analysis section later. The flexibility of the computer method is evident here because of the ease of working with various permutations and combinations of a greater number of categories. There is no pressing need to collapse, and therfore lose, the original data.

TABLE 4

Frequency of Cloud Cover Events 1715-1852

	York Factory Frequency		Churchill Factory Frequency	
	Absolute	Rel.(%)	Absolute	Rel.(%)
Clear	27714	27.5	18248	29.7
Cloudy	18371	18.2	13019	21.2
Overcast	7984	7.9	4781	7.8
Flying Clouds	474	0.5	71	0.1
Part Clear	110	0.1	22	0.0
Part Cloudy	113	0.1	27	0.0
Part Clear/Part Cloudy	5551	5.5	1470	2.4
No Record	40379	40.1	23811	38.7
	100698	100.0	61449	100.0

5.2.11 <u>Thunder</u>

Although it is physically impossible to have thunder without lightning and vice versa they can be noted independently hence the three categories of thunder, lightning, and thunder and lightning used as shown in Table 5. The most difficult aspect of this climatic indicator lies in the accurate distinction by the observer between thunder and other human or environmental noises. Ideally one should credit the observer with as much accuracy as possible and work from the assumption that what is recorded as thunder was in fact thunder and not ice cracking on the river or in the Bay. There is a possibility that it could on occasion be mistaken for thunder, particularly if it is a distant sound. The problem is further complicated by the fact that the first thunder would tend to be coincident with the breaking up of the ice, either because of warmer temperatures or because of wind shifts that tend to cause the ice to shift, in both cases cracking of the ice would occur that could be mistaken for thunder.

Another possibility is that the sound of a ship's cannon, which were used as signalling devices often by ships approaching the Factory, could be easily be mistaken for a clap of thunder. However, this is of less concern because it is possible to check on the arrival or departure of ships coincident with the time of the recorded thunder. Finally, the assumption was made that lightning and thunder always occur together, even though the observer only notes one or the other. The term thunder is recorded most often which is probably attributable to the fact that the ears are omni directional, while the eyes have a restricted field.

The significance of the variable is the association of cumulonimbus clouds with the influx of warm moist southerly air. An early northward migration of the Polar Front would possibly result in sufficient instability to allow the formation of cumulonimbus clouds.

TABLE 5

Total Recorded Thunder and Lightning Events 1715-1852

	York Factory Frequency Absolute	York Factory Frequency Rel.(%)	Churchill Factory Frequency Absolute	Churchill Factory Frequency Rel.(%)
Thunder	243	0.2	170	0.3
Lightning	45	0.0	30	0.0
Thunder and Lightning	372	0.4	155	0.3
	---		---	
Total	660		355	

5.2.12 Temperature, Non-instrumental records

The previous temperature category was used to list instrumental readings but thermometers were not in existence or available during most of the time covered by this study. The non instrumental temperature category includes the fourteen subjective descriptions of temperature as shown in Table 6. These terms were found to be the most subjective of all the categories because they are very much a function of the observer's sensibilities. There are obvious difficulties with any subjective record of temperature especially if the people making those observations are not indigenous to the country. One of the observers, John Newton who was at York Factory in 1749 and 1750, had spent thirty years as a merchant captain in the Mediterranean; therefore when he notes that it is extremely cold it is a different perspective and measure than that of James Isham who spent approximately thirty years on Hudson Bay.

A total frequency count of the categories is presented in Table 6. No analysis of these data was carried out in this study because it was felt that they had potential in future studies as supporting information for trends established by other more instructive variables.

TABLE 6

Frequency of Subjective Temp. Observations 1715-1852

	York Factory Frequency		Churchill Factory Frequency	
	Absolute	Rel.(%)	Absolute	Rel.(%)
Extreme Hot	6	0.0	45	0.0
Very Hot	97	0.2	172	0.2
Hot	270	0.4	441	0.4
Very Warm	205	0.3	212	0.2
Warm	1579	2.6	1416	1.4
Cool	93	0.2	143	0.1
Sharp	1739	2.8	2220	2.2
Very Sharp	208	0.3	438	0.4
Extreme Cold	401	0.7	585	0.6
Very Cold	744	1.2	672	0.7
Cold	3693	6.0	3759	3.7
Freezing	277	0.5	125	0.1
Warm For Time	225	0.4	170	0.2
Cold For Time	167	0.3	170	0.2

5.2.13 Weather, General

Another subjective category was necessary because of the frequent use of such general terms as fair, fine or moderate, which are listed in Table 7. This category tends to be even more subjective than the previous because it refers to the general climatic conditions rather than a single variable.

TABLE 7

Frequency of General Weather Comments 1715-1852

	York Factory Frequency Absolute	York Factory Frequency Rel.(%)	Churchill Factory Frequency Absolute	Churchill Factory Frequency Rel.(%)
Pleasant	539	0.5	293	0.5
Fine/Good	6596	6.6	5088	8.3
Mild	1352	1.3	2215	3.6
Moderate	2522	2.5	1647	2.7
Stormy	669	0.7	284	0.5
Close/Thick	1571	1.6	2278	3.7
Fair	1768	1.8	2334	3.8
Sultry	372	0.4	234	0.4
Variable	385	0.4	402	0.7
Total	5774		4775	

5.2.14 Melting

In the computer coding the term melting was used to avoid confusion between th(aw) and th(under). The interesting point here is the obvious awareness of ambient air temperatures and radiation balance and their abilities to create thawing. These are reflected in a good example of empirical evidence of process without the mechanism being understood. This category is important because it provides measurement of the onset of spring, an event that is closely related with the retreat of the Arctic Front. The low number of observations is due to the very short period in each year when this phenomenon is occurring.

TABLE 8

Frequency of Melting Events 1715-1852

	York Factory Frequency		Churchill Factory Frequency	
	Absolute	Rel.(%)	Absolute	Rel.(%)
Thawed	363	0.4	245	0.4
Thawed At Noon	166	0.2	220	0.4
Thawed All Day	281	0.3	322	0.5
Thawed In Lee	22	0.0	8	0.0
Thawed In Sun	39	0.0	49	0.1
Thawed Out Of W	6	0.0	9	0.0
	----	---	----	---
	877		853	

5.2.15 Frost

A category that occurs almost exclusively in the spring after most of the snow has melted and in the fall before any significant snow has fallen. It is therefore, a very important indicator of the transition from one season to the next. The categories shown in Table 9 distinguish between the type of frost and the time when the frost occurred.

TABLE 9

Frequency of Frost Events 1715-1852

	York Factory Frequency		Churchill Factory Frequency	
	Absolute	Rel.(%)	Absolute	Rel.(%)
Frost	329	0.3	339	0.6
Hard Frost	245	0.2	379	0.6
Hoar Frost	67	0.1	8	0.0
Froze Hard At Night	287	0.3	199	0.3
Froze Last Night	131	0.1	92	0.1
	----	---	----	---
	1059		1017	

5.2.16 Drift

The word drift, was often used in the general sense 'drifting weather', implying low scudding clouds and generally unsettled conditions. However the terms of this group apply specifically to snow drifting. Low drift refers to ground drift, that is, snow being blown and moving within a half metre of the surface. Table 10 also includes drifting and heavy drift which imply snow drifting in the lower atmosphere but above the half metre of low drift. The difference between the two has the potential to allow a crude measure of wind speed as critical speeds are necessary to create low drifting.

TABLE 10

Frequency of Drift Events 1715-1852

	York Factory Frequency		Churchill Factory Frequency	
	Absolute	Rel.(%)	Absolute	Rel.(%)
Drifting	2298	2.3	2639	4.3
Low Drift	335	0.3	950	1.5
Heavy Drift	892	0.9	1334	2.2
Total	3525		4923	

In a general way this category tends to support the validity of the records. Churchill is on the tundra side of the tree line with the result that it is a more exposed site than York Factory. The frequency counts indicate that there is a higher total number of days of drift as would be expected. More importantly the categories of low drift and heavy drift account for most of the total difference in frequency of drifting between York Factory and Churchill, again as would be expected in an open and exposed location.

5.2.17 Remarks

Throughout the journals extreme or unusual events are commented upon. Similarly synoptic or analytical comments occur that indicate a great deal about the weather and the observer's perception. Also phenological events which can prove of great interest in determining variability of weather were recorded. If any such entry occurred notes were made and a computer code was created for ease of reference. In contrast to the basic approach of content analysis that enumerates only the presence or absence of the item in question, the overall coding technique outlined above allows for two questions. Both require only a presence or absence response after which the nature or type of presence is provided with a code. For example if precipitation is present it is acknowledged as being rain, snow or another form such as hail, by a prefix code of 1, 2 or 3 respectively. Then the type of precipitation, showers, heavy rain etc. is identified by a second coding. A major problem of content analysis is outlined by Moodie and Catchpole when they point out that,

> If the information required from the documents is to be retrieved via the categories in a numerical fashion, this places immense constraints upon the ways in which the categories can be employed to extract the information required as it necessitates, in the case of written documents, the conversion of lexical material into number. Moreover, the enumeration can be effectively accomplished only if the lexical characteristics to be quantified are precisely identified.
> (Moodie and Catchpole, 1975, p. 13)

Rather than trying to quantify root words and the range of variations of references to the event in question it is necessary only to acknowledge the presence of a climatic variable and then to provide a numerical code indicating its nature, thus avoiding the normal content analysis problem.

In order to keep errors to a minimum coding was carried out from the copies transcribed from the original to a specially prepared coding form by the author alone. coding form. All of this was carried out by the author.

5.3 SUMMARY

Because of the volume of data

each IBM card was punched with the first case occupying columns 1 through 40 and the second case columns 41 through 80. This meant that two cases could be placed on a single card thus reducing the number of cards required. Correction of errors and editing funcions were carried out once the complete data set was transferred from cards to magnetic tapes.

Obviously it was not possible to edit the complete data set for coding or keypunching errors, but to ensure as much accuracy as possible three methods were applied. The first method entailed the use of the Statistical Package for the Social Sciences (SPSS) computer system. A cumulative frequency count of all variables was printed, thus any errors that provided codes or values other than the normal were identified. This did not pick out errors that fell within the normal coded values, but were in fact in error, therefore a random selection of cases was selected and printed out by the computer. Approximately 1 case in 10 was selected and then proof read against the original coded data. Finally, any extreme values that showed up in the SPSS printout were checked back to the original coded data to ensure that they were correct. Finally a sequence check was performed that ordered the computer to print out any cases that showed any illogical sequences or numbers. Errors were corrected by referring back to the original data.

Once the data had been checked for accuracy programs were run using the IBM facility at the University of Manitoba, Winnipeg, Canada. Separate programmes were written in Fortran language to yield the statistical information discussed in chapter 6. Similarly programmes were written to provide all graphical displays used throughout the thesis.

As noted in Chapter 1 the objective of the thesis is to establish a general study over an extended period of time that might serve as a datum for other research. Two categories of data are defined. Primary data comprise the dates of occurrence of specific climatic events, which include;

a) first day of snow in the fall
b) first day of rain in the spring
c) first day of frost in the fall
d) first day of thaw in the spring
e) date of first sighting of geese in the spring
f) first day of thunder and/or lightning in the spring

or they comprise the frequency of occurrence of the following climatic events;

a) number of days with snow each month
b) number of days with snow each year
c) number of days with rain each month
d) number of days with rain each year
e) number of days with heavy snow each month
f) number of days with heavy snow each year
g) number of days with heavy rain each month

h) number of days with heavy rain each year

i) number of days with thunder each month

j) number of days with thunder each year

k) number of days with north, northwest and northeast winds each month.

l) number of days with north, northwest and northeast winds each year.

m) number of days with south, southwest and southeast winds each month.

n) number of days with south, southwest and southeast winds each year.

o) number of days with east winds each month

p) number of days with east winds each year

q) number of days with west winds each month

r) number of days with west winds each year

The secondary data essentially could be classified as attempts at synthesis and, ultimately, at synoptic analysis of the primary data. The goal of achieving an understanding of climatic change must not be forgotten. Most statistical techniques require that time series be independent of one another but in climatic change trends, cycles, periodicities and simple persistence tend not to be independent or random. One of the techniques used to generate secondary data is the use of power spectrum analysis. This method

> ...is based on the premise that time series are not necessarily composed of a finite number of oscillations, each with a discrete wavelength (as one tacitly assumes when one applies classical harmonic analysis), but rather that they consist of virtually infinite numbers of small oscillations spanning a continuous distribution of wavelengths. The spectrum, therefore, yields a measure of the distribution of variance in a time series over a continuous domain of all possible wavelengths...

(W.M.O., 1966, p. 27)

Observing the limitations as noted in the W.M.O. Technical Note #79 spectrum analysis was carried out on the frequency counts of the number of days of precipitation, that is rain, snow, and no precipitation, events for both stations in the early and most continuous period of the record, in order to determine whether there are any variations at a fixed period, or oscillations which do not have a fixed period but are predictable to some extent.

Only one piece of phenological information is examined in this study. It is considered to be a significant portion of the validation of the data because it combines the actual climatic variables with a phenological event that is a function of climate. The phenological event is the date of arrival of geese at both York Factory and Churchill Factory, while the climatic variable is the percentage of southerly winds occurring in the month of arrival. As will be seen later, studies indicate that the geese fly north in the spring preferably when they have a tail wind.

Since we are dealing with the attributes of the first sighting of geese it was decided to use the phi coefficient. The correlation of attributes can apply to a contingency table of any size, however a phi coefficient requires a 2 x 2 table. Average date of arrival and average percentage of southerly winds served as the variables with the conditions being whether the geese arrived early or late and whether the percentage of winds was above or below average.

The methods outlined in this section can be grouped between those that attempt to deal with the original data, its collection, standard ization and storage, and those that test the validity of the original data and the methodology. The fundamental assumption was that simple techniques are the most powerful and preserve the greatest amount of the original data.

TABLE 11

Listing of Post Journals at York Factory and Journalists

Year	No. of Observations	Journalist
1714	108	James Knight
1715	406	James Knight
1716	393	"
1717	412	"
1718	453	"
1719	442	"
1720	431	"
1721	411	"
1722	390	"
1723	366	"
1724	367	"
1725	370	"
1726	386	James Knight to 29 Aug
1727	385	Anthony Beale from 30 Aug
1728	369	Anthony Beale to 10 Aug; Thomas Macklish from 11 Aug
1729	364	Thomas Macklish
1730	361	"
1731	360	"
1732	355	"
1733	361	"
1734	371	Thomas Macklish to 8 Aug; Thomas White from 9 Aug
1735	383	Thomas White
1736	384	"
1737	406	Thomas White to 6 Aug James Isham from 7 Aug
1738	420	"
1739	267	"
1740	153	"
1741	392	James Isham to 9 Aug Thomas White from 10 Aug
1742	410	Thomas White
1743	396	"
1744	395	"
1745	390	"
1746	406	Thomas White to 13 Aug James Isham from 14 Aug
1747	415	James Isham
1748	448	James Isham to 27 Aug John Newton from 28 Aug
1749	493	John Newton
1750	477	John Newton to 27 Aug Scrimsher from 29 Jun to 28 Aug
1751	412	Scrimsher to 28 Aug

		James Isham from 29 Aug
1752	423	James Isham
1753	389	"
1754	402	"
1755	383	James Isham
1756	384	"
1757	384	"
1758	397	James Isham to 15 Sep Humphrey Marten from 16 Sep
1759	393	Humphrey Marten to 28 Sep; James Isham from 29 Sep
1760	365	James Isham
1761	383	"
1762	400	"
1763	380	"
1764	378	"
1765	371	"
1766	369	"
1767	374	"
1768	377	"
1769	375	"
1770	371	"
1771	699	James Isham to 3 Sep Andrew Graham from 4 Sep
1772	986	Andrew Graham to 20 Aug; Ferdinand Jacobs from 21 Aug
1773	379	Ferdinand Jacobs
1774	940	"
1775	2127	"
1776	2186	Ferdinand Jacobs to 26 Aug; Humphrey Marten from 27 Aug
1777	2190	Humphrey Marten
1778	1696	" -- Instrumental Record
1779	2166	" Instrumental Record
1780	1569	" -- Instrumental Record
1781	379	Humphrey Marten
1782	252	Humphrey Marten Fort Captured
1783	109	Humphrey Marten
1784	395	"
1785	410	"
1786	440	"
1787	479	"
1788	469	Humphrey Marten to 27 Aug; Joseph Colen from 28 Aug
1789	450	Joseph Colen
1790	417	"
1791	460	"
1792	446	"
1793	641	"
1794	1338	"
1795	1290	"

1796	1315	"
1797	691	Joseph Colen
1798	445	Joseph Colen
1799	384	"
1800	385	"
1801	368	"
1802	335	Joseph Colen to 14 Sep; William McNab from 14 Sep
1803	61	William McNab
1804	24	"
1805	41	"
1806	47	"
1807	28	"
1808	42	"
1809	30	William McNab to 14 Aug; William Cook from 15 Aug
1810	9	William Cook
1811	15	"
1812	7	"
1813	15	"
1814	285	"
1815	983	William Cook to 27 Sep J. Swain from 28 Sep
1816	544	J. Swain
1817	0	"
1818	51	"
1819	139	"
1820	100	"
1821	173	"
1822	234	"
1823	396	J. Swain
1824	382	"
1825	375	"
1826	405	"
1827	774	J. Swain

TABLE 12

Post Journals at Churchill Factory

Year	No. of Observations	Journalist
1718	122	Richard Stanton
1719	412	"
1720	441	"
1721	427	"
1722	477	Nathaniel Bishop June 30-July 1 1723
1723	520	Richard Norton & Thomas Bird from July 1 1723
1724	444	Richard Norton
1725	388	"
1726	386	"
1727	393	Richard Norton from Aug 1-5 1727; Thomas Bird Aug 6-22 1727
1728	402	Thomas Bird for Anthony Beale Aug 23 1727
1729	426	Thomas Bird for Anthony Beale
1730	448	Thomas Bird
1731	416	Richard Norton
1732	406	"
1733	389	"
1734	388	"
1735	430	James Napper
1736	445	Richard Norton
1737	409	"
1738	433	"
1739	403	"
1740	407	"
1741	410	James Isham
1742	427	"
1743	408	"
1744	411	"
1745	416	Robert Pilgrim
1746	421	"
1747	409	"
1748	406	Joseph Isbister
1749	413	"
1750	402	"
1751	412	"
1752	408	Ferdinand Jacobs
1753	393	"
1754	392	"
1755	396	"
1756	407	"
1757	387	"
1758	382	"
1759	395	Moses Norton
1760	373	Ferdinand Jacobs
1761	379	"

1762	401		Moses Norton
1763	375		"
1764	378		"
1765	374		"
1766	367		"
1767	369		"
1768	621		"
1769	864		John Fowler
1770	373		Moses Norton
1771	378		"
1772	381		"
1773	368		Moses Norton from 3 Sep 1773 to 29 dec 1773;
1774	365		Andrew Graham from 29 Dec 1773
1775	363		Andrew Graham
1776	386		Samuel Hearne
1777	383		"
1778	393		"
1779	390		"
1780	391		"
1781	253		"
1782	missing		
1783	109		"
1784	385		"
1785	382		"
1786	385		"
1787	370		William Jefferson
1788	369		"
1789	368		"
1790	373		"
1791	376		"
1792	381		Thomas Stayner
1793	369		Thomas Stayner
1794	372		"
1795	375		"
1796	372		"
1797	365		William Auld
1798	261		"
1799	missing		
1800	108		Thomas Stayner
1801	75		John McNab
1802	21		William Auld
1803	1		"
1804	7		"
1805	57		"
1806	13		"
1807	27		"
1808	6		"
1809	13		Thomas Topping
1810	10		"
1811	572--	Instru-	"
1812	1464	mental	"
1813	1041--	Record	"
1814	54		J. Charles
1815	284--	Instru-	"
1816	582	mental	Adam Snodie
1817	645--	Record	"

1818	416		"
1819	113		W. Ross
1820	4		"
1821	41		Hugh Leslie
1822	88		"
1823	117		"
1824	109		"
1825	151		"
1826	165		George Taylor
1827	249		Unsigned
1828	274		Robert Harding
1829	280		"
1830	142		"
1831	237		"
1832	395		"
1833	363		"
1834	399		John Lee Lewis
1835	370		Robert Harding
1836	329		"
1837	370		"
1838	1063	--Instru-	"
1839	705	Mental	"
1840	803		"
1841	1091	--Record	"
1842	1095	--Instru	Robert Harding
1843	1094		"
1844	1098		Unsigned
1845	693		"
1846	789		"
1847	600		"
1848	334		"
1849	444	Mental	"
1850	140		"
1851	318		"
1852	465		"
1853	506		"
1854	454		"
1855	547	--Record	"
1856	613	!	"
1857	572	!	"
1858	336	\!/	James Hackland

TABLE 13

Instrumental Record: Kept at York Factory

Year	Duration of Record	Obs	Journalist
1771	6 Sep - 31 Dec	1685	Thomas Hutchins
1772	1 Jan - 31 Jun	1685	Thomas Hutchins
1774	6 Sep to 31 Dec	940	
1775	1 Jan to 31 Dec	2127	
1776	1 Jan to 31 Dec	2186	
1777	1 Jan to 31 Dec	2190	
1778	1 Jan to 31 Dec	1696	Joseph Colen
1779	1 Jan to 31 Dec	2166	Joseph Colen
1780	1 Jan to 27 Aug	1569	Joseph Colen
1791	7 temp observations	7	D. Thompson
1792	10 " "	10	D. Thompson
1793	12 Oct to 31 Dec	641	Peter Fidler
1794	1 Jan to 31 Dec	1338	Peter Fidler
1795	1 Jan to 31 Dec	1290	Peter Fidler
1796	1 Jan to 31 Dec	1315	
1797	1 Jan to 12 Sep	691	
1827	1 Jun to 31 Dec	774	Unknown
1828	1 Jan to 31 Dec	474	Robert Miles
1829	1 Jan to 31 Dec	642	Robert Miles
1830	1 Jan to 31 Dec	1076	Robert Miles
1831	1 Jan to 31 Dec	1095	Robert Miles
1832	1 Jan to 31 May	456	Robert Miles
1837	8 Oct to 31 Dec	255	Unknown
1838	1 Jan to 31 Dec	1095	Unknown
1839	1 Jan to 31 Dec	1069	Unknown
1840	1 Jan to 12 Jul	582	Unknown
1841	1 nov to 31 Dec	183	Unknown
1842	1 Jan to 31 Dec	1095	Unknown
1843	1 Jan to 31 Dec	1095	Unknown
1844	1 Jan to 31 Dec	1098	Unknown
1845	1 Jan to 31 Dec	1202	Unknown
1846	1 Jan to 5 may	892	Unknown
1847	1 Sep to 31 Dec	366	Unknown
1848	1 Jan to 31 Dec	1098	Unknown
1849	1 Jan to 31 Dec	1094	Unknown
1850	1 Jan to 31 Dec	1095	Unknown
1851	1 Jan to 31 Dec	1095	Unknown
1852	1 Jan to 31 Aug	732	Unknown

The record from this year on was maintained by Canadian Government representatives.

TABLE 14

Instrumental Records Kept at Churchill

Year	Duration of Record	Obs.	Journalist
1768	7 Sep to 31 Dec	372	Wales & Dymond Scientists of the Royal Society
1769	1 Jan to 23 Aug	739	"
1811	12 Aug to 31 Dec	572	Thomas Topping
1812	1 Jan to 31 Dec	1464	"
1813	1 Jan to 15 Sep	1029	J. Charles
1815	13 Oct to 31 Dec	222	"
1816	1 Jan to 15 June	530	Adam Snodie
1817	1 Jan to 31 Dec	645	"
1838	1 Jan to 31 Dec	1063	Robert Harding
1839	1 Jan to 31 Dec	705	"
1840	1 Jan to 31 Dec	803	"
1841	1 Jan to 31 Dec	1091	"
1842	1 Jan to 31 Dec	1095	"
1843	1 Jan to 31 Dec	1094	"
1844	1 Jan to 31 Dec	1098	"
1845	1 Jan to 31 Dec	693	Unsigned
1846	1 Jan to 31 Dec	789	"
1847	1 Jan to 31 Dec	600	"
1848	1 Jan to 31 Dec	334	"
1853	1 Jan to 31 Dec	506	"
1854	1 Jan to 31 Dec	454	"
1855	1 Jan to 31 Dec	547	"
1856	1 Jan to 31 Dec	613	"
1857	1 Jan to 31 Dec	336	"
1858	1 Jan to 31 Dec	488	"

Chapter VI

ANALYSIS

The analysis of descriptive climatic information should proceed in two stages. The primary analysis involves the numerical investigation of individual weather elements. For the most part this analysis of descriptive climatic information seeks to define two types of parameters, namely, parameteorological, phenological indicators, and measures of intensities and frequencies of occurrence. Secondary analysis involves synthesis of multiple weather elements in the study of synoptic systems. As explained in Chapter 1 the major objective of this study is to establish a base for other historical climatological studies. This infers that the thesis is for the most part descriptive, a fact that the author concedes and defends vigorously in the light of the paucity of information for the time and the region. It does mean however, that the greater part of the analysis involves primary analysis.

The results of the analysis are intended to serve two purposes, 1) to confirm the homogeneity and validity of the raw data. 2) to perform secondary analysis intended to try to validate further the data and also to relate the results to the current knowledge of climate in the northern hemisphere.

Finally it is necessary to clarify two terms. Phenology is by definition a part of the wider subject of bioclimatology and includes the study of the responses of plants and animals to seasonal elements. One portion of this study includes a true phenological indicator namely, the date of the first sighting of geese in the spring. It is argued that this date is, to a great extent, determined by the wind patterns in April and May.

The second term is the word parameteorological. Lamb uses the term in his epic work Climate: Present, Past and Future. Since there is no standard reference for these terminologies it was suggested by Lamb that parameteorology would be used to refer to events such as, the first day of frost in the fall, the first day of thaw in the spring etc. Phenology would be restricted to a narrow definition of climatic indicators as manifested by changes in plant or animal behaviour. There are of course many difficulties with these decisions. For example there can be no doubt that a very early first day of frost could result in severe damage to vegetation for that season. However, Bonacina (1976) implies in his article that a single season would not result in a phenological change. Secondly it is necessary to note that it is also a matter of derivation. Phenological events create results that are indicators of environmental change from the response of plants and animals, while parameteorological events are indicators of environmental change measured by changes in meteorological events, for example the first yearly occurrence of condensation when the ambient air temperature is below freezing. Changes in the latter case is also clearly an indication of environmental change.

6.1 PARAMETEOROLOGICAL INDICATORS.

6.1.1 Date of first rain in summer (Figure 17).

There are occurrences of rain events recorded over the period examined in this study at both Churchill and York Factory in every month of the year, but it was felt that events prior to the 1st of March should be considered as extreme or rare events. They will be discussed in a separate section.

Similarity is evident between the two curves particularly in the portion of the graph up to 1765. After that date the homogeneity is still in evidence except that Churchill generally shows a later date of first occurrence than York Factory. This divergence appears to last until approximately 1795 at which time the curves become coincident, although the range of dates seems more variable from year to year.

The only other feature of immediate significance occurs at the beginning of the record where both curves show a gradual change in the date of first record from the last two weeks of April in the period from 1715 to 1720 to the first two weeks of May after 1735.

It should be noted that the York curve has the following sequences of exceptionally early first date of recorded rain. 1722, 1742, 1768, 1794, 1828, and 1851. In these cases the rain occurred before March 25th. The interval created by these years is as follows; 22, 26, 26, 34, and 23. It is impossible to draw any conclusions from this sequence, partic-

FIRST DAY OF RAIN AFTER MARCH 1 AT YORK FACTORY AND CHURCHILL

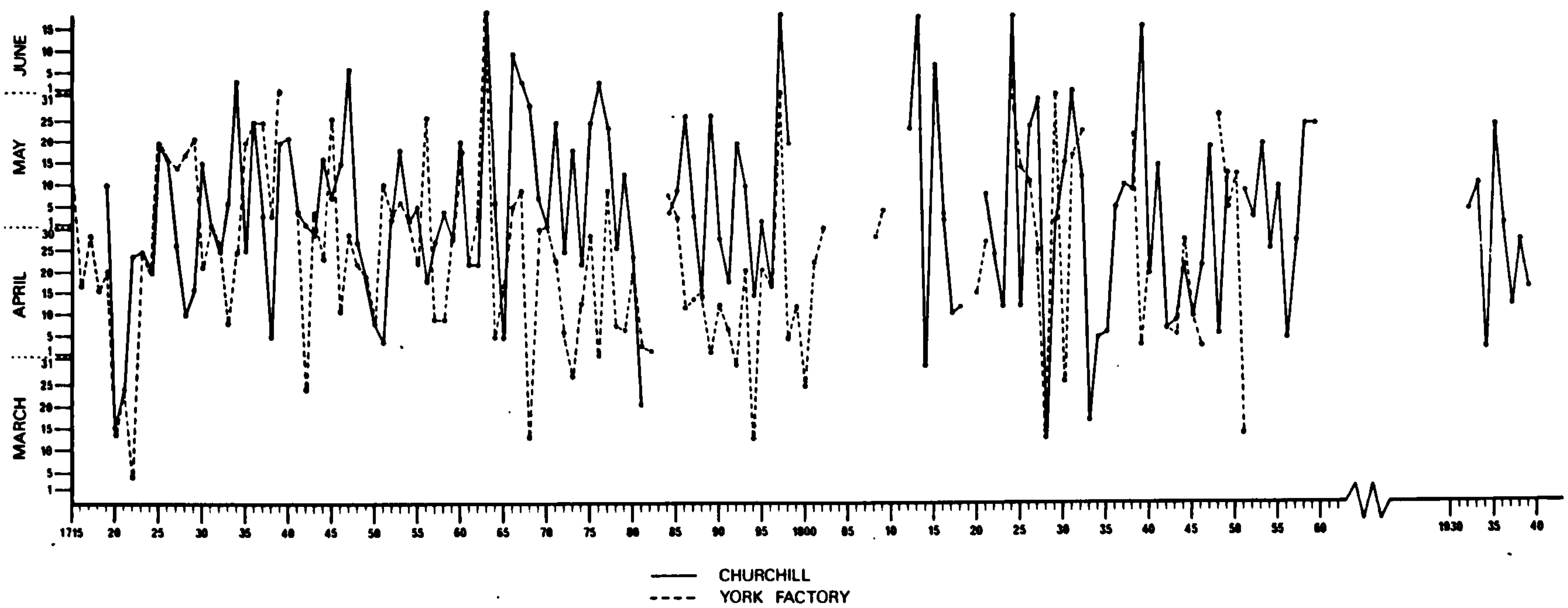


FIGURE 17

ularly because extremely early events occurring before March 1st are eliminated from the record; nonetheless they are intriging.

6.1.2 Date of first snowfall in winter. (Figure 18)

August has the lowest records of snow for both York Factory and Churchill however there are unique events that required the establishment of a base date. In this case the first snowfall refers to the first record after the 1st of August; it does not distinguish between snow flurries or a continuous or heavy fall.

The most obvious feature of these curves is the degree of homogeneity between the curves that would appear to provide strong evidence of the validity of the data. There is far less variability in the curves and no evidence of divergence of the curves as was seen in Figure 17 showing the first day of rain. The difference between the snow and rainfall curves can probably be accounted for by the following reasons. The position of the Arctic Front can vary from season to season, however the mean position lies somewhere between York Factory and Churchill in the summer. The result is that York Factory, the more southerly of the two sites, more frequently experiences the onset of either frontal or convective rainfall, while Churchill's first day of rain is more dependent upon the more extreme northerly positions of the front. Churchill thus remains in the cool stable Arctic air more often than York Factory.

Snowfall at both locations is associated with the movement of the Arctic Front southward to its mean winter lati-

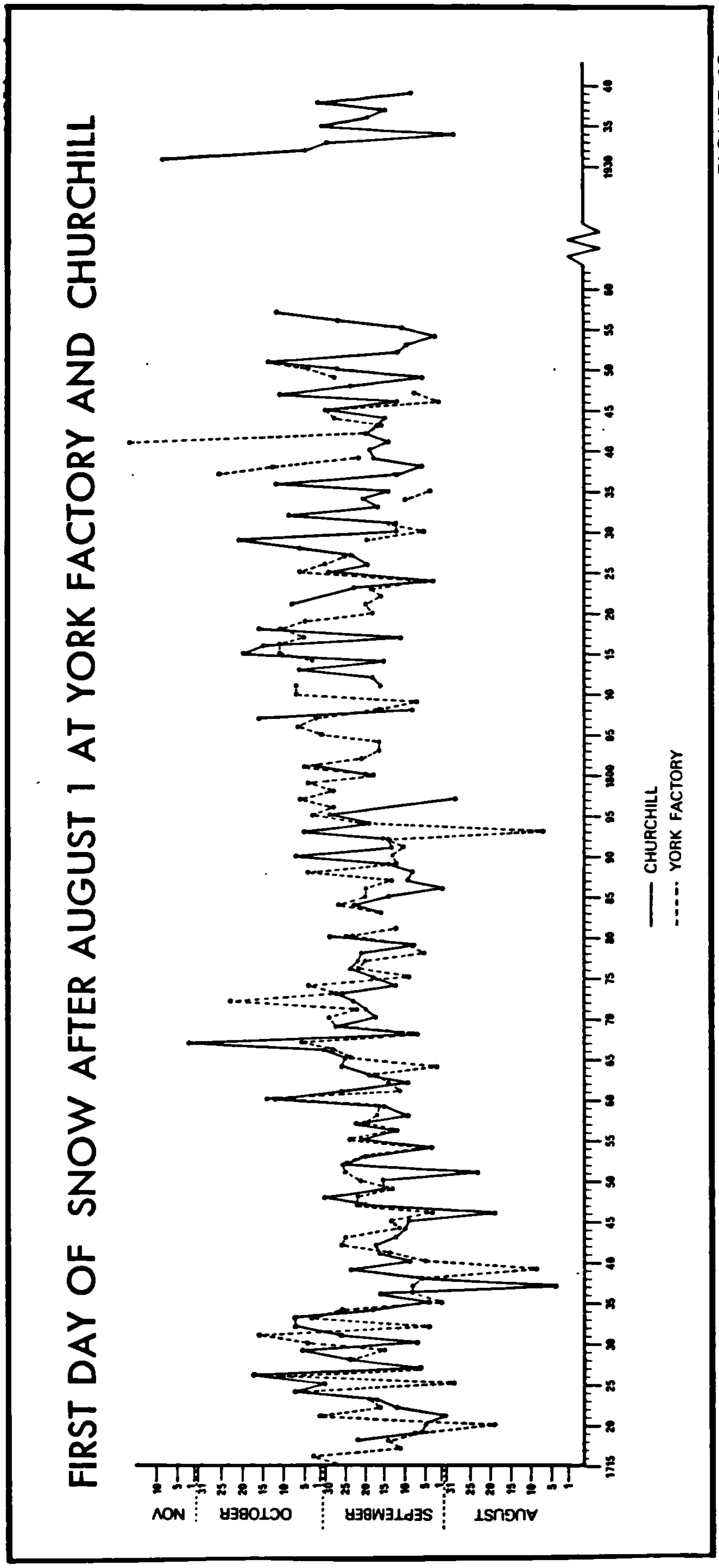

FIRST DAY OF SNOW AFTER AUGUST 1 AT YORK FACTORY AND CHURCHILL
CHURCHILL
YORK FACTORY
AUGUST
SEPTEMBER
OCTOBER
NOV

FIGURE 18

tude. Both stations are thus more consistently experiencing their first snowfall event as the front passes through at approximately the same time.

Variations in the date of first snow appear to be clear indications of variability of climate associated with longer term shifts in the mean position of the Arctic Front. The apparent trends are as follows:

1. There is an overall long trend that indicates a gradual shift of the date of first snow from approximately the first week of September in 1715 to the first week of October in 1820, followed by a gradual decrease back to the middle of September by 1850.
2. Between 1720 and 1735 there is a shift from the first week of September to the last week of September.
3. In 1735 the occurrence reverts to the latter part of August from which time it shows a progressively later date of arrival up until 1765.
4. From 1765 to approximately 1815 there is a gradual progression of date of arrival of the first snow from the second and third week of September to the last week of September and the first week of October.
5. From 1815 to 1855 the date gradually returns to occurring in the second and third week of September, although the range of variability increases slightly.

6.1.3 Date of first thaw in the spring. (Figure 19)

The base date for this analysis was also established as the 1st of March and records prior to that date will also be shown in a later study. Table 8 lists six classes of thaw

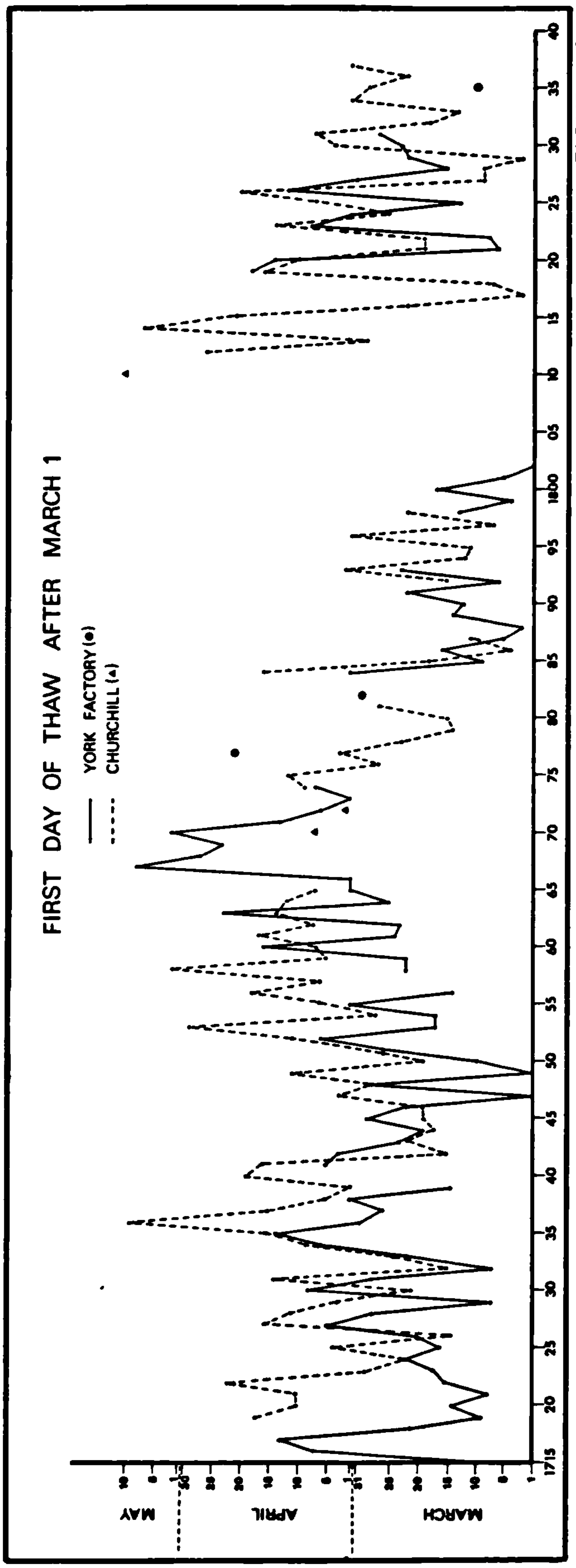

FIRST DAY OF THAW AFTER MARCH 1
YORK FACTORY (•)
CHURCHILL (▲)
MARCH
APRIL
MAY

FIGURE 19

with each indicating in its own way an awareness by the observer of important environmental differences. Pyranometers for measuring global radiation were not developed until 1916 even though Angstrom had developed an instrument for measuring long-wave radiation in 1905. The observers were all indoctrinated into a uniform Company system; also they were, through the Company's affiliation with the Royal Society, probably aware of general meteorological knowledge. Edmund Halley had conducted experiments as early as 1694 that showed the effect of sun and wind on evaporation and in 1760 Joseph Black had advanced the concept of latent heat.

If their knowledge was not obtained from the Royal Society via the Company training then it was empirical information of a relatively sophisticated type. As can be seen from Table 8 they distinguished between: thaw in lee, due to above freezing ambient air temperatures and; thaw in sun, due to a positive net radiation balance. There was no attempt to distinguish between these types in the computer selection, although it would be an interesting project to distinguish the various types and their date of occurrence.

The general factors to note about the two curves can be listed as follows;

1. There is a clearly defined homogeneity between the curves as they tend to follow each other.
2. Generally the date of first thaw is earlier at York (the more southerly station) than at Churchill.
3. The curves are relatively uniform in their movements from 1715 to approximately 1750 with dates of thaw tending to occur between March 15th and April 15th.

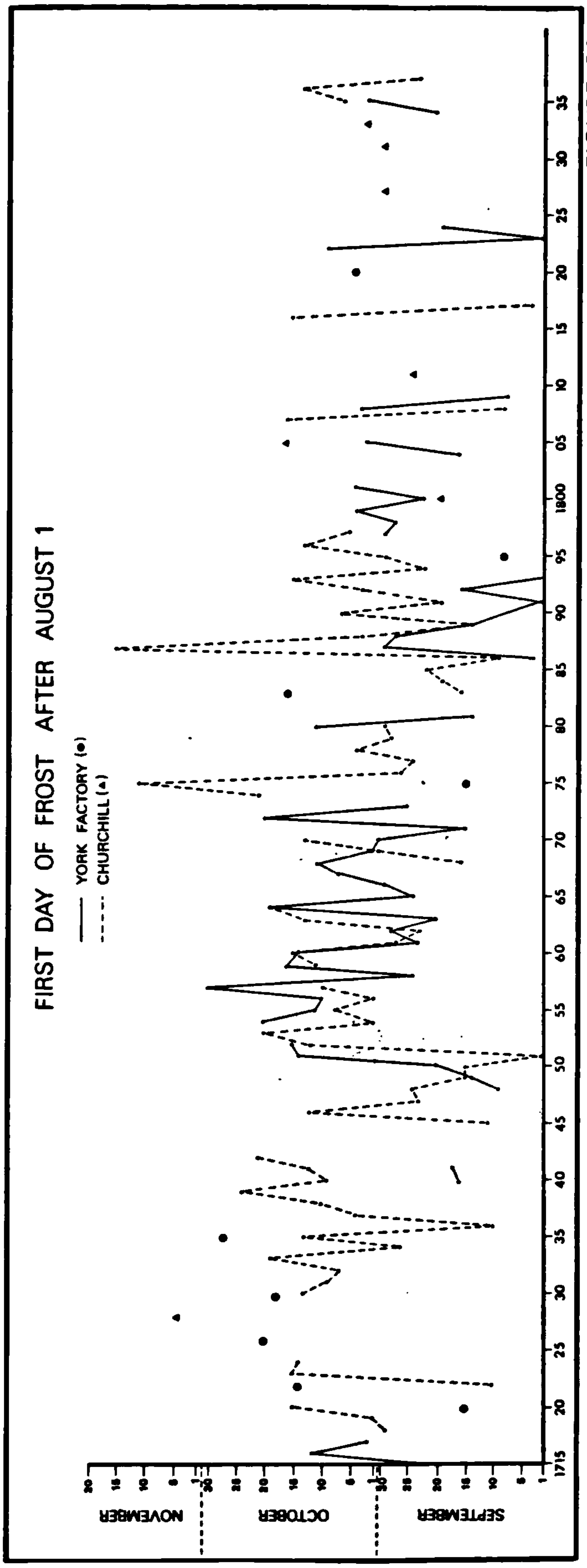
After 1750 the curves tend toward a later date of first thaw with the range shifting to between March 25th and April 25th. This continues until a distinctive downturn begins in approximately 1770 with the first thaw dates tending to occur between the 1st of March and March 25th at both sites. The latter portion of the curve, that is from 1815 to approximately 1835, indicates two things a) the variability is at its greatest for any portion of the record in 1815 but shows a gradual reduction towards 1835. b) the dates have returned to approximately the same range of dates that occurred in 1715-50.

6.1.4 Date of first day frost in the fall. (Figure 20)

Unfortunately this is one of the most incomplete of the graphs presented, nonetheless trends appear to be evident. The computer was programmed to select the first recorded day of frost after Aug. 1.

There is some difficulty with this particular parameteorological indicator because of the problems of definition of frost. It is felt, however, that there is a value in presenting this information.

The problem of identifying frost stems from a clear lack of distinction between visible frost and the use of the term "froze", merely to indicate a relative thermal cooling. In the classification system frost is seen in two categories, the first under the element of 'other precipitation' where it is recorded as rime or thick rime. The second under the element 'frost', which includes degrees of frost, but also



FIRST DAY OF FROST AFTER AUGUST 1
YORK FACTORY (●)
CHURCHILL (▲)
SEPTEMBER
OCTOBER
NOVEMBER
1715
1800

FIGURE 20

has a category labelled hoar frost. While establishing the classification system it was determined that for the most part the term rime, also recorded as 'roak' or 'sea roak', was used to indicate the type of ice that would occur from ice fog drifting in from open water in Hudson Bay. It is important to note that the occurrences of rime is usually associated with an easterly component wind. For this reason rime was classified as a form of advected precipitation and therefore distinguished from frost occurring due to temperatures falling below the dew point with the air temperature below the freezing point.

Tentative comments that can be made about Figure20 are as follows.

1. There is apparent homogeneity of movement between the two stations as the curves tend to follow each other.
2. The curves appear to show a gradual change of the date of occurrence from the first week of October in the 1720s to the third week of September in the 1790s. From that decade the curve appears to remain fairly steady; however there are less references points to precisely determine a trend.

6.1.5 Date of first night frost. (Figure 21)

Unlike the date of first day frost, the record of night frost is restricted to only two categories, namely, 'froze hard at night', or 'frost at night'. Again there is the difficulty of distinguishing hoar frost or condensed frozen water droplets from an actual drop in the ambient air temperature below the freezing point. For the time being it has

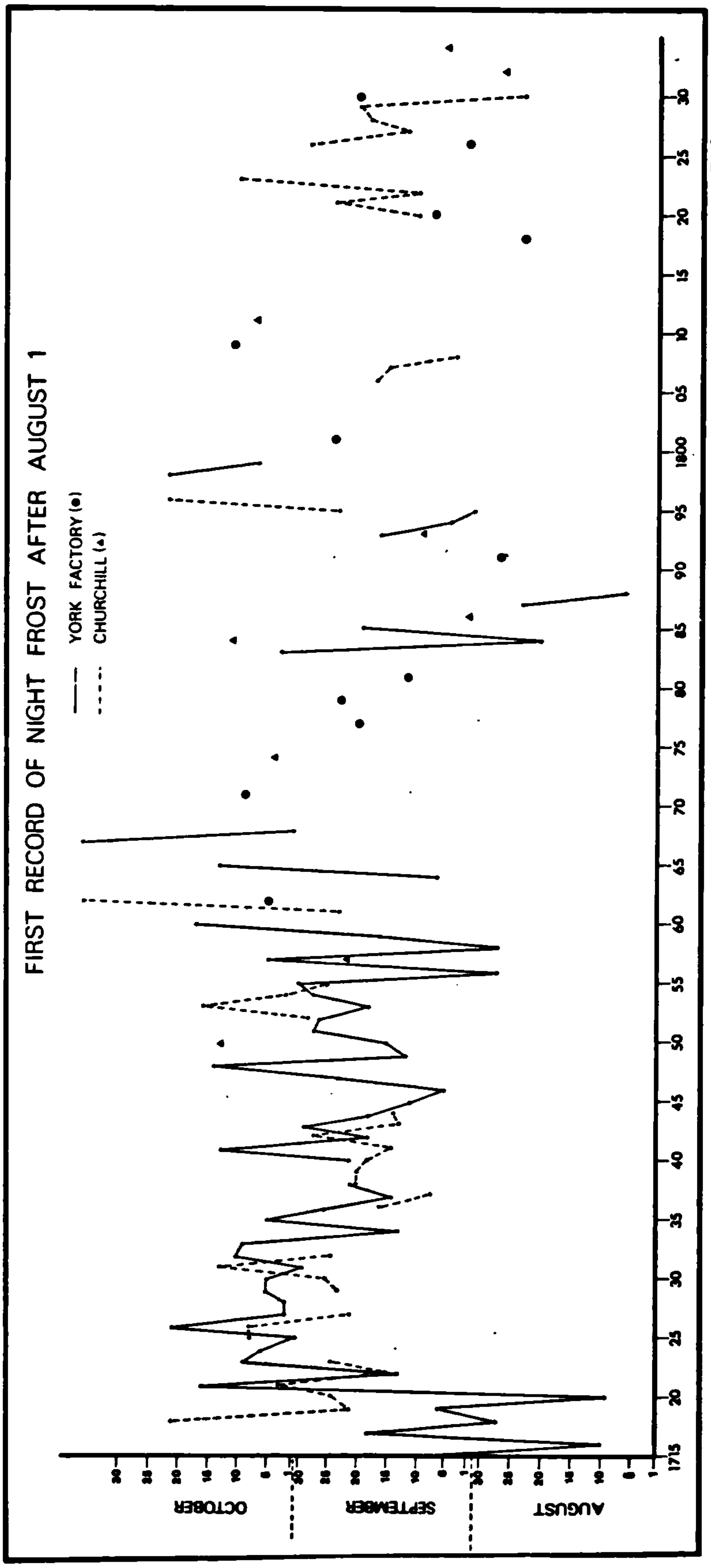

FIRST RECORD OF NIGHT FROST AFTER AUGUST 1
YORK FACTORY (●)
CHURCHILL (▲)
AUGUST
SEPTEMBER
OCTOBER
1715
1800

FIGURE 21

been asumed that in both cases the temperature must fall below the freezing point. However the observers did apparently distinguish between precipitated frost and a drop in temperature that was manifested by thin layers of ice on water surfaces in the vicinity.

The most useable portion of Figure 21 is the period from 1715- 1760, after which the record is almost too sparse to be of any value.

1. Homogeneity between the curves is again in evidence.
2. The curves trend from the first week in October in the 1720's to the second week in the decade from 1735 to 1745. From that point the trend indicates a) a dramatic increase in the variability of the record b) a gradual shift back to the first week of October by 1765.
3. From 1765 onwards the curves appear to show a great deal of oscillation dropping to the last week of August in the 1790's and climbing back to the early weeks of September by 1810 and then to the last week of August by 1830.
4. The overall trend is a gradual change from the first week of October in 1715 to the first week of August in 1830.

6.1.6 <u>Date of first thunder in summer</u>. (<u>Figure 22</u>)

The most difficult aspect of this parameteorological phenomenon lies in the accurate distinction by the observer between thunder and other human or environmental noises. Although the observer records what was determined to be thunder that was not necessarily the case.

DATE OF FIRST THUNDER AFTER MARCH 1 AT YORK FACTORY AND CHURCHILL

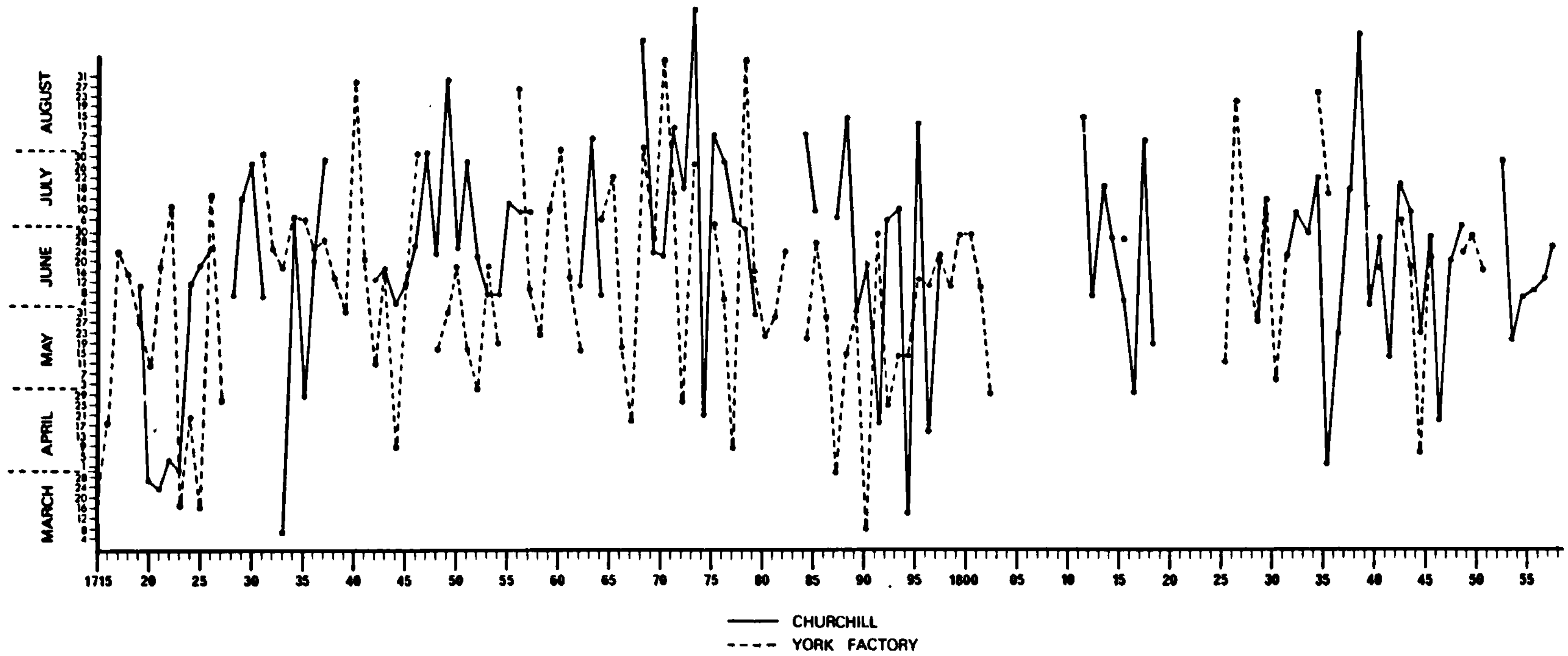


FIGURE 22

Having heard this sound myself there is a possibility that it could on occasion be mistaken for thunder, particularly if it is a distant sound. William Wales writes of another possibility for confusion,

> It was now almost impossible to sleep an hour together, more especially on cold nights, without being awakened by the cracking of the beams in the house, which were rent by the prodigious expansive power of the frost. It was very easy to mistake them for the guns on the top of the house which are three pounders. But those are nothing to what we frequently hear from the rocks up the country, and along the coast; these often bursting with a report equal to that of many heavy artillery fired together, and the splinters are thrown to an amazing distance.
>
> (Wales, 1770, p. 125)

These last comments are interesting but the concept of frost action throwing rock splinters an amazing distance is somewhat dramatic. Nonetheless the noises of ice and frost action in cold clear Arctic air are well illustrated.

A journal entry for the 11th of August (23rd August new calendar) 1746 reports hail stones 4 3/4 inches in circumference. (1 1/2 inches dia.). Although this is an extreme event for the whole record examined in this study, and although it does occur well into August it does suggest that the region is capable of clouds with very strong vertical development.

The curves in Figure 22 indicate the first record of thunder, lightning, or lightning and thunder after the 1st of March. As would be expected York Factory, with its more southerly location generally receives cumulonimbus developments before Churchill. Some important features of the curves appear to be;

1. 1) The general trend of the curves indicate homogeneity. There is a great variability in the dates. Churchill ranges

2. from the earliest record of the 7th of March in 1733 to the latest on the 16th of December in 1773. The latter must be considered a unique event and a more normal late date would be the 24th of September in 1768. At York the range is from the 14th of March in 1790 to the 16th of September in 1778.

3. 3) The general trend of the curves sees a progressive shift of the date of first occurrence from the early part of may in the 1729's to the first week of July in the 1760's. From that point the curves decline to the 1790's when the date is about the last week of May. Although from 1800 the curve is not as complete, it appears that the date of occurrence is relatively stable around the second week of June through to the end of the data in the 1850's.

6.2 PHENOLOGICAL INDICATORS.

In this study only one true phenological indicator is examined. There are a great many indicators available in the records, and hopefully they will all eventually be examined.

A journal entry for May 7th (May 19th new calendar) 1719 reads, "...if the wind has continued in its first station SW we might have better hopes of plenty of geese." The Factor was making note of the importance of the wind direction upon the date of arrival of the geese in their annual spring migration to the north. H.H. Lamb writes "...it seems unlikely that any systematic method for deriving past distributions of global climate from bird evidence alone could be worked out" (Lamb, 1978, p. 235). This section has no intention of disputing this particular point of view; nonetheless there is an aspect of the life pattern of some birds that could provide useful information about climatic changes. In order to find better environments for the different activities in their life cycle birds migrate from one region to another. These migrations are a practice of many species of birds and tend to be precipitated by changes in the seasons. It would seem logical then that if these were changes in the onset of these seasons there would be similar changes in the dates on which the migrations occurred.

A study by Blokpoel of geese migrations in central Canada showed no correlation between the environmental conditions at the migrating birds destination. "Thus, migrations were not dictated by weather and habitat conditions at the point of arrival at Kinoje." (Blokpoel, 1973, p. 27) However "...most species of migrant geese in North America return to their breeding grounds several weeks in advance of the spring breakup. Nest sites are sought out as soon as the thaw begins..." (Hanson, 1965, p. 89)

A study (Blokpoel and Gauthier, 1975) carried out on bird migrations in southern Manitoba attempted to create a predictive model that would reduce the probability of collisions between birds and aircraft. The results obtained were optimistic about the accuracy of the model for prediction. It was determined that, "...five weather factors appeared most useful for predicting spring migration: direction of surface wind and precipitation at Pilot Mound, and direction of surface wind and of geostrophic wind and precipitation at Winnipeg" (Blokpoel and Gauthier, 1975, p. 24). From a climatological point of view there are only three weather variables under consideration, namely, surface wind, geostrophic wind, and precipitation.

The most important aspect of this study appears to be found in the statistical analysis of the significance of wind direction.

> Most (71%) of the surface winds during the departures were tail winds. Side winds occurrred 18% of the time and head winds only 11% of the time. The preference for tail wind and avoidance of head and side winds were statistically significant...
> (Blokpoel and Gauthier, 1975, p. 11)

89% of the departures occurred when the wind was from the side or from behind the birds suggesting that the birds are essentially flying pressure patterns.[3] What is implied here is that these birds indicate the change in pressure patterns commensurate with the onset of spring in central and northern latitudes.

The foregoing suggests that the initial date of arrival of the geese might serve as an indicator of the onset of spring weather patterns. Also, a record of the date of first arrival of geese at one location over a long period of time should reflect any change in those patterns.

---

[3] 'Aircraft crossing the Atlantic in the pre-jet era would fly along what were called pressure pattern routes. That is, in many instances it was quicker to fly on the correct side (tail wind side) of a high or low pressure system to obtain a tail wind, even if the actual distance flown was greater. Apparently the geese use the same method of pressure pattern movement, although the reason is probably due more to lack of food enroute than the need for speed.'

The basic food supply for the Hudson's Bay Company posts during long winter months was the salted goose. They constituted the major ingredient of what were referred to as 'country provisions' as distinguished from 'English provisions'. The salted goose was not apparently a great delicacy with the men, but the Factor was well aware of the importance of the goose hunt and to that end a great deal of preparation was involved. Men were deployed early and the journals dutifully recorded the first sighting of the geese. Because of the consistency of the recoding and the importance of the hunt it would seem safe to assume that the data displayed in Figure 23 are relatively accurate.

The graph (Fig. 23) is a plot of the date of first sighting of geese at York Factory and Churchill as recorded by a succession of Factors from 1714 through 1852. From the same journals daily wind directions were determined and percentage frequency of occurrences of southerly winds are plotted in conjunction with the dates of first sighting. (Fig. 24) Because of Blokpoel and Gauthier's work a plot of the percentage frequency of occurrences of southerly winds are plotted in conjunction with the dates of arrivals of geese at both Churchill and York Factory. It was hypothesized that if the geese did fly with a southerly or tail wind then an early arrival date should coincide with a higher percentage of southerly winds in the period of migration. This proved to be the case.

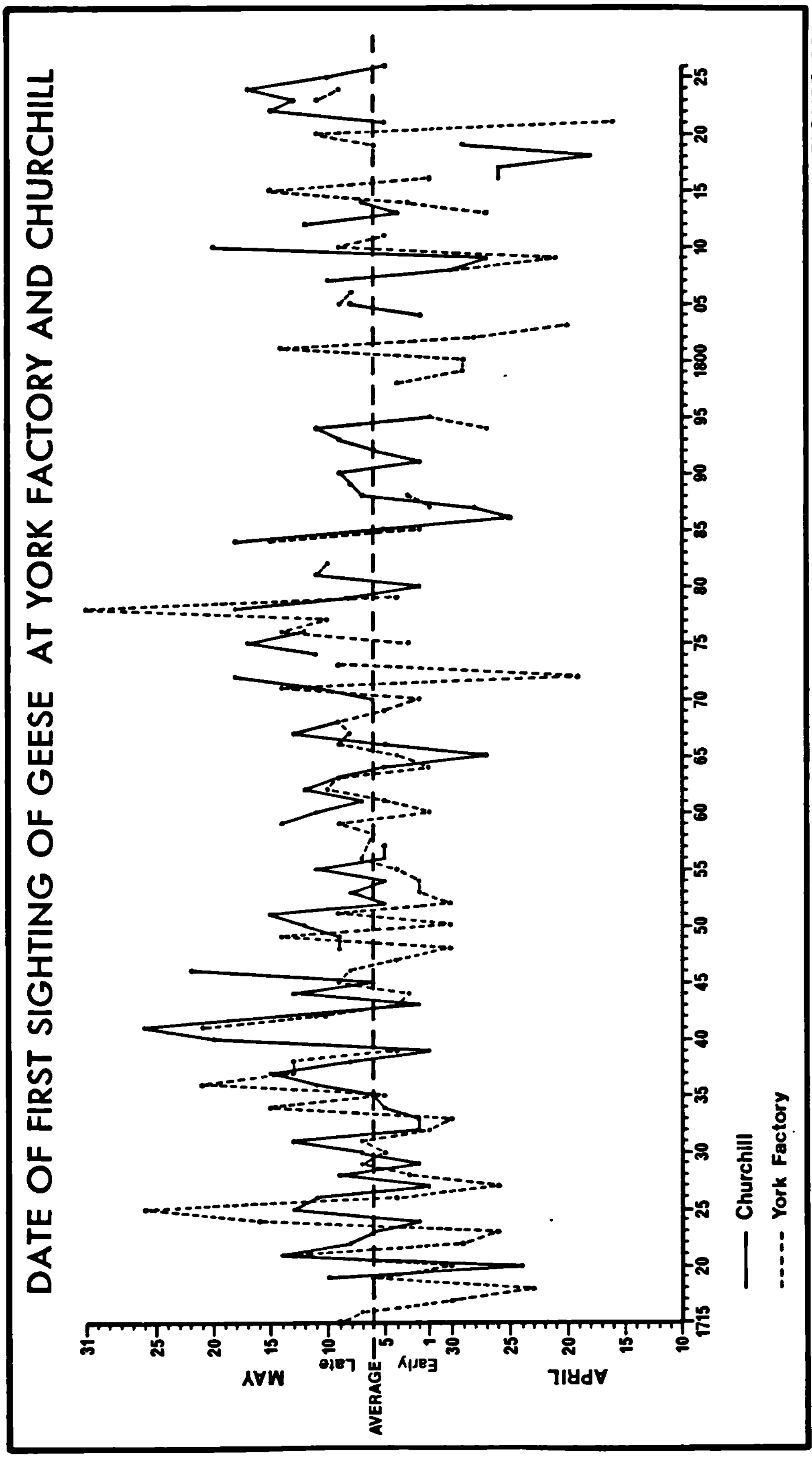

DATE OF FIRST SIGHTING OF GEESE AT YORK FACTORY AND CHURCHILL
MAY
APRIL
Late
Early
AVERAGE
31
25
20
15
10
5
1
30
25
20
15
10
1715
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
1800
05
10
15
20
25
Churchill
York Factory

FIGURE 23

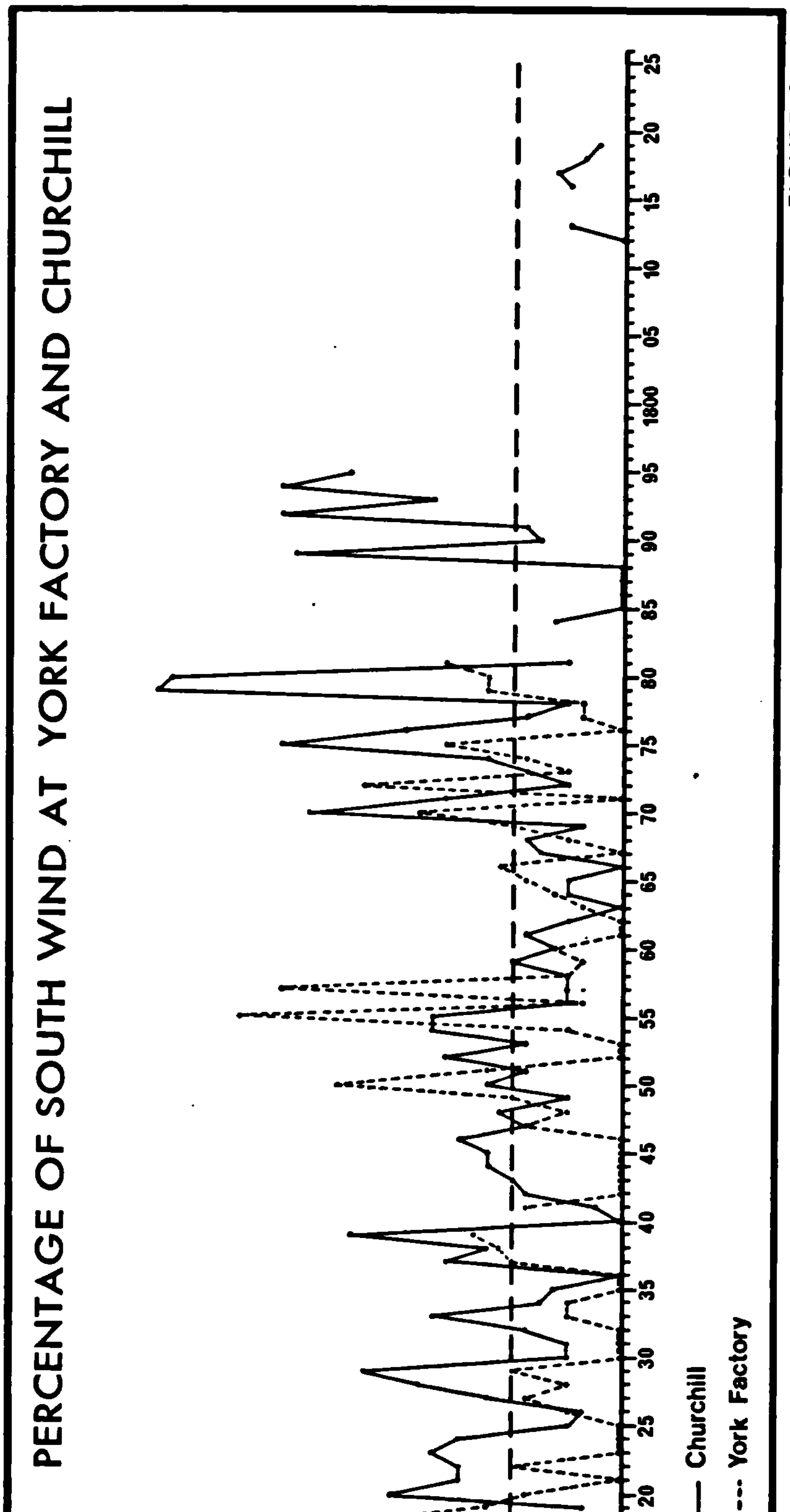

PERCENTAGE OF SOUTH WIND AT YORK FACTORY AND CHURCHILL
% of South Wind
AVE.
Above
Below
40
35
30
25
20
15
10
5
0
1715
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
1800
05
10
15
20
25
Churchill
York Factory

FIGURE 24

6.2.1 Date of arrival.

Visual correlation between the two date of arrival curves is apparent

and therefore serves as an indication of the accuracy of observation and homogeneity of the records. The written comments also provide support to the degree of relationship, particularly in extreme years. At York Factory in 1778 the geese did not arrive until June 1st, the latest date of the whole record. Samuel Hearne writes in the Churchill journal for may 18th of the same year, "Goose killed latest ever known at this place." It is possible that the difference between the dates at the two locations is attributable to the Polar Front being quasi stationary between Churchill and York with Churchill being south of the Front and therefore in the southerly flow while York was north of the Front and in the northerly flow. However the synoptic implications of many of these elements will be examined later.

Important trends apparent from Figure 23 are as follows:

1. There is a gradual change to a later date of arrival commencing in 1715 and progressing through until 1745.
2. The period from 1745 to 1770 exhibits a relatively stable period with little change.
3. From 1770 to 1810 the record shows a slight change as the curves gradually return to an earlier date of arrival.
4. Between 1810 and 1825 there is an apparent gradual reversal with a shift to a later date of arrival.

5. Except for the relatively stable period from 1745 to 1770 the record shows great variability in the date of arrival.

The term correlation has been used rather loosely in the discussion to this point. Statistics requires that the term specifically refer to a measurable relationship between two or more variables.

6.2.2 Date of arrival of geese at Churchill.

The date of first sighting of geese was compared with the percentage of southerly winds in the month of arrival using a phi coefficient. Norcliffe (1977) describes the phi coefficient as "...a special case of a more general method which is known as the correlation of attributes since the categories into which observations are placed may be considered as attributes of the observations" (Norcliffe, 1977, p. 111). Where the phi coefficient gives information about the strength of association between attributes, it requires a chi square test to determine the significance of the association. In this case the attributes of the observations that are tested for the strength of their association are a) whether the geese arrived before or after the average date of arrival and b) whether the percentage frequency of southerly winds were above or below the average for the period of record. The average date of arrival was determined as the 8th of May, a date that is remarkably close to the 1729 observation. Date of arrival was classified as being early or late if it was before or after this day. Those years when the date of arrival was the 8th of May were evenly divided between the early and late categories. The average percentage of southerly winds was the dividing point for the second contingency, although in this case none fell directly on the average. The contingency table is displayed as Table 15.

TABLE 15

Contingency Table Comparing Arrival of Geese with South Winds

Churchill

	Early Arrival of Geese	Late Arrival of Geese	
Above Average Percentage Of Southerly Winds	A 30	B 16	= 46
Below Average Percentage Of Southerly Winds	C 11	D 33	= 44
Total	41	49	90

Using the notation shown in the top right hand corner of each square, that is, A, B, etc., the phi coefficient which measures the degree of correlation between the observations is given by

$$= \frac{AD - BC}{\sqrt{(A+B)(C+D)(A+C)(B+D)}}$$

$$= \frac{990 - 176}{2016}$$

$$= 0.403$$

A phi value of 0.403 indicates a fairly strong positive association. Determining the chi square value from these data we obtain

$$= (.403) * 90$$

$$= 14.61$$

Checking this value for significance at the 0.001 confidence level with 1 degree of freedom shows that the of 14.61 which exceeds the critical value of 10.83 thus suggesting that the association is strong, highly significant and positive.

TABLE 16

Contingency Table Comparing Arrival of Geese with South Winds

York Factory	Early Arrival Of Geese	Late Arrival Of Geese	
Above Average Percentage Of Southerly Winds	A 36	B 13	= 49
Below Average Percentage Of Southerly Winds	C 12	D 24	= 36
Total	48	37	85

Calculating the value of phi for York Factory by the same method as before, we find that it is 0.400. As with the Churchill results a strong positive association is achieved. The chi square value is 13.60 which again indicates a strong, positive and highly significant association. The high degree of statistical correlation between the early arrival and the percentage of southerly winds suggests that the records maintained by the Hudson's Bay Company are reliable sources of climatic data. It also lends support to the studies that claim a tailwind component is an important element for determining the date of migration. Variations in the percentage frequency of south winds appears to indicate variations in the onset of spring and therefore early northward movement of the Arctic Front.

6.3 FREQUENCIES OF CLIMATOLOGICAL EVENTS.

One of the simplest but nonetheless one of the most effective methods of determining climate and climatic change is in the frequency and changes in frequency of climatic events. As this study is attempting to determine a base for subsequent work the determination and graphical display frequencies is deemed to be of great value. The computer technique developed for this study lends itself to rapid and accurate and voluminous determination of frequencies.

6.3.1 Number of days with rainfall from May through October.

Figure 25 indicates the total number of days on which rain was recorded for the period from May 1st through October 31st inclusive.

A synoptic study of climate conditions in the Canadian arctic presents a map showing isolines connecting points of equal rainfall days (Fletcher and Young, 1976, p. 43). A line indicating numbers of days of rain per year is shown running between York Factory and Churchill which means that based on the modern records Churchill has fewer rainfall days than York Factory each year. This agrees with the evidence of the records examined in this study and is what would be expected if the mean position of the Arctic Front was situated between the two situations. There are however several aspects of Figure 25 require comment;

NUMBERS OF DAYS PER YEAR WITH RAINFALL, FROM JUNE THROUGH OCTOBER

FIGURE 25

1. Overall the curves seem to follow the same trends, thus supporting the homogeneity of the records.
2. Changes in the curves begin with a gradual decrease in the number of days of rainfall from 1715, when the average is approximately 35 per year, to a low of approximately 20 in 1765.
3. From that year the curves rise rapidly to a peak of around 40 in 1780 which holds until 1785 when an even more rapid decline occurs to 1790.
4. Unfortunately there is a large gap in the record between 1800 and 1820, which from all other available comments and indications was an extremely interesting climatic period.
5. When the curves commence again in 1820 they appear to approximate levels of frequency previously seen in the period from 1740 through 1750, except that now the variability about the mean is greater.
6. A significant feature of the curves is the separation that begins in 1755 between the York Factory curve and the Churchill curve. The difference between the curves reaches a maximum in 1765. From that year onwards the difference remains relatively constant until the available data terminate in 1800. When the curves resume in 1820 the difference has disappeared and the curves are again relatively synchronous.

The possibility exists that the differences between the two curves commencing in 1755 could be the result of a change in the observers at one or both of the stations. The difficulty with this proposition is that the observers do change at both locations and yet none of these changes appear to be coincident with the variations in the record. The list of journalists in Tables 11 and 12 show that between 1755 and 1780 York Factory had 6 different observers while Churchill had 5. Further, one observer at York, James Isham, had been an observer for 10 years (1738, 1739, 1740, 1741, 1747, 1748, 1751, 1752 and 1754) prior to 1755 when the records were not separated. A second observer, Joseph Colen, was an observer whose term began during the time in question and extended beyond 1800.

A second possibility is that a change occurred in the location from which the observations were taken. There were changes. York Factory was moved a distance of approximately one mile in 1791. Churchill Factory saw two locations, the first from 1718 to 1739, and again from 1783 onwards, the second was at Fort Rrince of Wales from 1740 to 1782. None of these dates appear to be coincident with changes in the record. Also, as discussed extensively in the section on the different sites, there is such uniformity of terrain that it is considered unlikely that these minor geographical relocations would create significant changes.

6.3.2 Number of days with snowfall, October through May. (Fig. 26)

The graph indicates the total number of days on which snow was recorded for the period from October 1st to May 31st. In the computer count of these total days there was no attempt to distinguish between different types of snowfall.

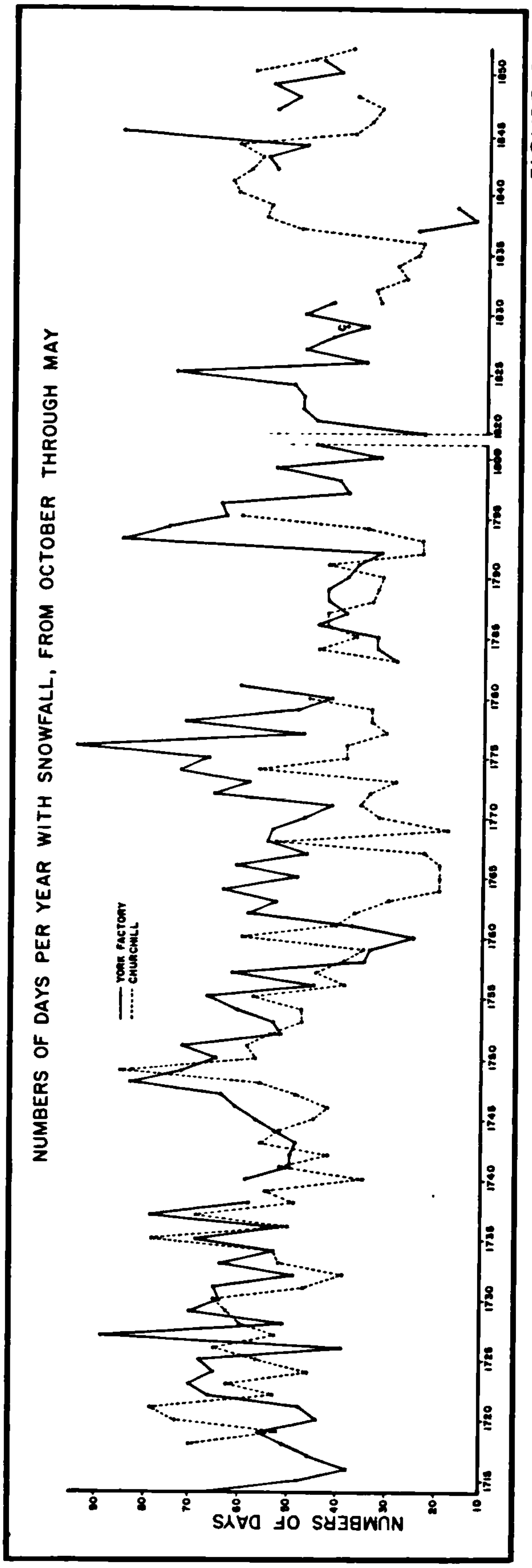

NUMBERS OF DAYS PER YEAR WITH SNOWFALL, FROM OCTOBER THROUGH MAY
YORK FACTORY
CHURCHILL
NUMBERS OF DAYS

FIGURE 26

NUMBER OF DAYS OF RAIN, JAN.-DEC.

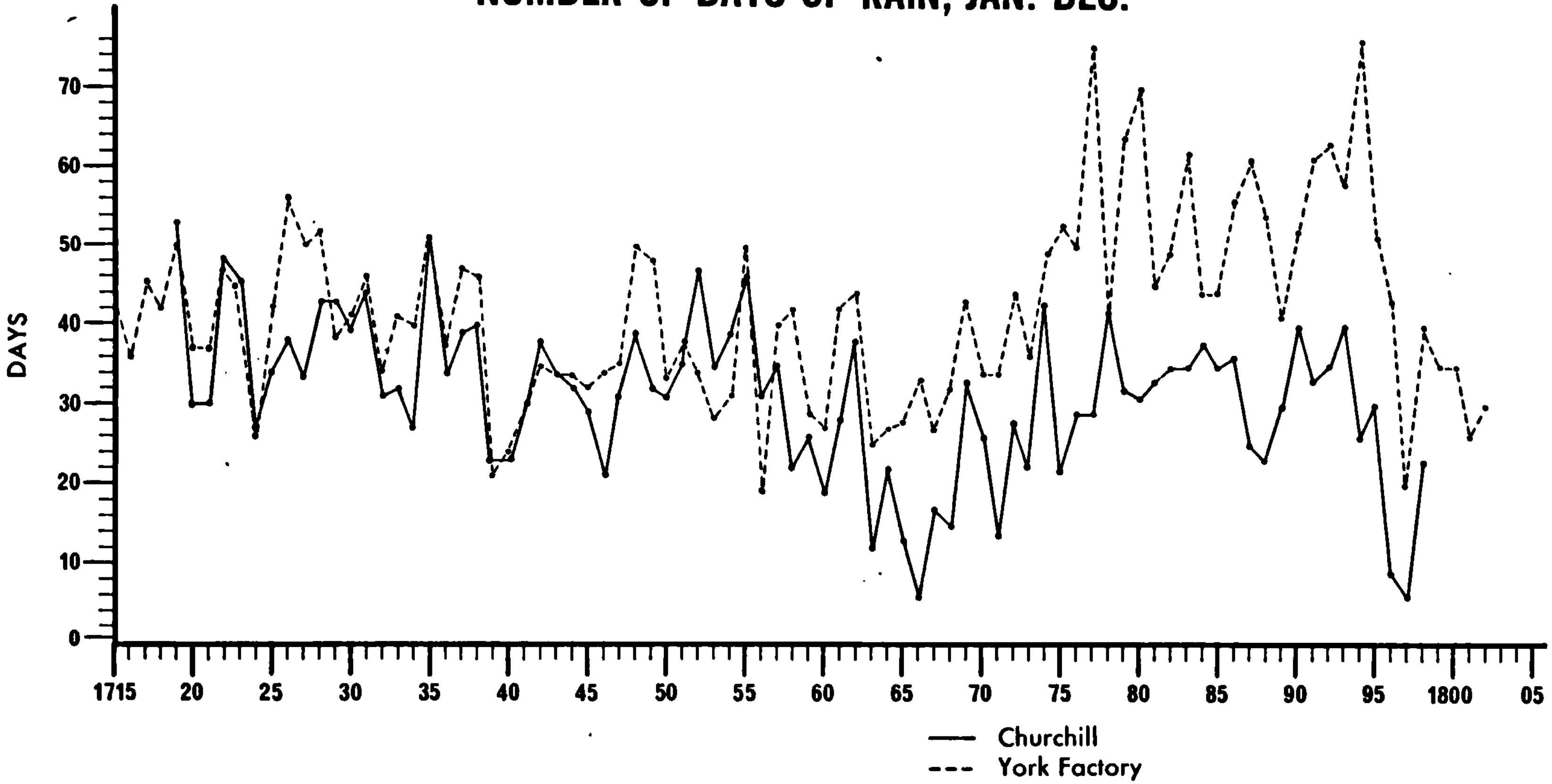


FIGURE 27

NUMBER OF DAYS OF SNOW, JAN.-DEC.

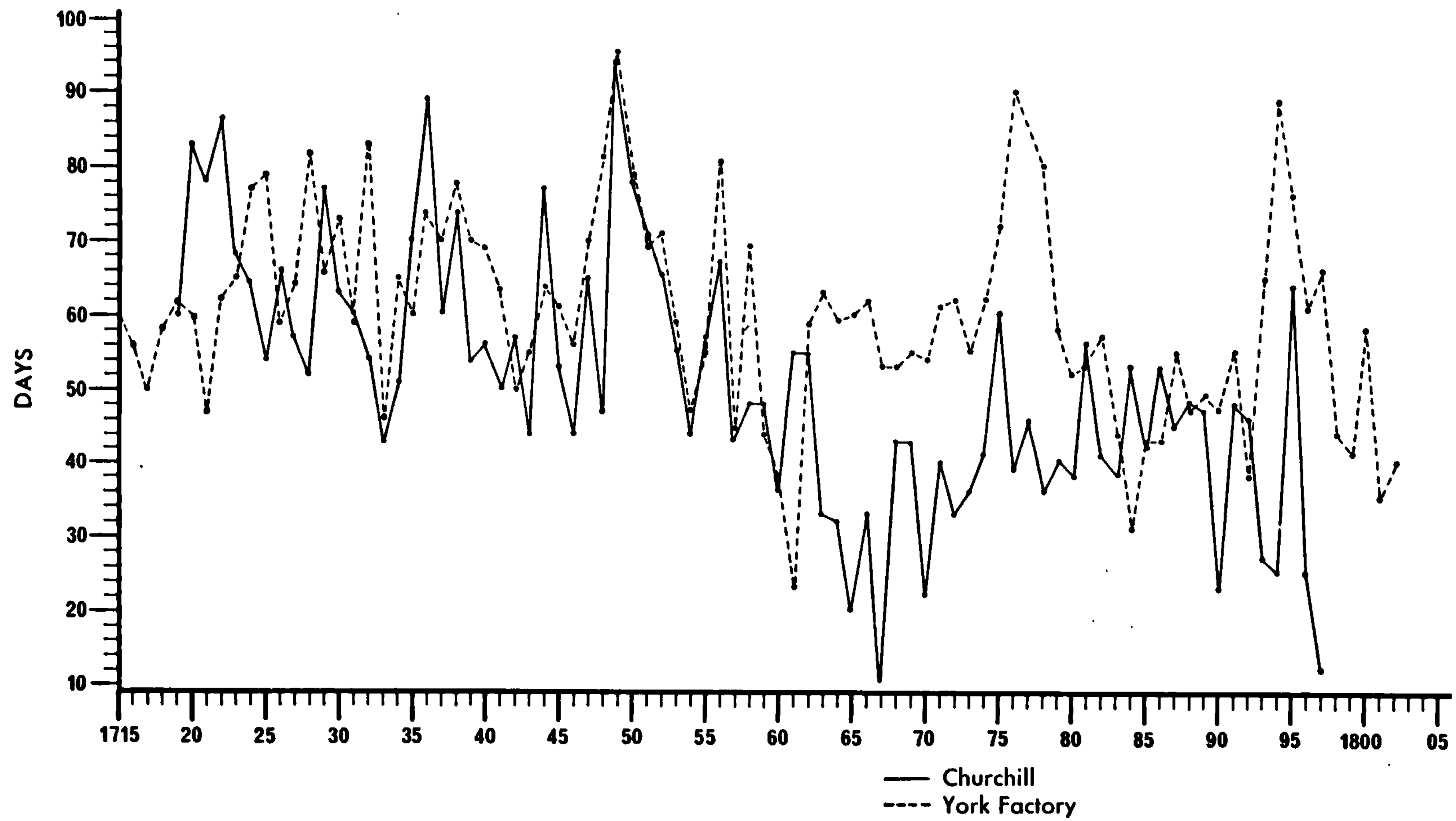
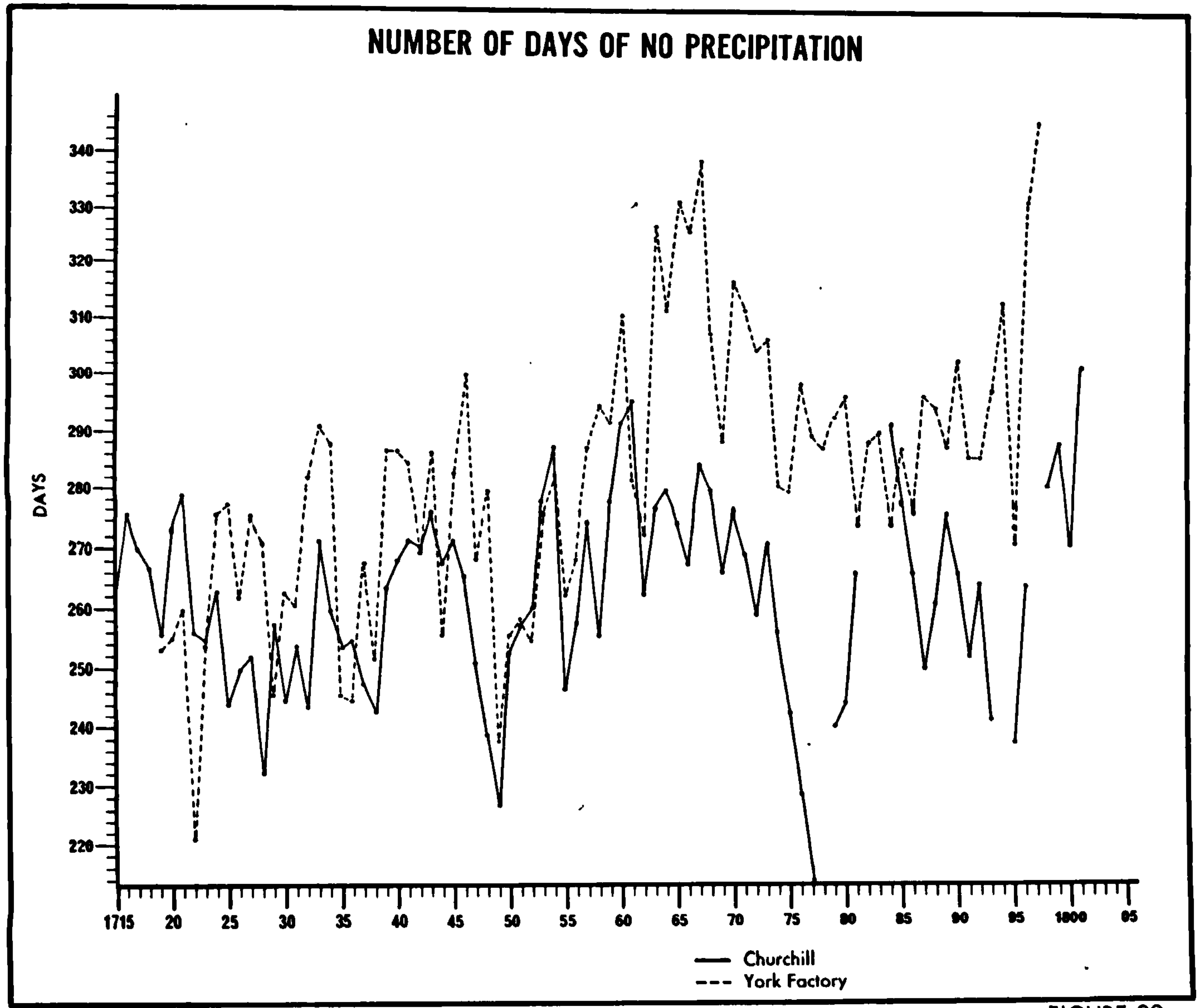


FIGURE 28



NUMBER OF DAYS OF NO PRECIPITATION
DAYS
340
330
320
310
300
290
280
270
260
250
240
230
220
1715
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
1800
05
Churchill
York Factory

FIGURE 29

1. There is apparent homogeneity between the York Factory and Churchill graphs, but it is not as distinct an homogeneity as in the rainfall graph. Much of the lower level of homogeneity can probably be attributed to the very localized occurrence of snow showers originating from open water in Hudson Bay. This would be particularly true in the fall and spring and probably more noticeable at York Factory than at Churchill. In a description of the climate of Hudson Bay H.A. Thompson writes.

   > Not only is there a noticeable southward increase in snowfall over Hudson Bay, but during the open-water months of autumn, snowstorms are characteristically heavier and more frequent along the east coast than on the west coast.
   >
   > (Thompson, 1970, p. 269)

   The curve at York Factory appears to support this comment as it shows that generally there are more days of snow than at Churchill.

2. The curves show a gradual decline in the number of days from an approximate average of 60 per year in 1715 to 50 per year in 1850.

3. Variation of the number of days of snowfall is much higher than that for the number of days of rainfall.

4. The general trend of the two curves are synchronous up until 1762 at which point the curves diverge in a similar manner to the rainfall curves. There is a major difference in that the curves approach each other again as the observed values are roughly equal in 1780.

5. On a smaller scale the trends appear to suggest a fairly stable pattern from 1715 to 1740 when a brief decrease until 1745 is followed by a rapid increase to a peak in 1750. After 1750 the values decline quite dramatically until 1760 after which there is a gradual increase until 1780. From 1780 to 1793 the values fall to an average of approximately 35 and variability is drastically reduced. By 1795 the values have returned to the range of preceding decades and this trend continues through to the end of the data in 1850.
6. The five years from 1760 to 1765 appears to mark a point of significance in the rainfall and snowfall curves at both York and Churchill.

6.3.3 Power spectrum analysis of num. of days of precip. (Fig. 30 to 35)

The data for these analyses are shown in Figs. 27 - 29, while the results are shown in Figs. 30 - 35. The use of a power spectrum in climatology was briefly justified in a previous chapter but its use will be further elaborated here. Spectrum analysis is the name given to methods of estimating the variance spectrum of a time series. In this particular case the data are continuous series of the frequency of number of days of rain, snow and no precipitation for each month over approximately a 90 year span for each station.

The first problem was to create a series of sufficient length and continuity to be statistically acceptable. At both Churchill and York Factory the most continuous sequences are found at the beginning of the record, that is from 1719 to approximately 1798 and from 1715 to 1802 respectively. The Churchill data have only one gap in this span that being from September 1781 to September 1783 due to capture of the Fort by the French. York has a gap at the same time and for the same reason, and it also has a gap from September 1739 to September 1740, due to a shipwreck and loss of the journal. The missing data were filled in by an average figure that was obtained by two different methods dependent upon how many days of information were available. If there were

1. Less than 10 days of record in the month the number of days of precipitation of the same month in the preceding and subsequent years were averaged and used.
2. More than 10 but less than 20 days, the number recorded was added to an average of the preceding and subsequent years.

Computations were carried out by means of an SAS programme. Input to the programme used monthly counts of rainfall days rather than annual frequencies because of the need to attain as large a number of lags as possible. Spectral resolution is dependent upon the number of lags used and therefore the higher the number of lags the greater the number of spectral estimates that can be achieved. Unfortunately as spectral resolution is increased there is a corresponding decrease in the number of degrees of freedom. W.M.O. Tech. Note 79 suggests that the maximum number of lags should be approximately one-third of the number of points in a series. The SAS programme allows for a maximum lag of 199 and since the shortest series for Churchill has 948 points this value was used.

When using spectral analysis on data that has a known trend or seasonality, or both, it is a common practice to pre-whiten the raw data. This consists of making a linear transformation of the raw data in order to create a smoother spectrum. Initially a non-prewhitened programme was run to determine if the 6 month and 12 month trends would be visible. This had the effect of verifiying the data and the programme. The prewhitened power spectra for the number of days of rain, snow, and precipitation free days for York Factory and Churchill are shown in Figures 30 through 35.

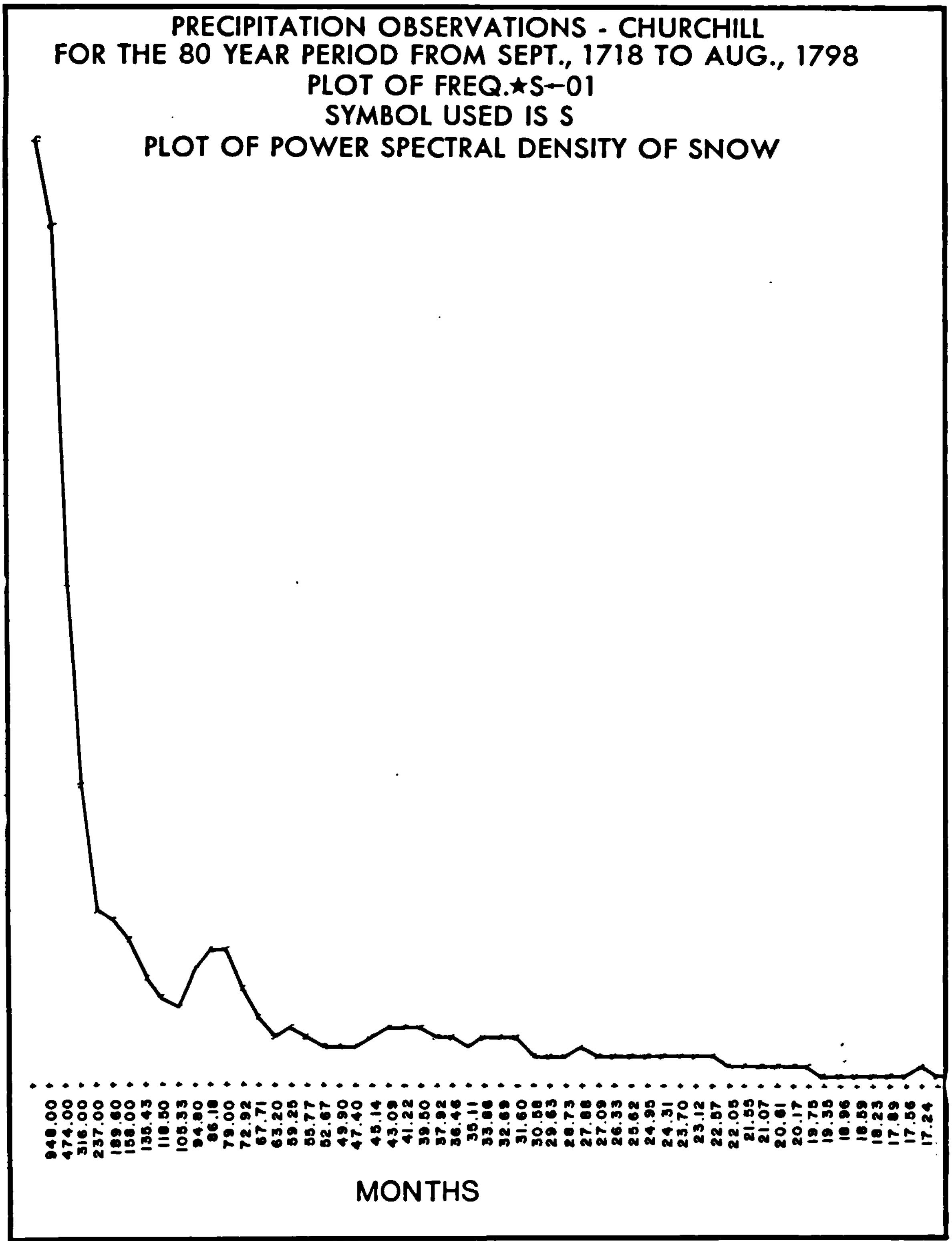

PRECIPITATION OBSERVATIONS - CHURCHILL
FOR THE 80 YEAR PERIOD FROM SEPT., 1718 TO AUG., 1798
PLOT OF FREQ.*S--01
SYMBOL USED IS S
PLOT OF POWER SPECTRAL DENSITY OF SNOW
948.00 474.00 316.00 237.00 189.60 158.00 135.43 118.50 105.33 94.80 86.18 79.00 72.92 67.71 63.20 59.25 55.77 52.67 49.90 47.40 45.14 43.09 41.22 39.50 37.92 36.46 35.11 33.86 32.69 31.60 30.58 29.63 28.73 27.88 27.09 26.33 25.62 24.95 24.31 23.70 23.12 22.57 22.05 21.55 21.07 20.61 20.17 19.75 19.35 18.96 18.59 18.23 17.89 17.56 17.24
MONTHS

FIGURE 30

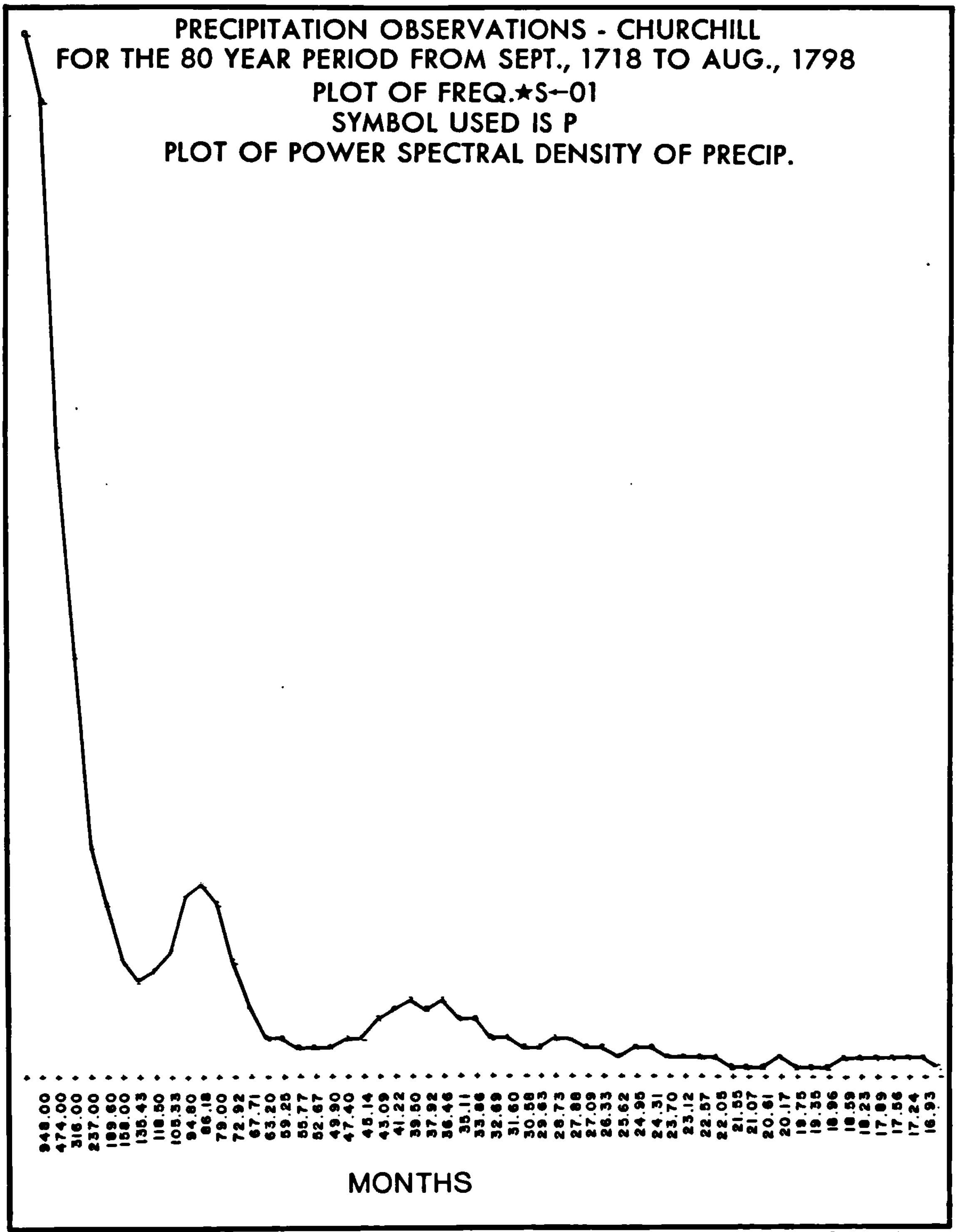

PRECIPITATION OBSERVATIONS - CHURCHILL
FOR THE 80 YEAR PERIOD FROM SEPT., 1718 TO AUG., 1798
PLOT OF FREQ.★S←01
SYMBOL USED IS P
PLOT OF POWER SPECTRAL DENSITY OF PRECIP.
948.00 474.00 316.00 237.00 189.60 158.00 135.43 118.50 105.33 94.80 86.18 79.00 72.92 67.71 63.20 59.25 55.77 52.67 49.90 47.40 45.14 43.09 41.22 39.50 37.92 36.46 35.11 33.86 32.69 31.60 30.58 29.63 28.73 27.88 27.09 26.33 25.62 24.95 24.31 23.70 23.12 22.57 22.05 21.55 21.07 20.61 20.17 19.75 19.35 18.96 18.59 18.23 17.89 17.56 17.24 16.93
MONTHS

FIGURE 31

PRECIPITATION OBSERVATIONS - CHURCHILL
FOR THE 80 YEAR PERIOD FROM SEPT., 1718 TO AUG., 1798
PLOT OF FREQ.★S-01
SYMBOL USED IS R
PLOT OF POWER SPECTRAL DENSITY OF RAIN

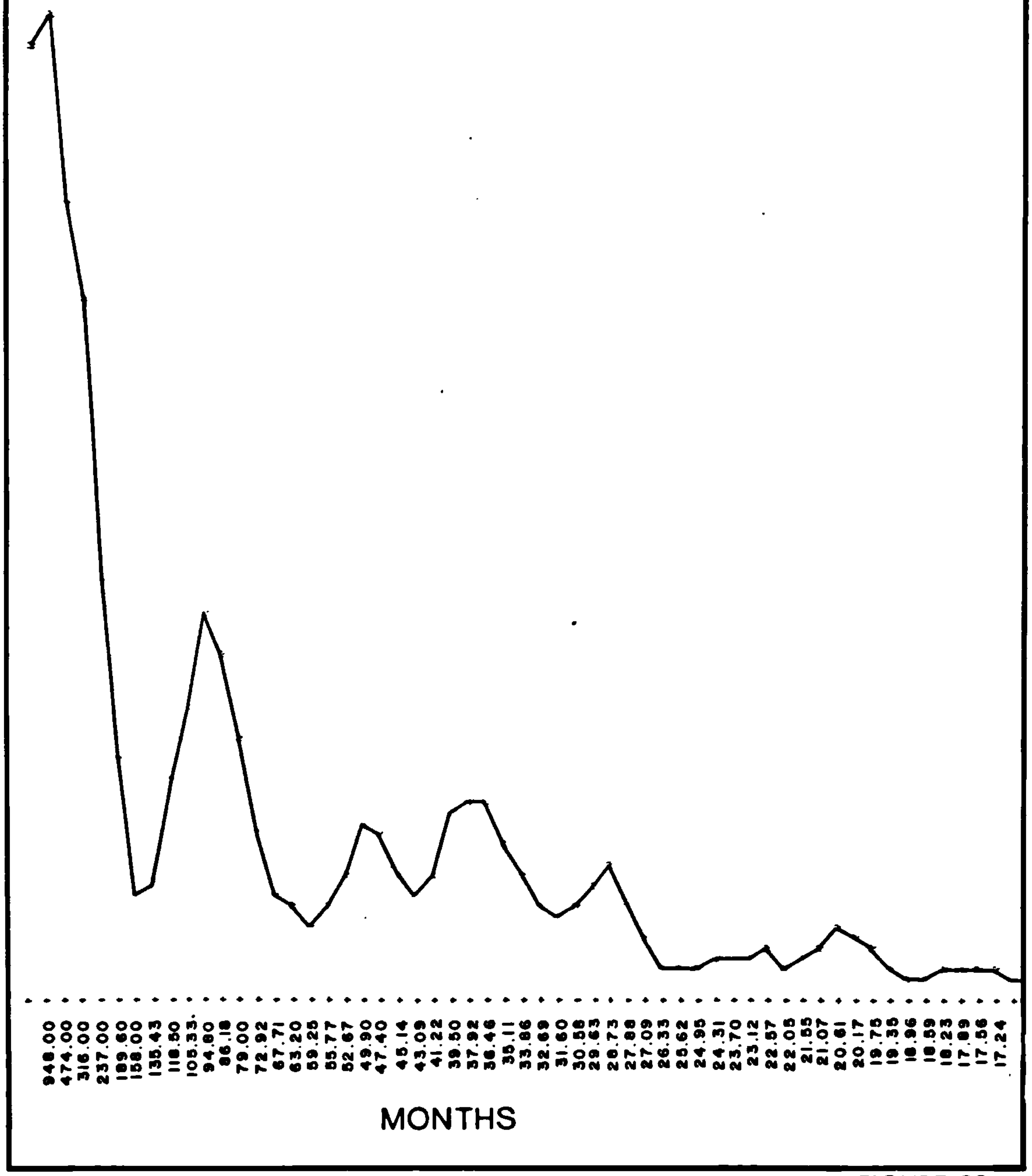


FIGURE 32

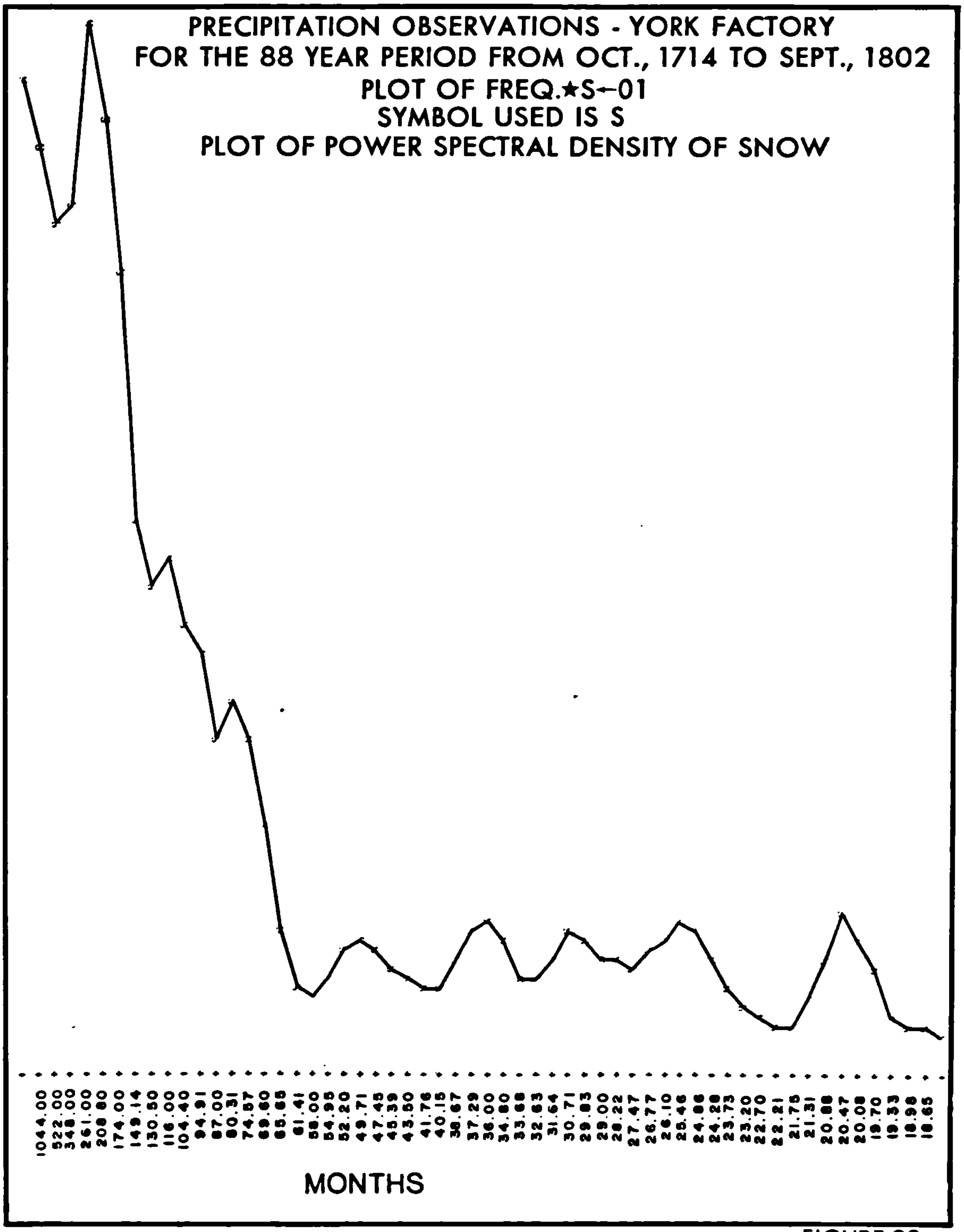

PRECIPITATION OBSERVATIONS - YORK FACTORY
FOR THE 88 YEAR PERIOD FROM OCT., 1714 TO SEPT., 1802
PLOT OF FREQ.*S←01
SYMBOL USED IS S
PLOT OF POWER SPECTRAL DENSITY OF SNOW
1044.00
522.00
348.00
261.00
208.80
174.00
149.14
130.50
116.00
104.40
94.91
87.00
80.31
74.57
69.60
65.25
61.41
58.00
54.95
52.20
49.71
47.45
45.39
43.50
41.76
40.15
38.67
37.29
36.00
34.80
33.68
32.63
31.64
30.71
29.83
29.00
28.22
27.47
26.77
26.10
25.46
24.86
24.28
23.73
23.20
22.70
22.21
21.75
21.31
20.88
20.47
20.08
19.70
19.33
18.98
18.65
MONTHS

FIGURE 33

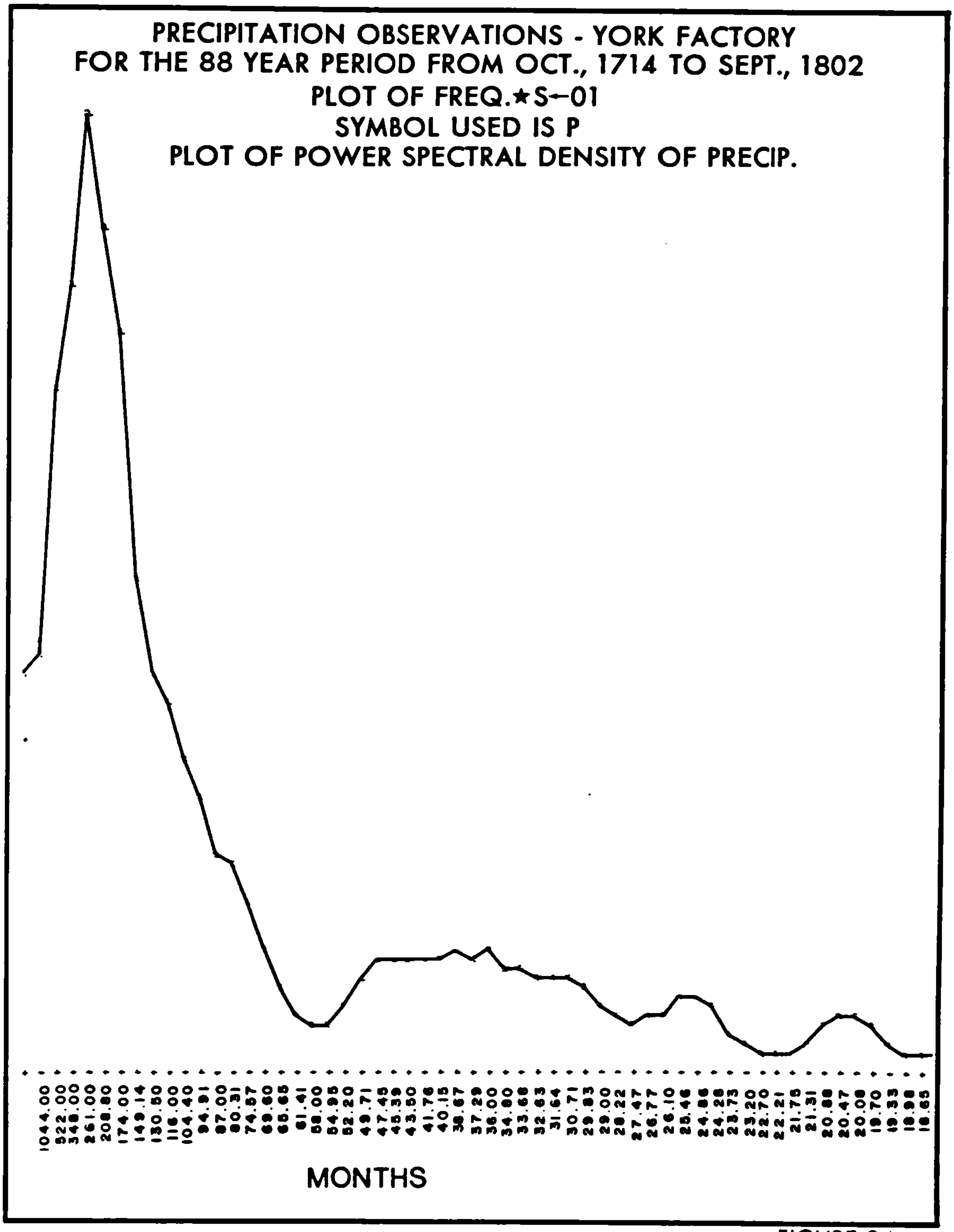

PRECIPITATION OBSERVATIONS - YORK FACTORY
FOR THE 88 YEAR PERIOD FROM OCT., 1714 TO SEPT., 1802
PLOT OF FREQ.*S--01
SYMBOL USED IS P
PLOT OF POWER SPECTRAL DENSITY OF PRECIP.
MONTHS

FIGURE 34

PRECIPITATION OBSERVATIONS - YORK FACTORY
FOR THE 88 YEAR PERIOD FROM OCT., 1714 TO SEPT., 1802
PLOT OF FREQ.★S−01
SYMBOL USED IS R
PLOT OF POWER SPECTRAL DENSITY OF RAIN

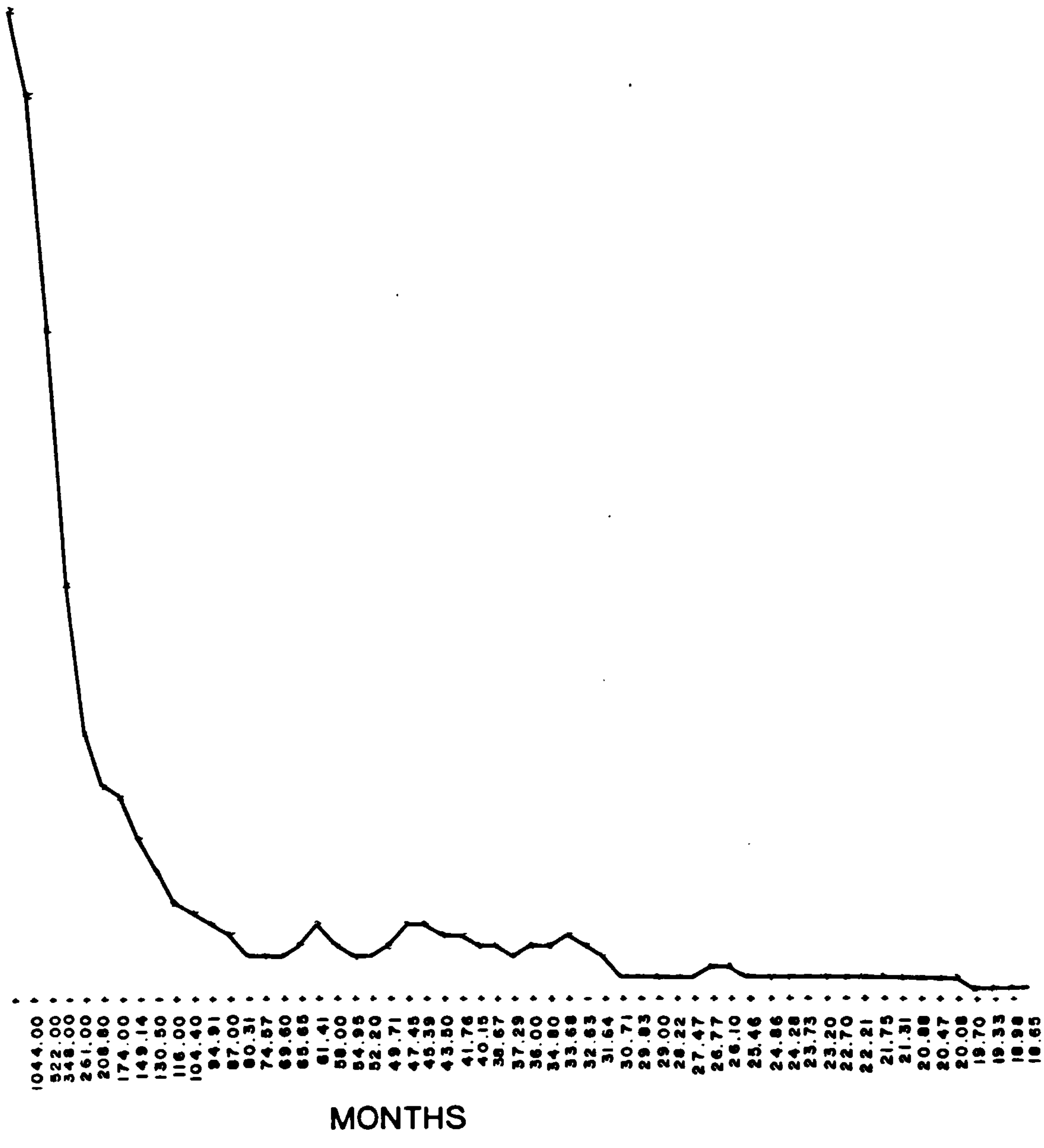


FIGURE 35

6.3.4 Spectrum of the numbers of days of rain. (Figs.32 & 35)

Figures 32 and 35 show the computer plots of power spectral estimates of the prewhitened data against frequency for the York Factory and Churchill data. The only similarity between the two curves is the high initial peak of power, at a wavelength close to infinity, which is indicative of a long term cycle with a frequency slightly longer than the period of time covered by the data. It also suggests that the trend is for a gradual increase in the power to a peak followed by a gradual decline over a period of approximately 300 years. The York Factory graph has no other peaks of significance while the Churchill graph has several points. Peaks occur at 79 years, 7.8 years, 4.1 years, and 3 years respectively. These results do not appear to relate to any existing studies of rainfall, although Bradley (1977) did identify a 3 year periodicity. The peak at 7.8 years is possibly a harmonic of the 79 year period.

6.3.5 Spectra of the number of days of snow. (Figs. 30 & 33)

Again the long term trend is in evidence at both locations. In contrast to the rainfall spectra it is the York Factory curve that has several peaks while the Churchill curve simply shows the long term trend. The peaks in the York Factory curve occur at 22 years, 9.7 years and 6.7 years respectively. It is difficult to determine whether the peak at 9.7 years is a cycle or merely an anomaly superimposed on the 22 year spike. There is no question that the latter represents a clearly defined trend as does the peak at 6.7 years.

The 22 year cycle is intriguing because there is a 22 year sunspot cycle that is apparently related to a 22 year drought cycle in the Great Plains Region of North America.

6.3.6 Spectra of the number of days with no precipitation. (Figs. 31 & 34)

The Churchill curve shows the long term trend again that was exhibited in the previous graphs. Two peaks appear to be significant, one at 7 years and another at 3 years.

The York Factory curve is quite different. It still exhibits a long term trend although it is not as pronounced as in the other graphs. There is a very distinctive peak at 22 years and a lesser peak at 3.2 years. The 22 year peak is distinctive because of the intensity of the peak but also because it correlates with the previously mentionned sunspot and drought cycle. It would appear that the occurrence of the 22 year cycle at York Factory while it is not in appearance at Churchill is part of the evidence that York is in the Boreal forest zone while Churchill is in the tundra region.

6.3.7 Number of days with rainfall for each month. (Fig. 36-38)

These graphs were prepared for two reasons: first, to provide graphical display of descriptive data and determine the degree of relative homogeneity of the record at the two stations at a more detailed level than previously achieved; second, to attempt to ascertain if there are any differences in particular months with regard to climatic change.

FIG. 36a NUMBER OF DAYS OF RAINFALL IN APRIL AT CHURCHILL

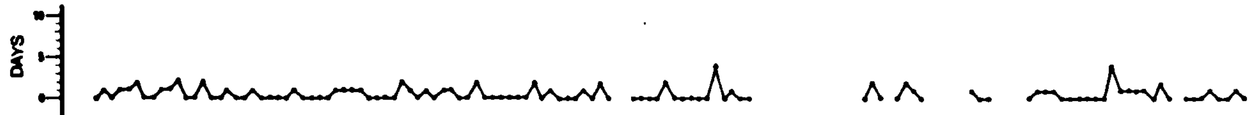
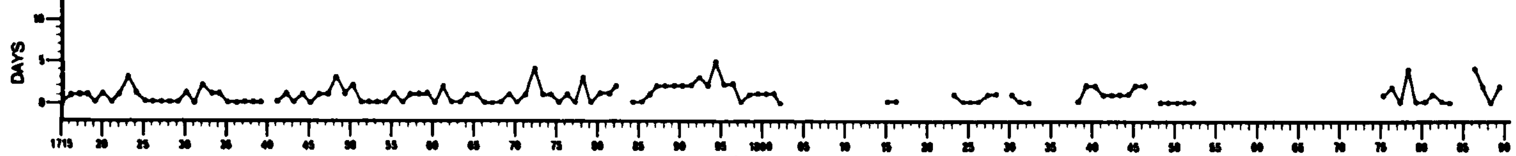


FIG. 36b
NUMBER OF DAYS OF RAINFALL IN APRIL AT YORK FACTORY



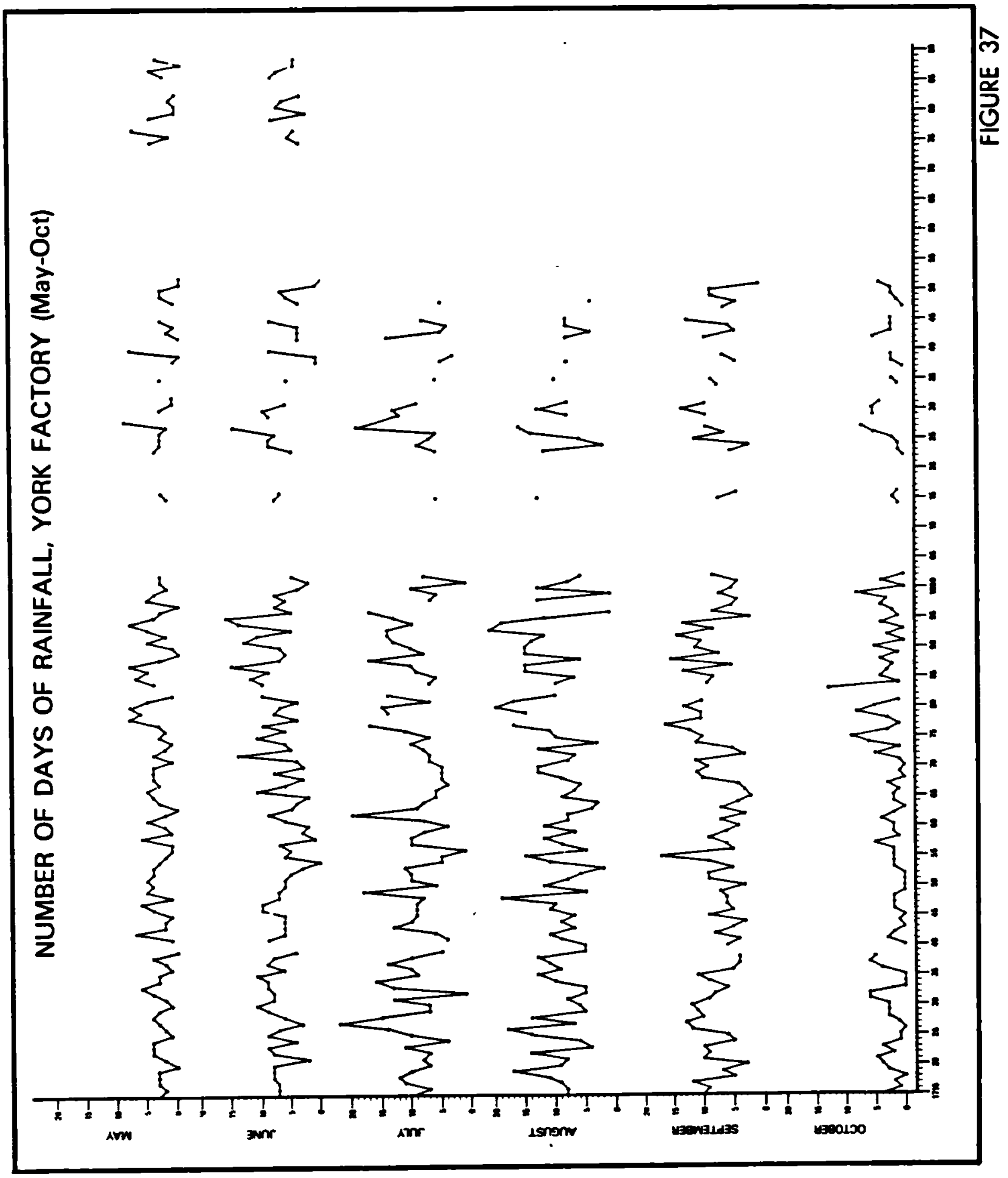
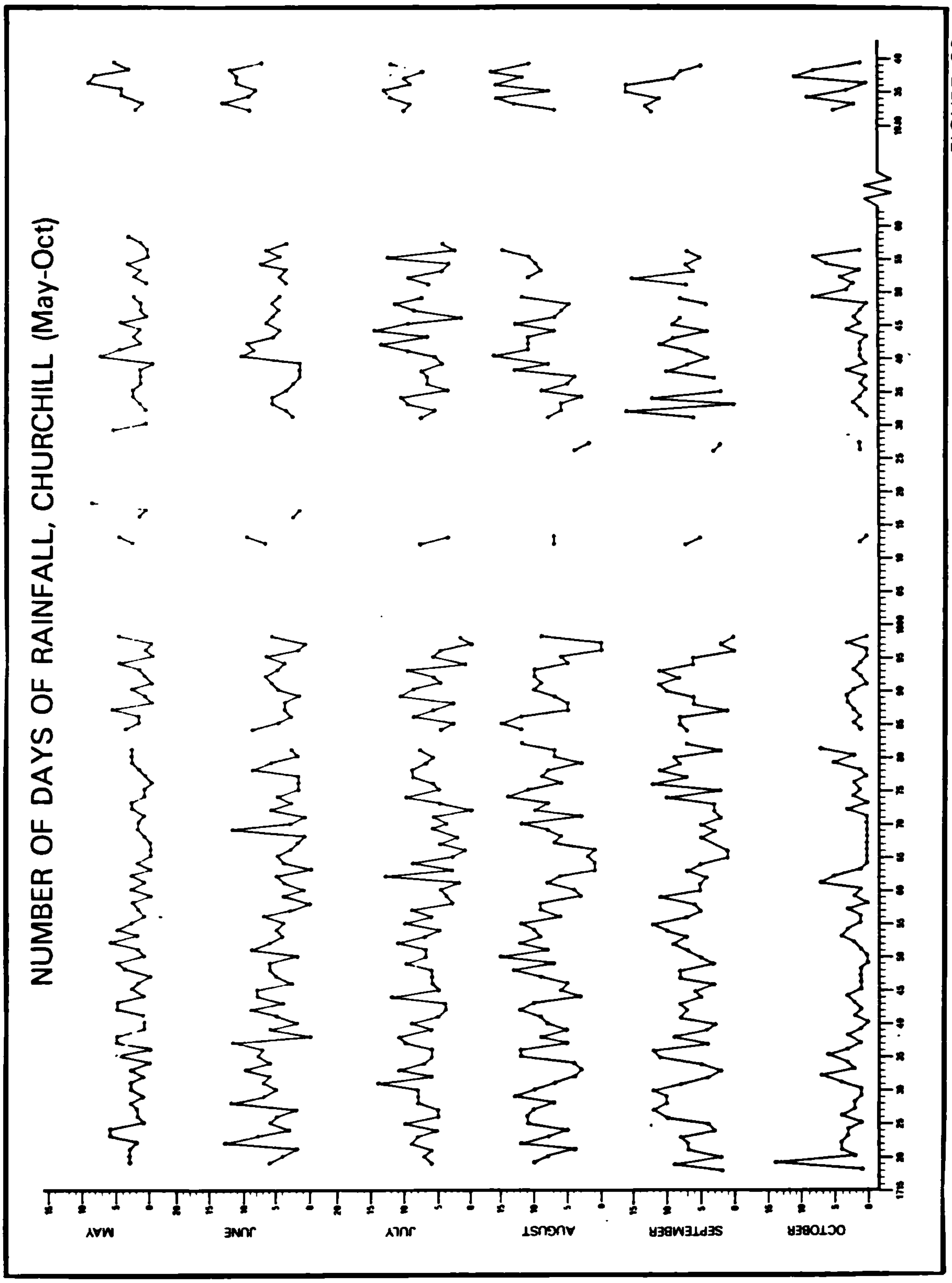


Figure 37: Number of days of rainfall, York Factory (May-Oct)


NUMBER OF DAYS OF RAINFALL, CHURCHILL (May-Oct)
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
FIGURE 38

Because the data are intended as a clear descriptive display the curves for the two stations have been presented separately. When the curves are superimposed the degree of homogeneity is evident.

6.3.8 Number of days with snow events for each month. (Fig. 39-42)

There are no months in which snow was not recorded at Churchill so a graph was drawn for all months of the year. The same is not true for York Factory and as a result July and August are omitted.

A similar degree of homogeneity is seen between the snowfall graphs as was observed in the rainfall graphs.

The curves for July and August at Churchill are interesting as they indicate occurrences of snow in the early record, that is from 1719 to 1750, after which there are very few cases.

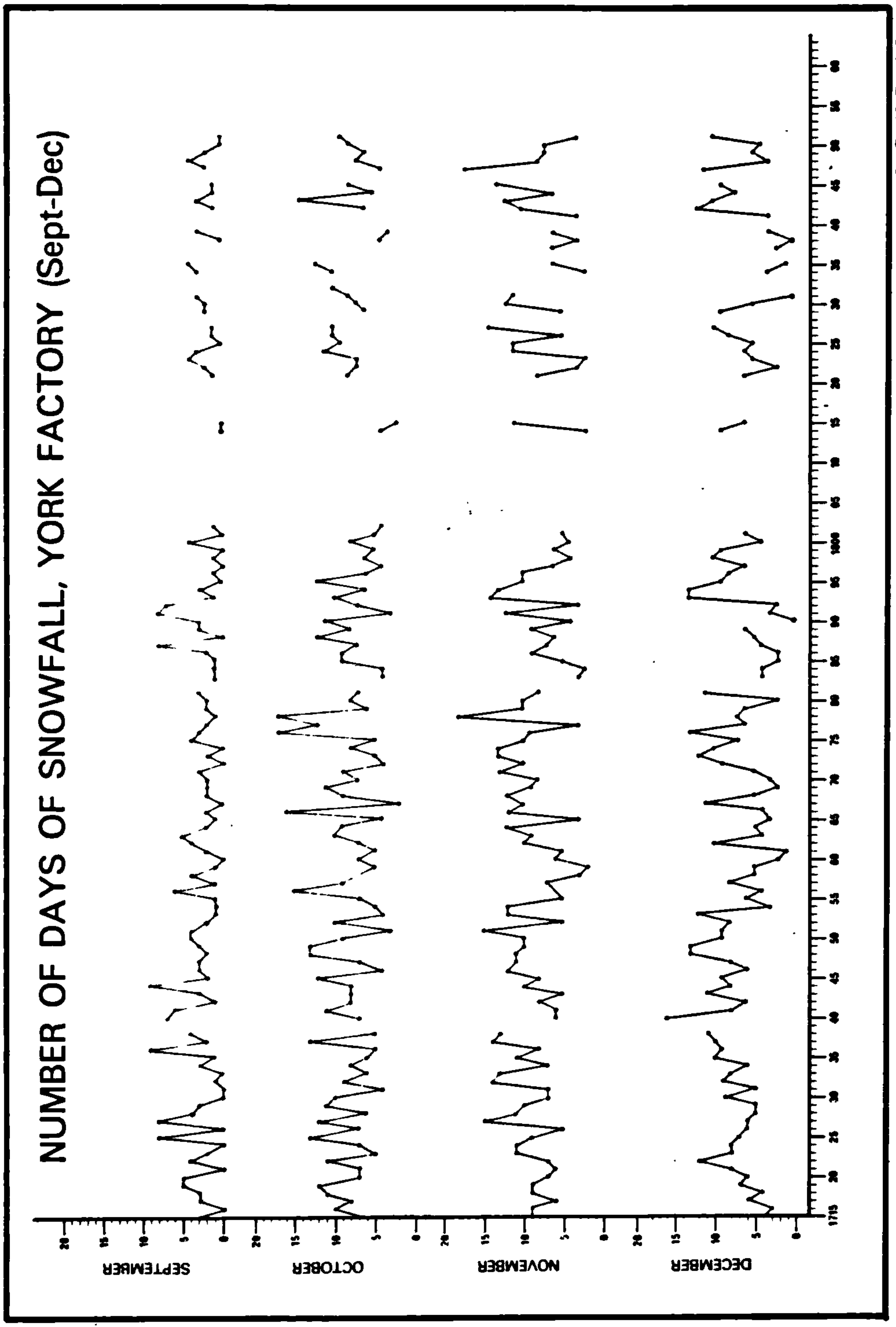

NUMBER OF DAYS OF SNOWFALL, YORK FACTORY (Sept-Dec)
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER

FIGURE 39

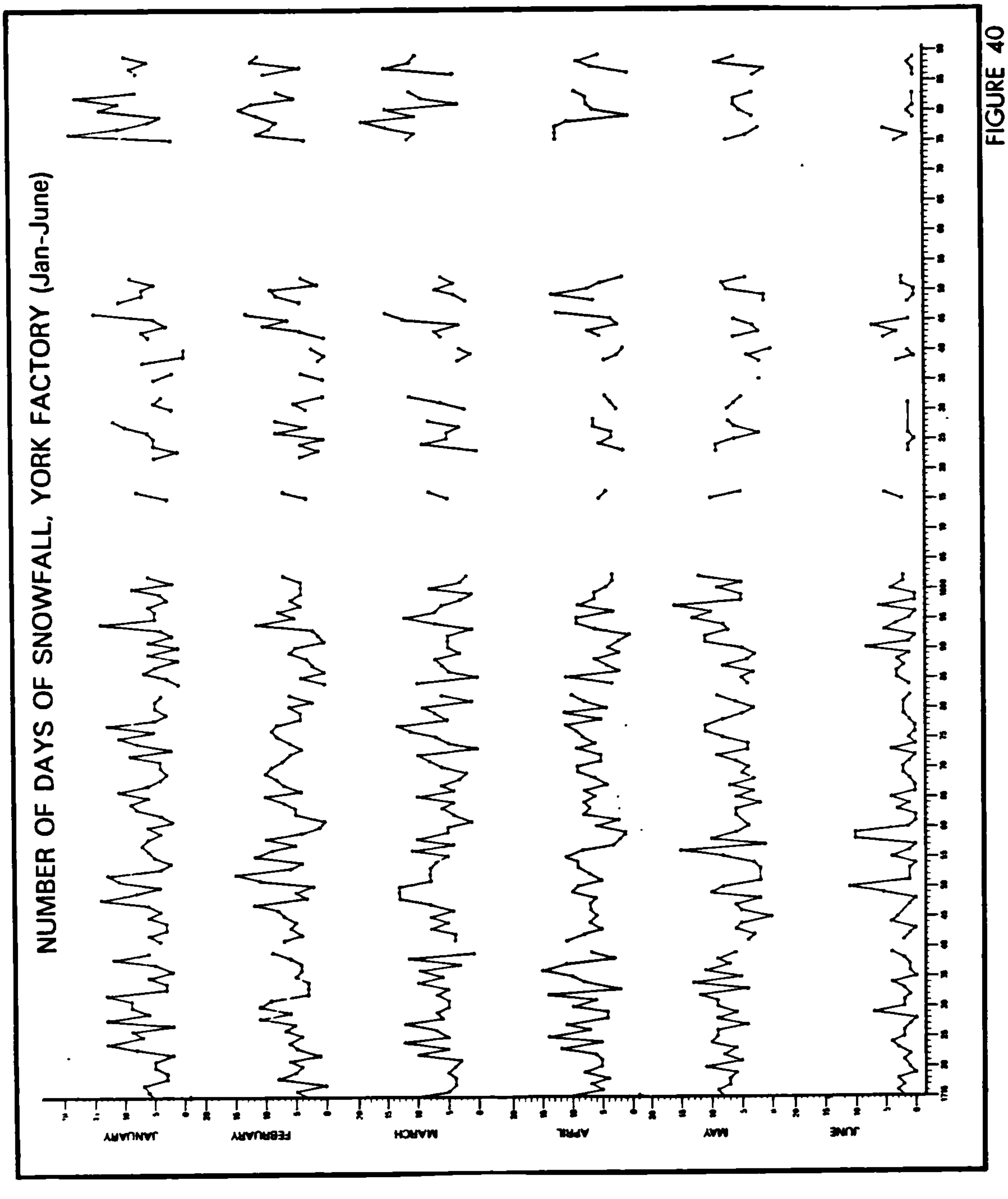


Figure 40: Number of days of snowfall, York Factory (Jan-June)

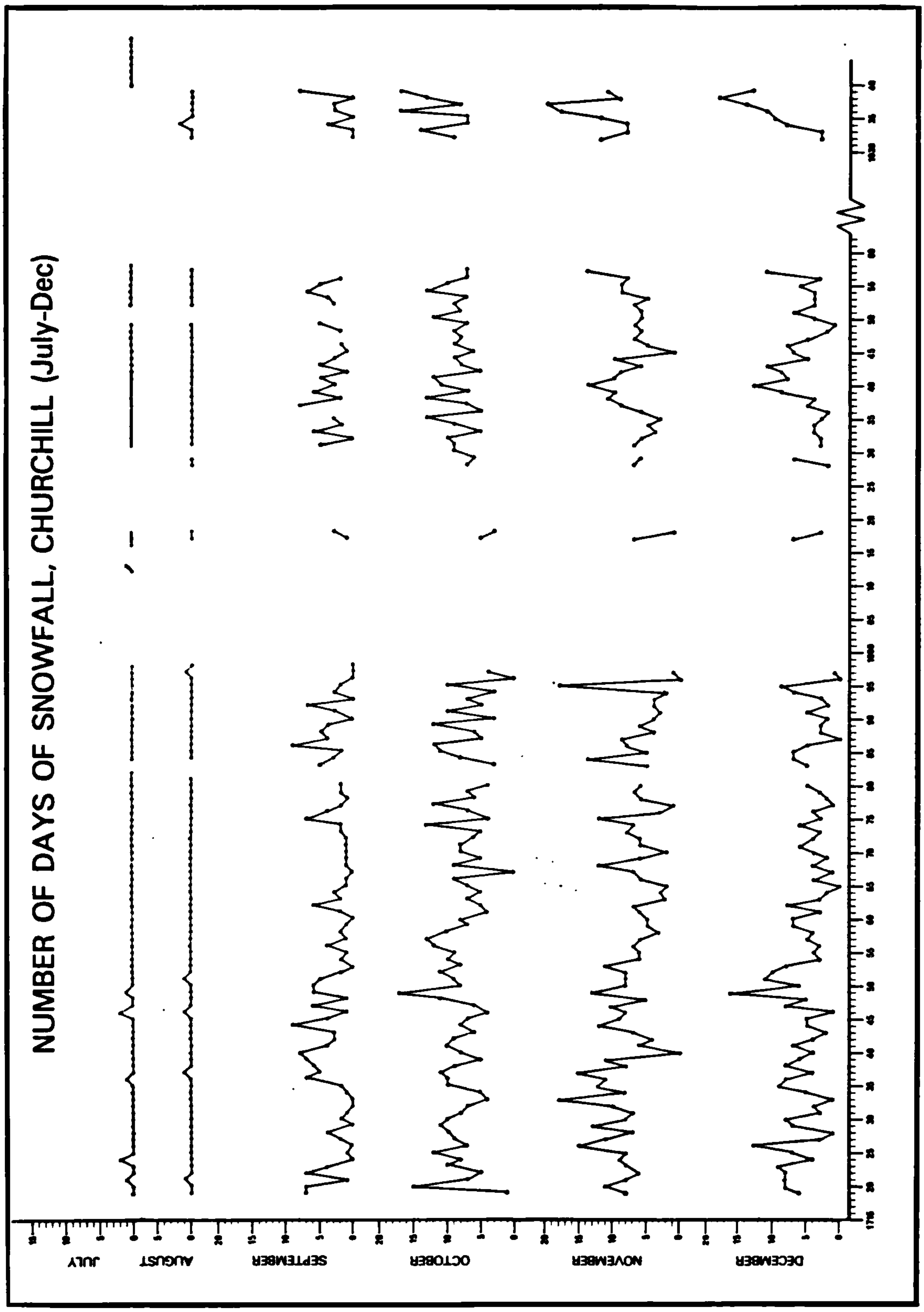

NUMBER OF DAYS OF SNOWFALL, CHURCHILL (July-Dec)
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER

FIGURE 41

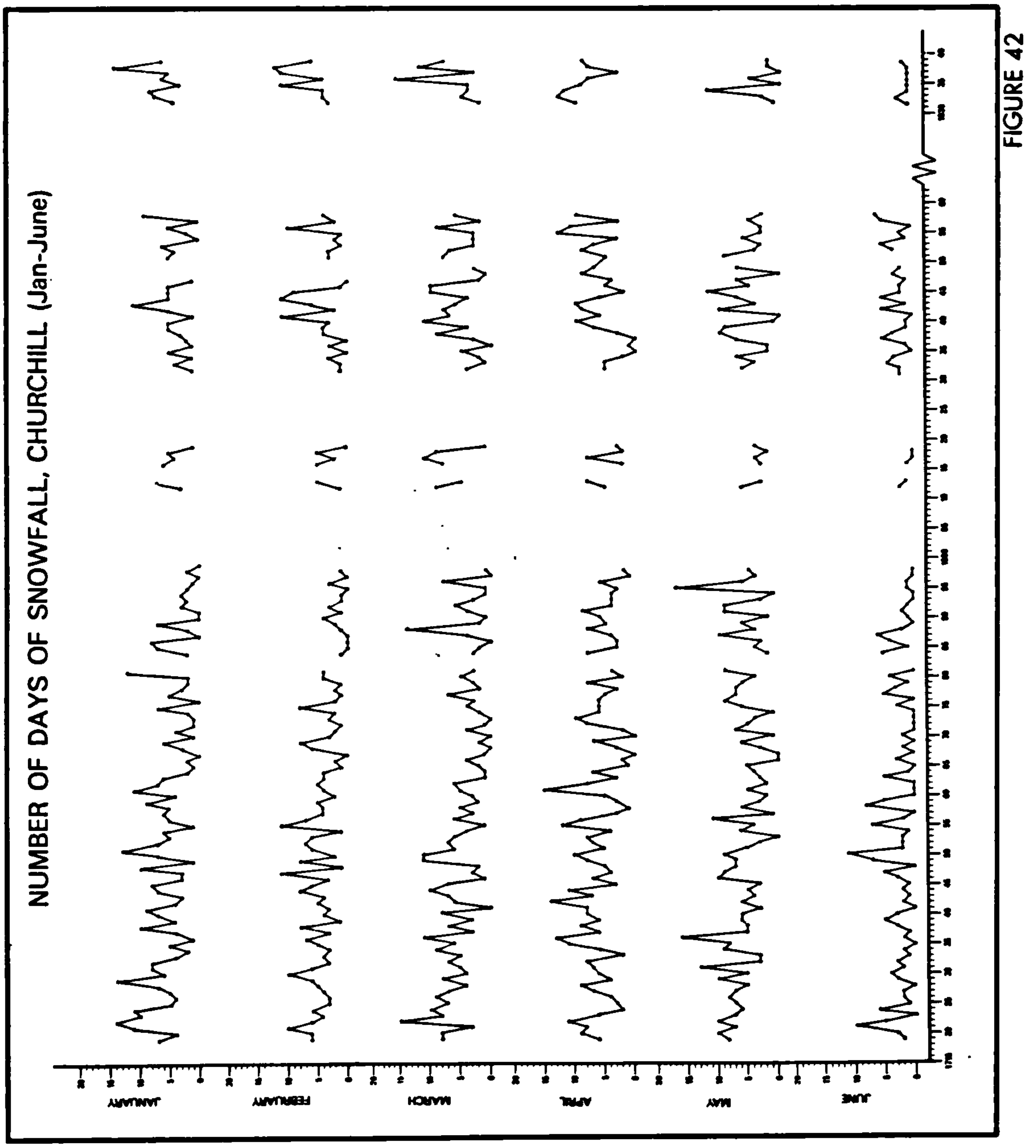


Figure 42: Number of days of snowfall, Churchill (Jan-June)

6.3.9 Number of days with heavy or continuous snow events. (Fig. 43)

In many ways this curve provides the most dramatic results of any of the data presented. Most snowfall data showed variability and some interesting trends but nothing as clearly patterned as are seen in these results. The computer was required to select the following classes heavy snow (208), continuous snow (209), most of day (210).

There is a degree of homogeneity between the graphs at the two stations, but as previously discussed the proximity of open water and the position of the Polar Front are critical factors in creating differences. Generally it can be argued that a measure of validity is given to the data because the elimination of showers of snow as one of the classes has created a greater degree of homogeneity than in the total snowfall frequencies. Further it could be argued that remaining in-homogeneities are due to significant circulation changes that occurred at York Factory but not at Churchill, or vice versa. A specific example of this appears to be evident in the period from 1763 to 1778.

Other features of note are as follows:

1. From 1715 there is a significant increase in the frequencey until a peak is reached in 1738. Churchill experiences this increase slightly later than York Factory suggesting that the change might be due to a gradual northward movement of the circulation system. This argument appears to be further supported by the fact that the decline in frequency is experienced first at Churchill.

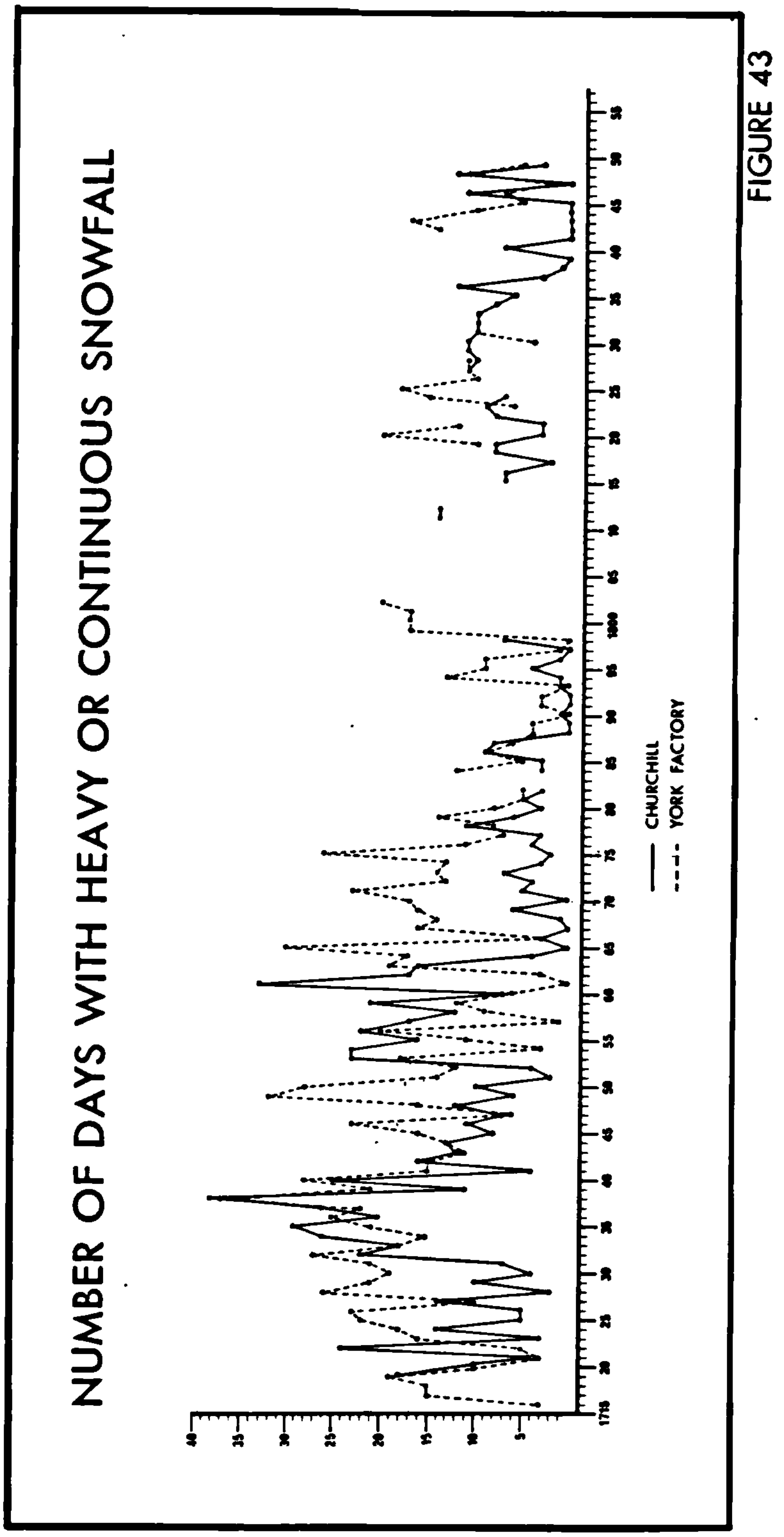


Figure 43: Number of days with Heavy/continuous snowfall- Both sites

2. Between 1744 and 1765 there is extreme variability in the curves, although there is a general decline in frequency.
3. From 1766 to 1779 York Factory experiences a slight increase while Churchill shows a very low frequency. This situation seems to be comparable to the present day situation as outlined by Bryson, with York being south and Churchill north of the Arctic Front.
4. 1779 to 1793 sees a decline in frequency at both sites to the lowest level of the records.
5. Between 1815 and 1850 the record is incomplete however the indications are that both stations are experiencing relatively normal conditions. That is, no extremes of variation coupled with a relatively consistent frequency of heavy or continuous snow events.

6.3.10 Number of days with heavy or continuous rainfall. (Fig. 44)

The range of distinctions between various types of rainfall is as admirable as the distinctions for all other climatic elements recorded by the observers. Because of these distinctions it is possible to infer the various meteorological causes of the different types of rainfall. For example rain showers, either light or heavy, in summer months should be indicative of cumulus development due to diurnal heating, whereas continuous rainfall should indicate cyclonic activity.

The classes included in this analysis are those listed in Table 3 as heavy rain (108), continuous rain (109), or most

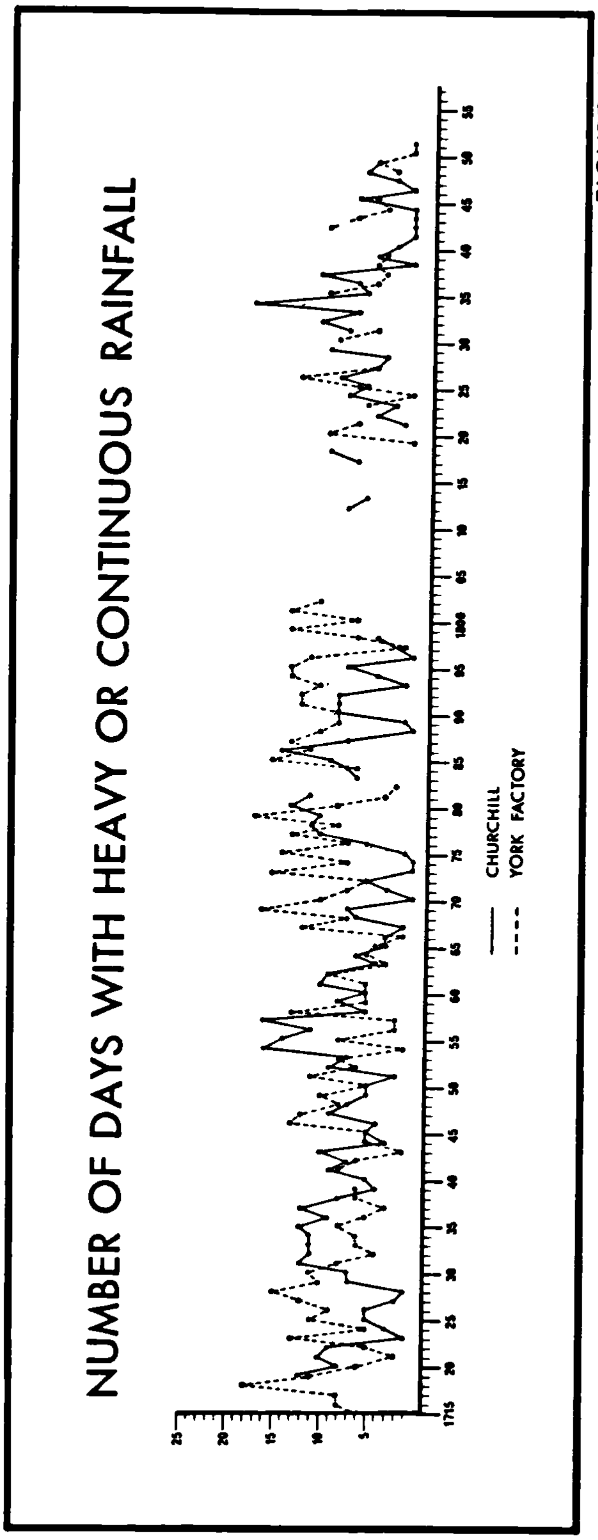


Figure 44: Number of days with Heavy/continuous rainfall-
Both sites

of day (110): there are some difficulties with the selection of these classes as being representative of cyclonic or frontal precipitation.

Continuous rain is the least troublesome as it was used in conjunction with references to completely overcast skies and is clearly precipitation other than that produced by cumulus, heavy cumulus or cumulonimbus. 'Most of day' is more troublesome because there is intimation of breaks in the activity, however it is the author's opinion that this phrase was almost invariably used to describe a day in which there was precipitation occurring as the day began which then continued through most of the day, or that precipitation began in the morning and then continued through the hours of darkness.

The categories of heavy rain and heavy snow are the most difficult to determine accurately as being caused by frontal or cyclonic activity. A slow moving and intensively developed cumulus cloud can provide heavy snow or rain events that last for 1 to 3 hours. We must refer to the comments of H.A. Thompson: "The uniformly cold waters of Hudson Bay tend to inhibit shower development in summer" (Thompson, 1970, p. 282). As we shall see in the next section this cooling has an inhibiting effect on the formation of thunderstorms. Both of these factors would suggest that the number of heavy cumulus events and particularly those that would provide 1 to 3 hour downpours are infrequent.

There will be two sections in this analysis of heavy /or continuous rainfall events. The curves of heavy or continuous rainfall events for York Factory and Churchill shown in

Figure 44 are in contrast to the heavy or continuous snowfall events, these curves have a narrower range of the number of days of these events. This is similar to the results found between the total number of rainfall and snowfall events.

It is difficult to detect any great degree of homogeneity between the curves of York and Churchill. This could be attributed to several causes; a) the observers did not accurately distinguish between various forms of heavy rain. b) the error developed through inconsistant transcriptions from the primary sources, c) the lack of homogeneity is due to meteorological causes.

There are two fairly distinct patterns visible. The first being the periods when the curves are relatively limited in variability and both stations are quite similar. These occur in the periods from 1740 to 1765 and from 1820 to 1850. The second pattern occurs in the periods from 1715 to 1740 and from 1765 to 1800 when there is great variability and both stations have distinctly different curves. 1800 and 1820 are not the actual limits of the periods that they are defining above but exist due to missing data in that period.

After the number of days with heavy or continuous rainfall graph had been plotted and the lack of homogeneity noted the author returned to the primary source to check all references to heavy rain (664 for York Factory, 487 for Churchill). Three transcription errors were detected, a number that was deemed acceptable to climate item (b) above.

Item (a) is extremely difficult to verify because although the modern records record precipitation events and occurrences of thunder they do not classify the type of precipitation event. It was possible to determine the volume of precipitation and the length of time over which that took place, thus establishing an intensity level, but this would have little applicability to the historical data that do not indicate length or volume occurring with each event.

The most telling argument in favour of the validity of the observations lies in establishing that the variability and lack of homogeneity is due to meteorological causes. Homogeneity of precipitation observations is clearly seen in Figure 25, suggesting that variations are due to climatic causes. That is the total number of days of precipitation, which include heavy or continuous events, do show homogeneity but when this event is isolated homogeneity is not seen. Modern records indicate that rainfall at Churchill is quite variable from month to month and from year to year. It is difficult to determine if heavy or continuous events in the modern record show similar variability as mentionned above but it does seem reasonable that this type of precipitation, which is normally a function of unstable atmospheric conditions, would also show a high degree of variability.

Another factor in favour of the validity of the data is seen in the fact that for most of the record York Factory, the more southerly of the stations, has a higher frequency of heavy or continuous events!

6.3.11 Number of days of thunder at Churchill and York. (Fig. 45)

"The stabilizing effects of the cold water surface show up in the low frequency of thunderstorms in summer..." "Southern locations such as Churchill and Great Whale River report two to six thunderstorms per year" (Thompson, 1970, p. 282). Although this quote refers specifically to thunderstorms it does indicate that thunderstorms, which are created by the same physical process as those that generate thunder and lightning, occur with quite low frequencies in this region. Modern records for the period from 1941-1970 indicate a yearly average of 5.6 records of thunder per year. Table 17 provides a comparison of Churchill and York with the modern record.

Thompson's comment about the stabilizing effect of the cold water surface of Hudson Bay is probably valid through the period of this study even though it can be assumed that the water temperature of that body was not constant. Variations in a body of water of that size would probably only manifest themselves over relatively long periods of climatic change. For example it is possible that there has been a gradual warming in conjunction with the amelioration of world temperatures from the Little Ice Age to the present. Changes sufficient to affect the stability by reducing the differences in land sea temperature ranges are unlikely to have occurred through the period of record.

If the foregoing assumption is correct any changes in the frequency of thunder must be attributable to another cause, most likely to atmospheric changes. Variations in the in-

NUMBER OF DAYS OF THUNDER, CHURCHILL AND YORK FACTORY

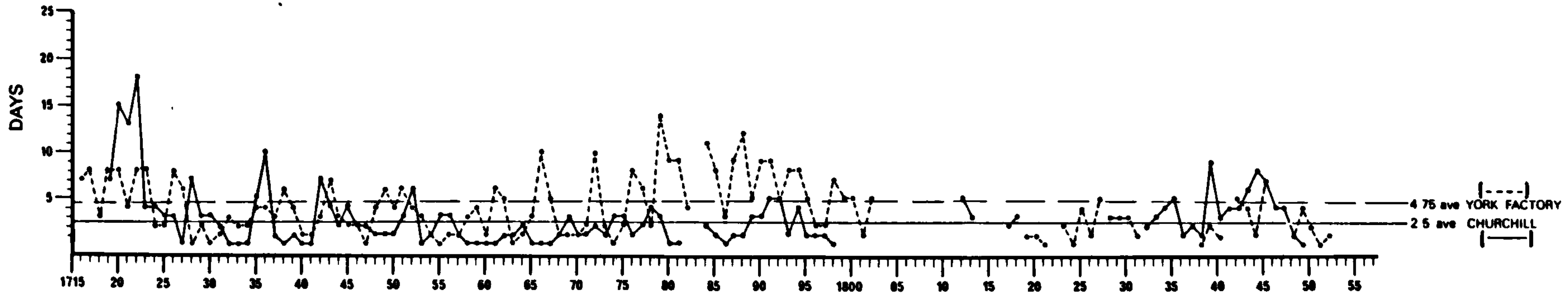


FIGURE 45

TABLE 17

Thunder/Lightning at Both Sites Compared With the Modern Record

Month	Churchill 1719-1798 Recorded Events	Ave	Absolute %	Churchill 1941-1970 Ave	York 1715-1803 Recorded Events	Ave	Absolute %
April	19	0.24	10		14	0.15	3
May	13	0.16	7	0.2	32	0.36	8
June	34	0.43	18	1.2	70	0.79	18
July	64	0.81	34	2.1	136	1.54	34
August	44	0.55	24	1.7	118	1.34	29
September	11	0.13	6	0.3	23	0.26	6
October	2	0.02	1	0.1	7	0.07	2
Total	187	2.4	100	5.6	400	4.5	100

flux of southerly air would appear to be the most likely source of the moisture and temperature regimes necessary for the development of cumulonimbus.

Figure 17 again indicates the more southerly location of York Factory as that station has, on average, a higher number of days of thunder than Churchill.

1. The curves indicate homogeneity between the two locations, however the critical nature of these atmospheric events suggests that the Churchill graph is a more subtle indicator of significant differences. This is manifest in the greater variability about the mean of the Churchill graph.
2. Both curves are above their respective averages in the first 5 years, there is then a decline to below average values that continues until approximately 1775. At that point there is an increase in the frequency, particularly at York Factory. The trend is

downward to 1800 when the data end. When the records resume in the 1820s they suggest a below average trend, however the Churchill curve moves to an above average level by 1835 reaching a peak in 1844 followed by a rapid decline to 1850.

3. The most distinctive periods in both curves appear to be from 1715 to 1730, when they are above average; from 1730 to 1765 when they are generally below average; 1765 to 1800, a period of above average: from 1815 to 1835 it is difficult to clearly define trends, however Churchill appears to be above average while York is showing a slight upward trend but only about the average.

6.3.12 Frequency of wind from 8 points of the compass.

The W.M.O. Technical Note on Climatic Change comments that, "Valuable early records of wind directions are available from some exposed places, including the log-books of ships in port or patrolling stretches of coast" (W.M.O., 1966, p. 11). Beyond this they make little mention of other sources of wind information, are sceptical of reliability of observations both of direction and strength, and generally give little consideration to wind data from early records.

This scepticism is probably justified, and certainly the inherent problems they delineate are valid. In the case of the Hudson's Bay Company records we appear to have as detailed and accurate a source of information as possible from historic records.

Wind direction was noted by observation of a flag located on a large mast set out in front of the Factory. Graham notes in the introduction to his meteorological journal of 1770 that the mast was 50 feet high, and therefore well away from the influence of buildings. The low lying nature of the vegetation in the area of York and Churchill presented no interference. A mast of the type maintained by the Company, as well as the openness of the site at York is clearly visible in Figure 9.

The observers were all skilled mariners trained by the Company. Most of them became Factors only after having served an apprenticeship and gradual promotion through various positions within the Company. A great many of these men served as captains of the Company's sloops which spent most summers exploring and trading along the shores of Hudson Bay. The only Factor who is recorded as not having come up through the Company was John Newton who served at York Factory from the 28th August 1748 to the 28 June 1750 on which date he drowned while swimming in the Bay. One can question the sensibility of a man who would venture into those icy waters at any time of the year, nonetheless Newton was a qualified mariner for the records show that he spent 30 years as a merchant captain in the Mediterranean.

Evidence of the skills of these observers are seen in various ways. The use of nautical terminology is consistent throughout the record. Also the wind was recorded to 32 points of the compass, a practice that is not even carried out today. It is debatable whether or not this degree of accuracy is possible by visual observation of a flag located at the top of a mast, as discussed earlier. It does mean that in the reduction process the division of intermediate directions is made easier.

A greater difficulty, and one which receives no attention in any of the literature on methodology, is dealing with records of direction only. This is complicated by the fact that the numbers of observations vary from one a day to eight a day. If a meaningful climatological analysis is to be obtained a continuous and comparable series is required. A brief computer examination of two years of the modern record at Churchill was carried out to determine the validity of assuming that a single reading could be representative of the wind direction in a 24 hour period. Basically this is addressing the question of the persistence of the wind. It was found that it was possible to use a single reading as representative of a 24 hour period with approximately 60% accuracy, but this figure rose to 87% when a 12 hour time period was used. As a result of this examination the following assumptions were used.

1. That any significant changes in wind direction would be recorded. The record certainly demonstrates that most observers would comment on changes in wind direction that were a result of changes in synoptic conditions.
2. That a single reading in the day was representative of the entire day.
3. That this approach was valid even if (1) and (2) were not strictly correct because the method of recording was homogeneous throughout. Further, the reduction

of the data would result in the loss of some information but would also tend to reduce error factor.

4. That the day was divided into two 12 hour segments from midnight to noon and from noon to midnight.

The computer was programmed to determine the number of times that the wind blew from the various directions in these 12 hour segments. In addition the programme compared the current wind with that of the preceding 12 hour period and calculated what angular shift had occurred, and whether the wind was veering or backing. This information is not presented in this study other than to indicate those years in which the greatest changes in wind direction were occurring. The information would, however, appear to have a potential value as a more precise indicator of the shifts from zonal to meridional flow in various years.

The information obtained from the computer provided a frequency and percentage count of the number of times that the wind blew from different directions for each month and each year of the record. These results are displayed in Figures 46 through 48.

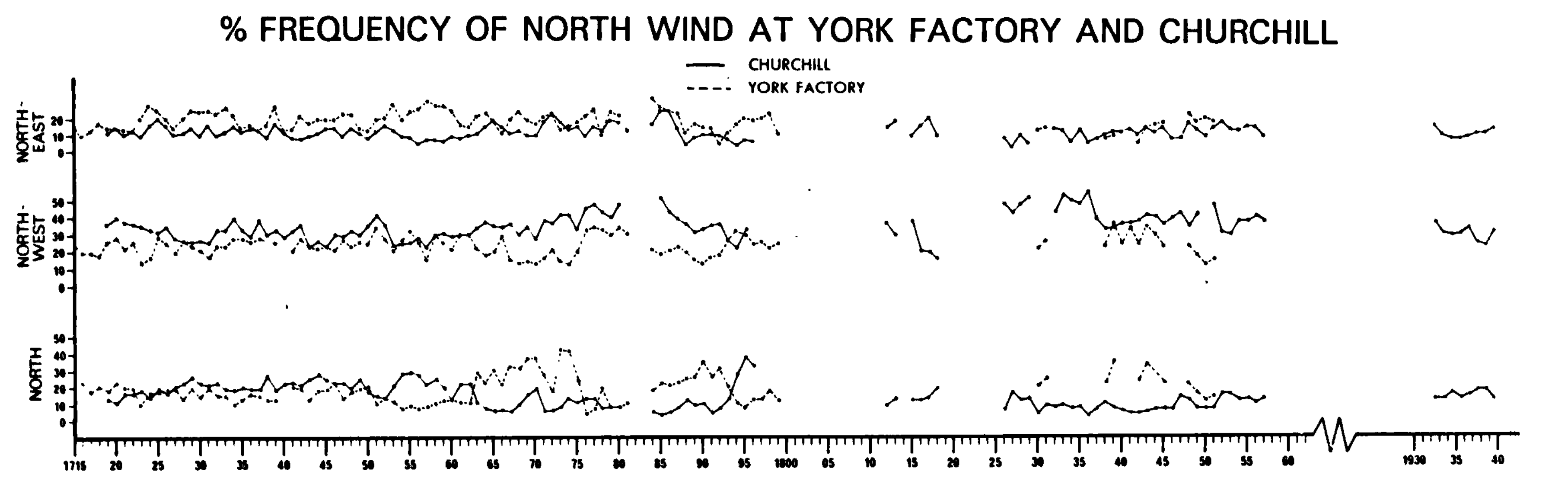

% FREQUENCY OF NORTH WIND AT YORK FACTORY AND CHURCHILL
CHURCHILL
YORK FACTORY
NORTH-EAST
NORTH-WEST
NORTH
1715
1800
1930

FIGURE 46

% FREQUENCY OF EAST AND WEST WINDS AT YORK FACTORY AND CHURCHILL

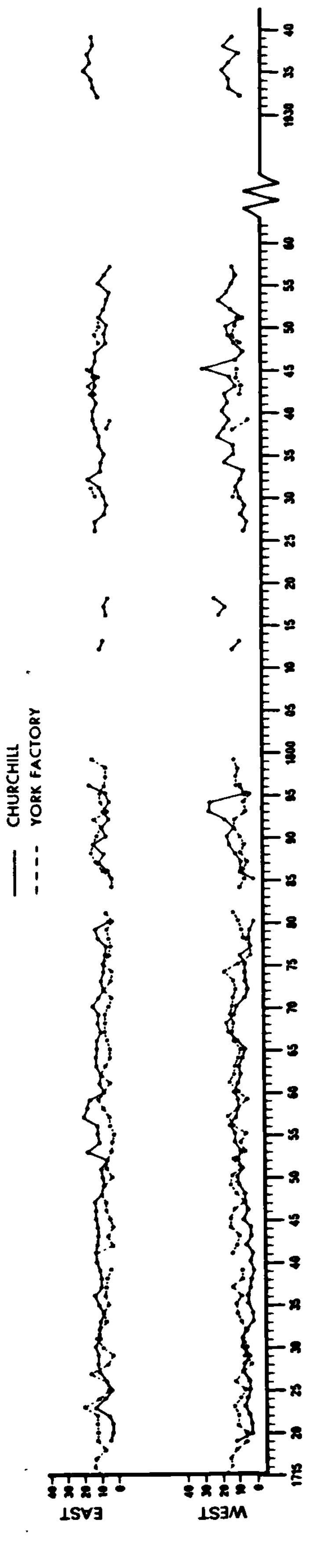


FIGURE 47

% FREQUENCY OF SOUTH WIND AT YORK FACTORY AND CHURCHILL

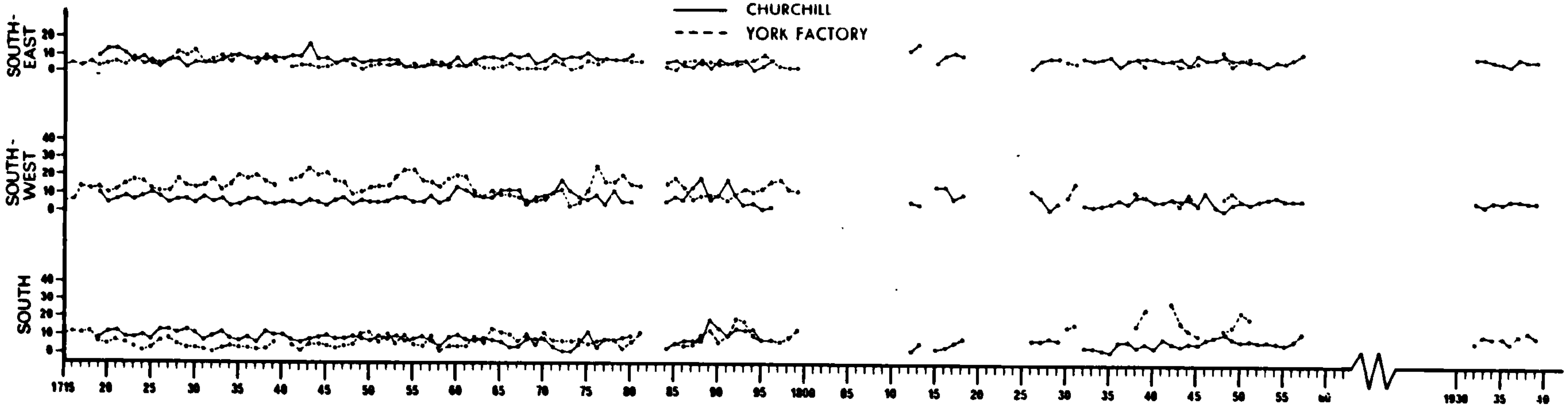


FIGURE 48

6.3.13 Percentage frequency of winds. (Figs. 46 through 48)

Before examining the percentage frequency graphs of winds illustrated in Figures 46 through 48 it is necessary to obtain an overview of the general factors influencing winds in the southern portion of Hudson Bay. As previously discussed our region lies on the southern limits of the zone of modified Pacific and Arctic air. The general or typical pattern of upper-air circulation over Hudson Bay is determined by the counter-clockwise flow around a cyclone centred in northern Baffin Island in winter and a less intense but still discernible flow in summer. This results in a general flow of air from the north and northwest across Hudson Bay for most of the winter. The strength of this flow results in very little penetration of southerly air. It is important to keep this point in mind because the implications of an increase of southerly flow and cyclonic activity in southern Hudson Bay is directly linked to the strength of flow generated by the persistent feature over Baffin Island.

In the spring, summer and fall, which seasons collectively equal the length of the single season winter, the Bay experiences an increase in the influx of cyclonic systems from the west and south. This comment is made using the length of permanent snow on the ground as the definition of winter. Even in the southern end of the Bay this period extends from November through April thus creating six months of the single season winter. These systems are often preceded by advections of warm, moisture laden air from the south and result in unsettled weather conditions despite the stabilizing affect of the extremely cold waters of the Bay.

If an historical synoptic climatology is to be developed without barometric pressure the only option lies in being able to establish daily surface wind patterns. Lamb and Johnson (1966) carried out this kind of study for the months of January and July from 1750. Subsequent work extended the series back to 1680, "...based on isolated barometric readings and more widespread data on wind direction frequencies, temperatures prevailing and weather character, has been carried out and tested in a similar manner to the maps for the later years in the eighteenth and nineteenth centuries" (Lamb, 1977, p. 487). There is no doubt that ultimately the wind data and similar variables of input as those used by Lamb are capable of producing similar information for the central region of Canada.

6.3.14 Annual winds.

The percentage frequencies of wind for each station were counted on an annual basis for each of eight points of the compass as shown in Figures 46-48.

6.3.15 North winds. (Figure 46)

The most obvious feature of these curves is their coincidence from 1720 through to 1752 at which point the percentage of north winds at Churchill increases while those at York Factory decrease. In 1763 the curves cross so that there is a higher percentage at York than at Churchill. This period from 1763 to 1776 marks the highest percentage of north winds at York Factory for the whole record. 1776 sees the curves become coincident until approximately 1782 when York shows another increase. The curves cross again in 1794 with a decline in the percentage at York Factory and an increase at Churchill.

It appears, from the scanty record, to suggest that the crossing pattern continues in the record at least until 1850. Starting in 1750 the sequence of years for the intersection points of the curves is as follows:

1750 - 1763 = 13 years

1763 - 1776 = 13 years
1776 - 1783 = 7 years
1783 - 1794 = 11 years

Herman and Goldberg write that, "Atmospheric circulation changes result from a spatial redistribution of atmospheric pressure, and, since the latter has been observed to correlate with solar activity, especially in terms of stationary planetary wave oscillations in the surface and 500mb pressures, one might conclude that some circulation changes may be indirectly responsive to solar influence" (Herman and Goldberg, 1978, p. 245). Later in discussing the location of the main trough of the ionosphere they state, "It is noteworthy that the latitudinal position of the trough places it in the vicinity of the polar vortex that is so well known to meteorologists. A southward movement of polar vortex in association with the geomagnetic storm time behavior of the main trough would tend to force the cold polar air equatorward..." "...during solar maximum years when geomagnetic storms occur often these would be frequent southward movement of the trough, polar vortex, and the jet stream,..." (Herman and Goldberg, 1978, p. 246)

Earlier in the same book the authors refer to the Schwabe Cycle (more familiarly the 11 year sunspot cycle) which they point out varies from 8.5 to 14 years beteen minima and 7.3 to 17 years between maxima with a 13 year cycle length in the epochs 1784-1797 and 1843-1856 (Herman and Goldberg, 1978, p. 13). There is a temptation to speculate on the coincidence of the crossover time spans and the activities on the sun but it will require more details than are evident at this point.

It should be noted that the stations being examined in this study are quite close together but as will be seen later the mean position of the Arctic Front lies between the two stations. The position of the Arctic Front appears to be related to variations in the polar vortex therefore it is likely that these stations are in critical positions for determining shifts in the Arctic Front and thereby reflecting changes in the polar vortex.

6.3.16 Northwest. (Figure 46)

The highest percentage of winds throughout the record are from the northwest at both locations. The most significant features of these curves appears to be as follows:

1. There is a distinct degree of homogeneity between the curves.
2. The percentages at Churchill are consistently higher than those at York Factory.

3. The curves are separated from 1720 to 1725 then are coincident from 1725 to 1763 at which date they diverge until 1793.

It would appear that there are longer term variations than were seen in the north wind percentages but there appear to be insufficient data to determine these trends.

6.3.17 Northeast. (Figure 46)

York Factory has a higher percentage of northeast winds during the period of record. It appears that these curves are the inverse of those for northwest winds. From 1720 to 1725 the curves are coincident while 1725 to 1765 sees them separated after which they are coincident again.

6.3.18 East. (Figure 47)

The percentage of east winds is very low at both stations therefore significant or recurrent trends are not immediately apparent. It is possibly important to note that from 1720 to 1725 York Factory has a higher percentage than Churchill but from 1725 to 1780 Churchill is higher. From 1785 to 1797 York Factory is dominant again.

6.3.19 West. (Figure 47)

The curves appear to reflect homogeneity but perhaps the most important feature is the gradual increase in percentage of west winds at Churchill from approximately 1740 to 1780 and again from 1825 as far as 1857 when the record ends.

6.3.20 South. (Figure 48)

Churchill had a higher percentage of south winds from 1720 to 1749, from that year through to 1796 the curves are coincident. There is evidence of a slight increase in south winds at both stations between 1788 and 1795. The period from 1825 to 1852 is incomplete but appears to show a much higher percentage of south winds at York Factory while Churchill percentages remain average.

6.3.21 Southwest. (Figure 48)

The percentage frequencies of this direction show York Factory experiencing the higher values for the period of record. From 1720 to 1763 the two curves are clearly separated, however from 1765 to 1775 they are coincident, 1775 to 1787 they are separated while from 1787 to 1793 Churchill had a higher percentage of southwest winds. Between 1825 and 1850 the curves appear to be coincident again.

6.3.22 Southeast. (Figure 48)

The overall percentage of this direction is low at both stations although Churchill Factory seems to experience a slightly higher percentage than York Factory. This is probably due to a sea breeze effect at Churchill, an hypothesis that is supported by the increase in southeast winds during the summer months.

6.3.23 Monthly percentage frequency of eight wind directions. (Figs. 49 to 96)

These graphs were constructed by connecting computer plotted percentages of the occurrence of eight wind directions for each month of the year at each station. The data illustrate the flexibility and ease of recovery of information from the coding methodology. It will also serve as a detailed source of information for analysis of shifts in the annual march of the seasons.

The validity of the original observations and the coding methodology is supported by the results displayed in these graphs. Modern records at Churchill indicate the following most prevalent wind directions by month;

January	NW
February	NW
March	NW
April	NW
May	N
June	N
July	N
August	NWW
September	N
October	NW
November	NW
December	NW

The record as illustrated in Figures 49 through 96 indicate a similar pattern of prevalent wind directions. If further analysis or at least comparative analysis of these

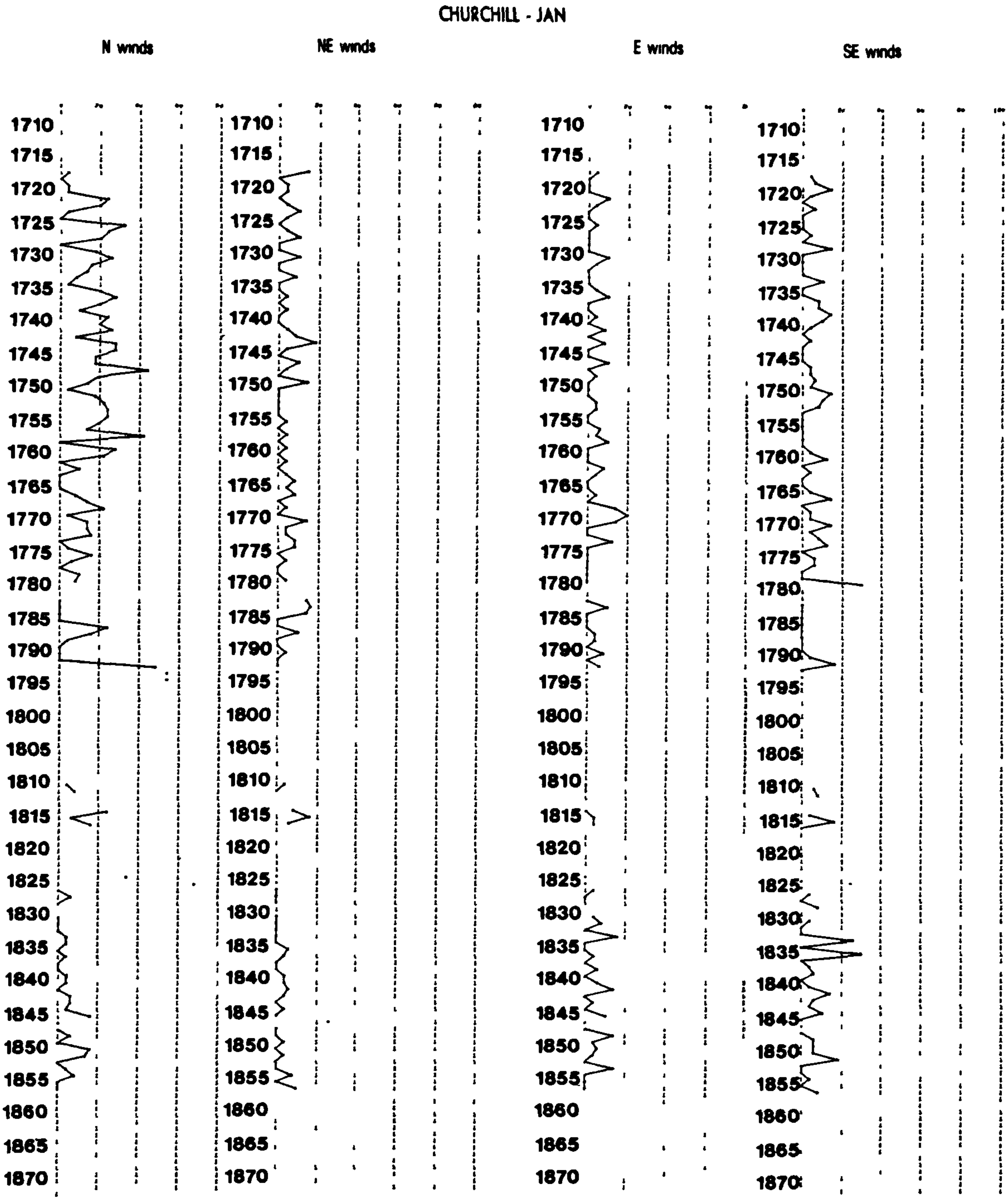


Figure 49: Percentage frequency of winds, Churchill - January

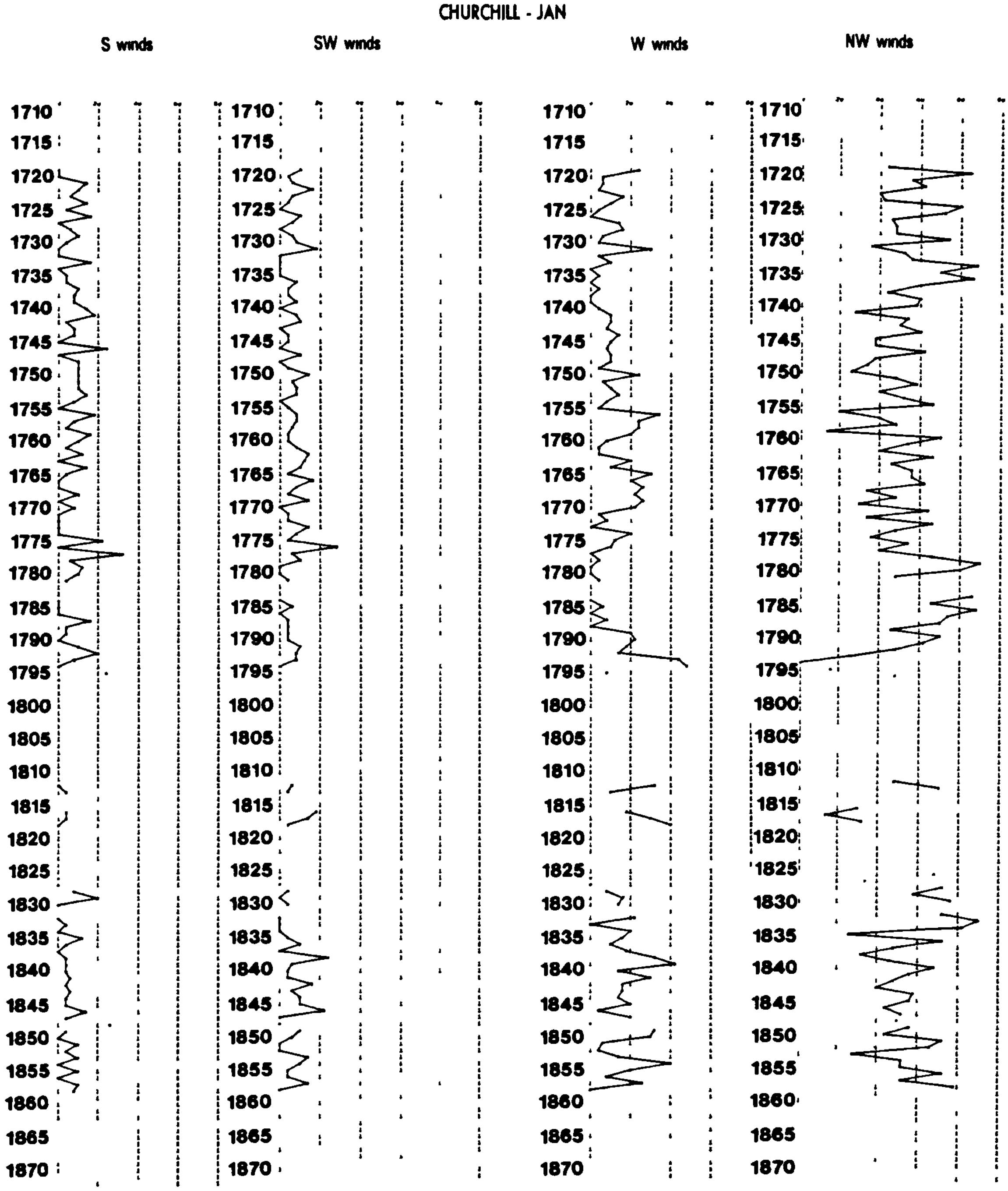


Figure 50: Percentage frequency of winds, Churchill - January

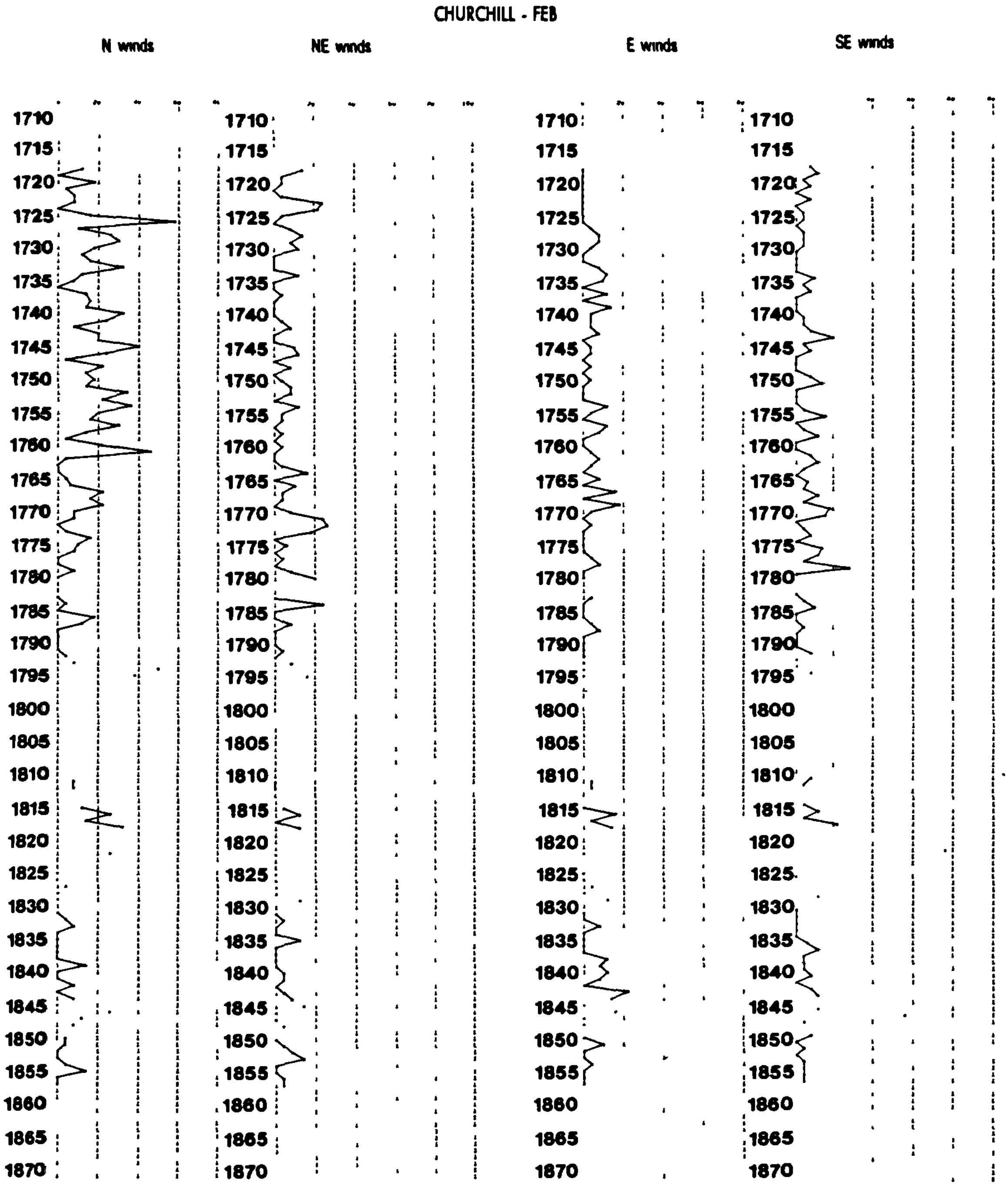


Figure 51: Percentage frequency of winds, Churchill - February

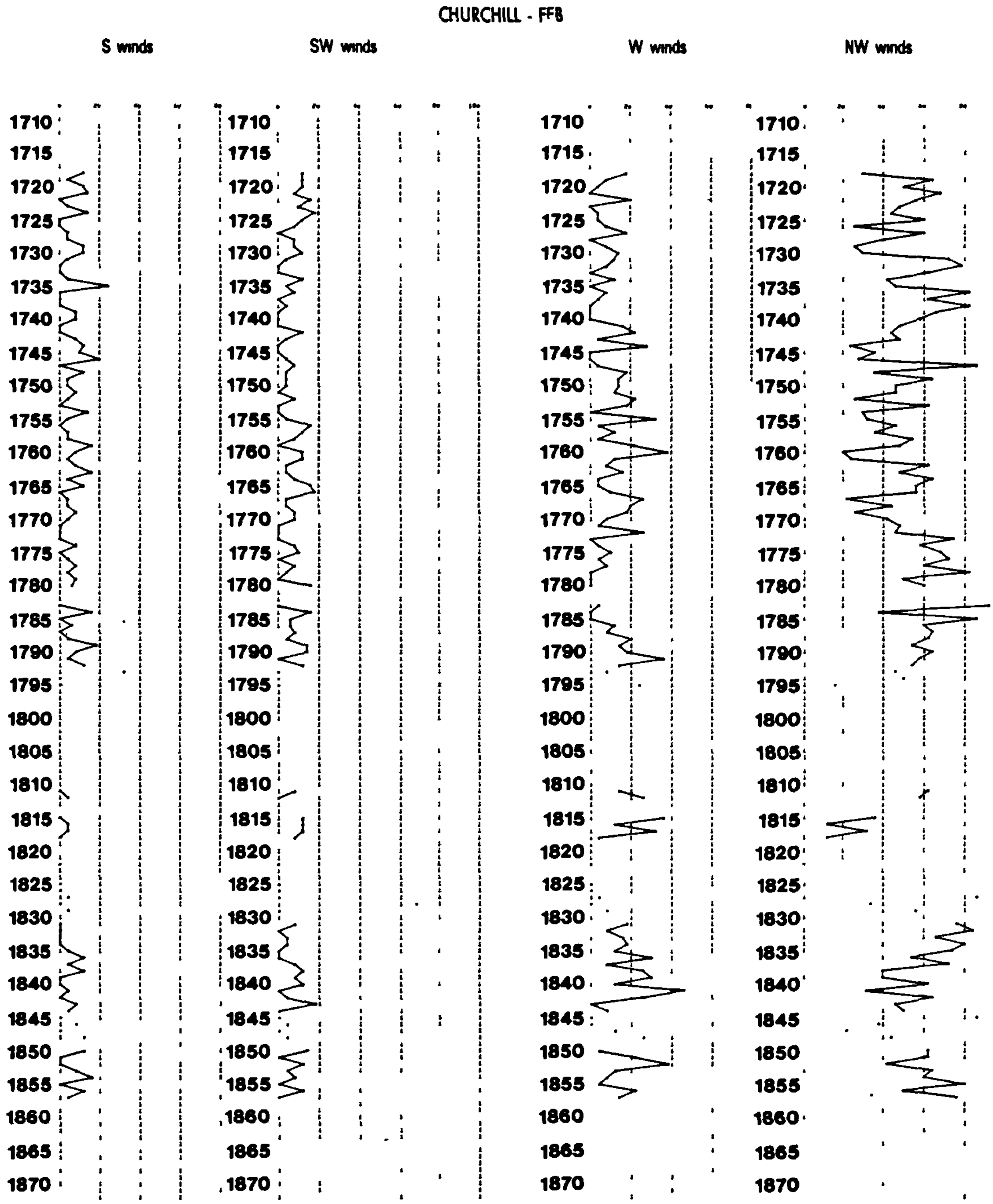


Figure 52: Percentage frequency of winds, Churchill - February

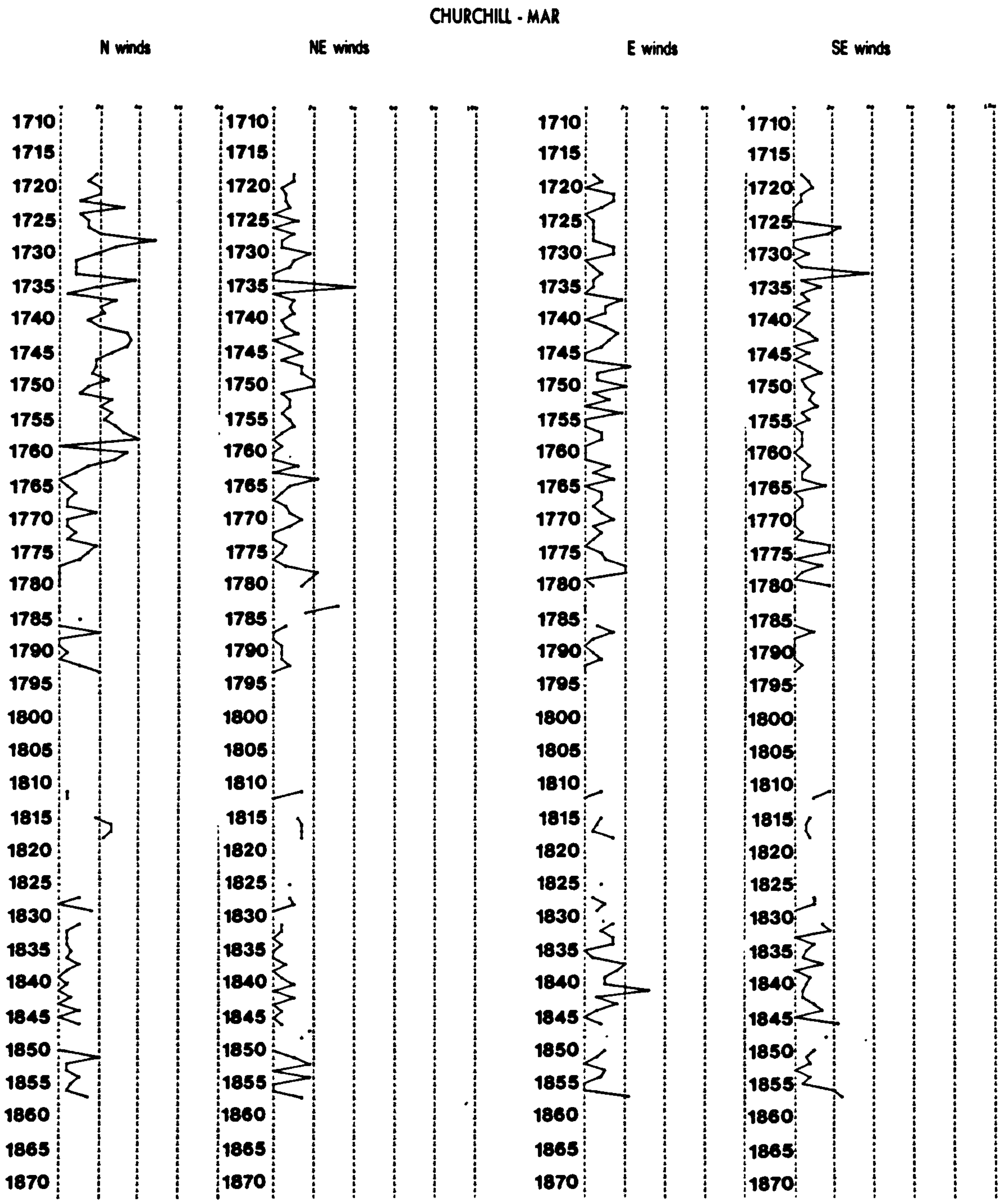


Figure 53: Percentage frequency of winds, Churchill - March

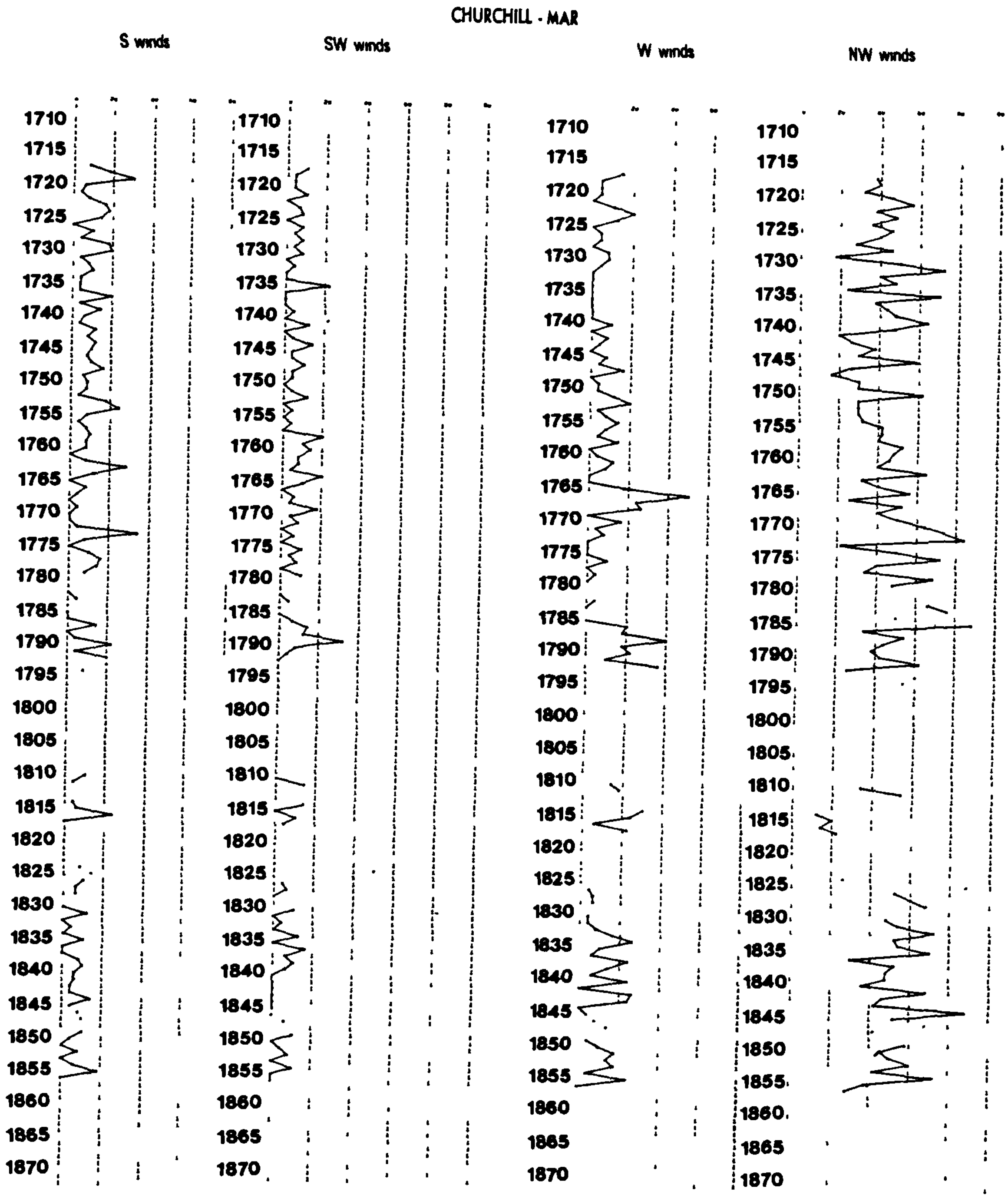


Figure 54: Percentage frequency of winds, Churchill - March

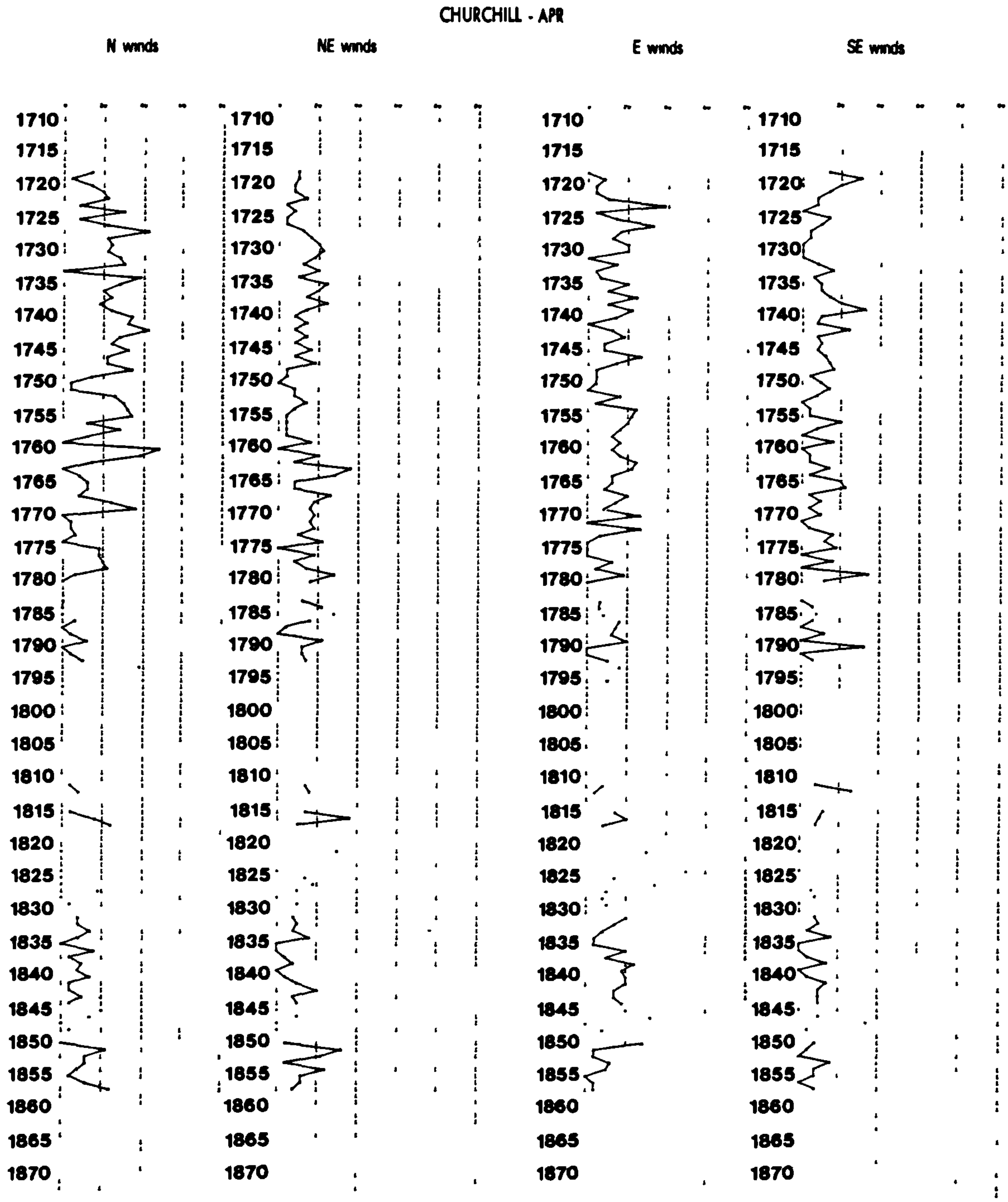


Figure 55: Percentage frequency of winds, Churchill - April

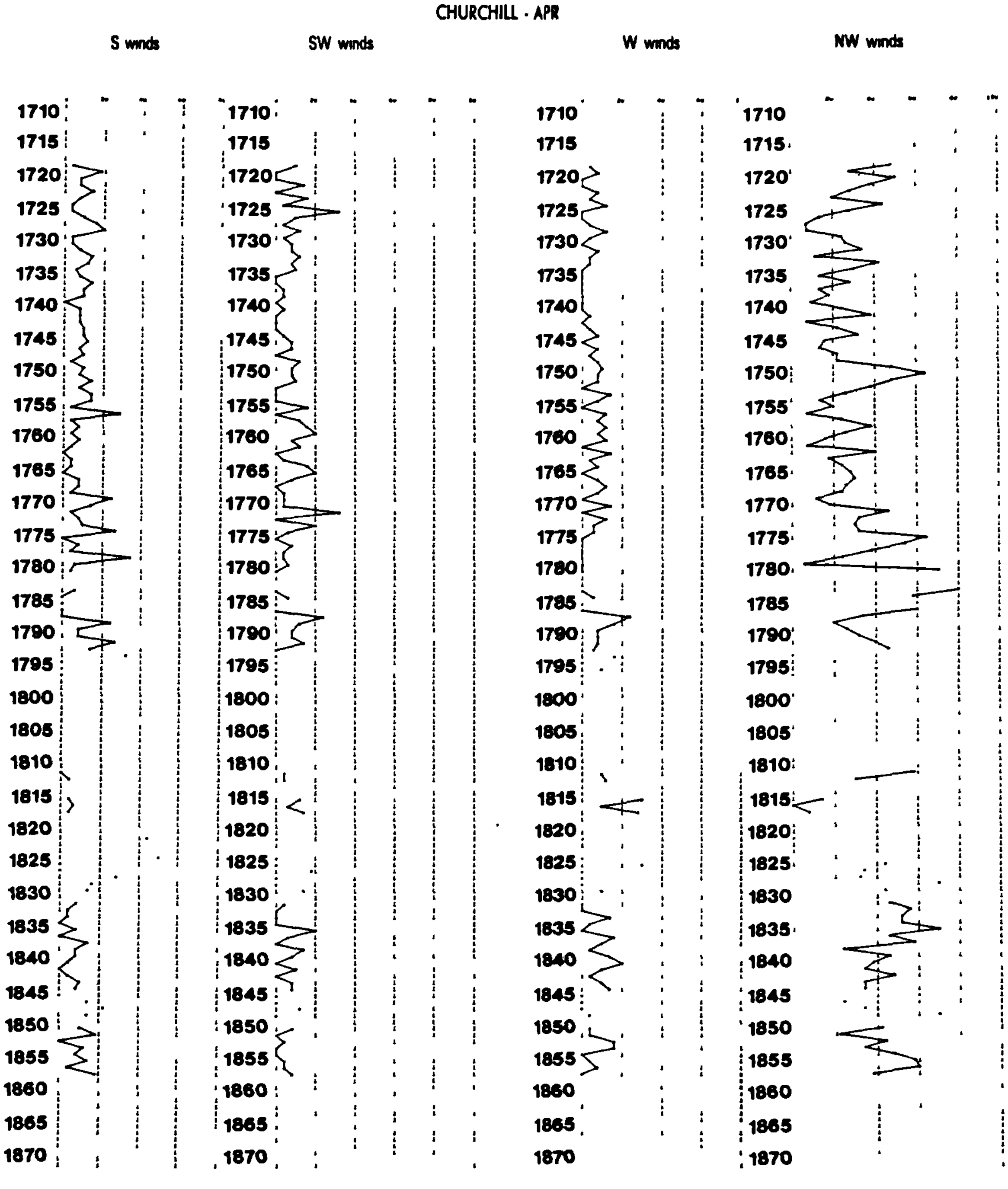


Figure 56: Percentage frequency of winds, Churchill - April

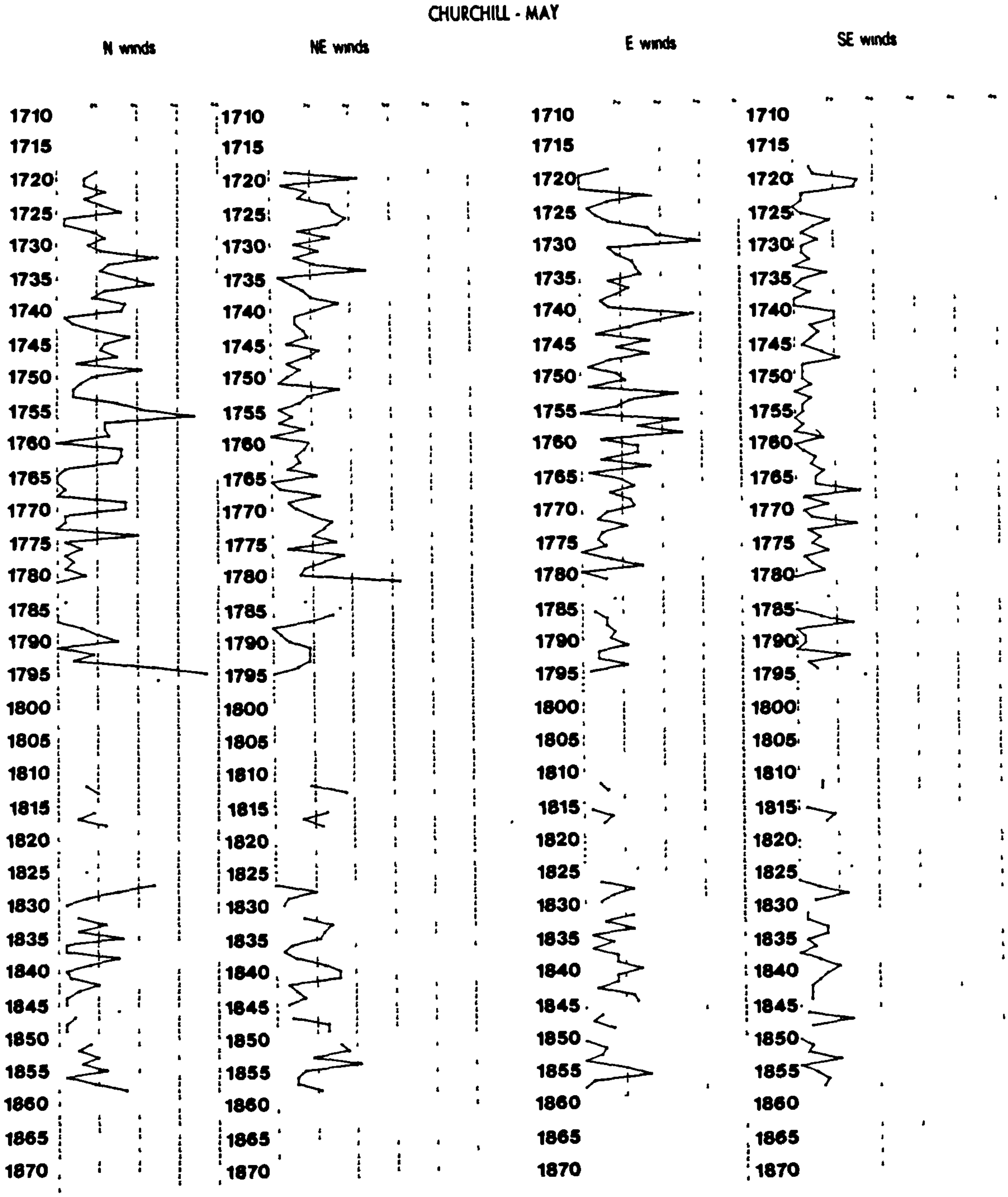


Figure 57: Percentage frequency of winds, Churchill - May

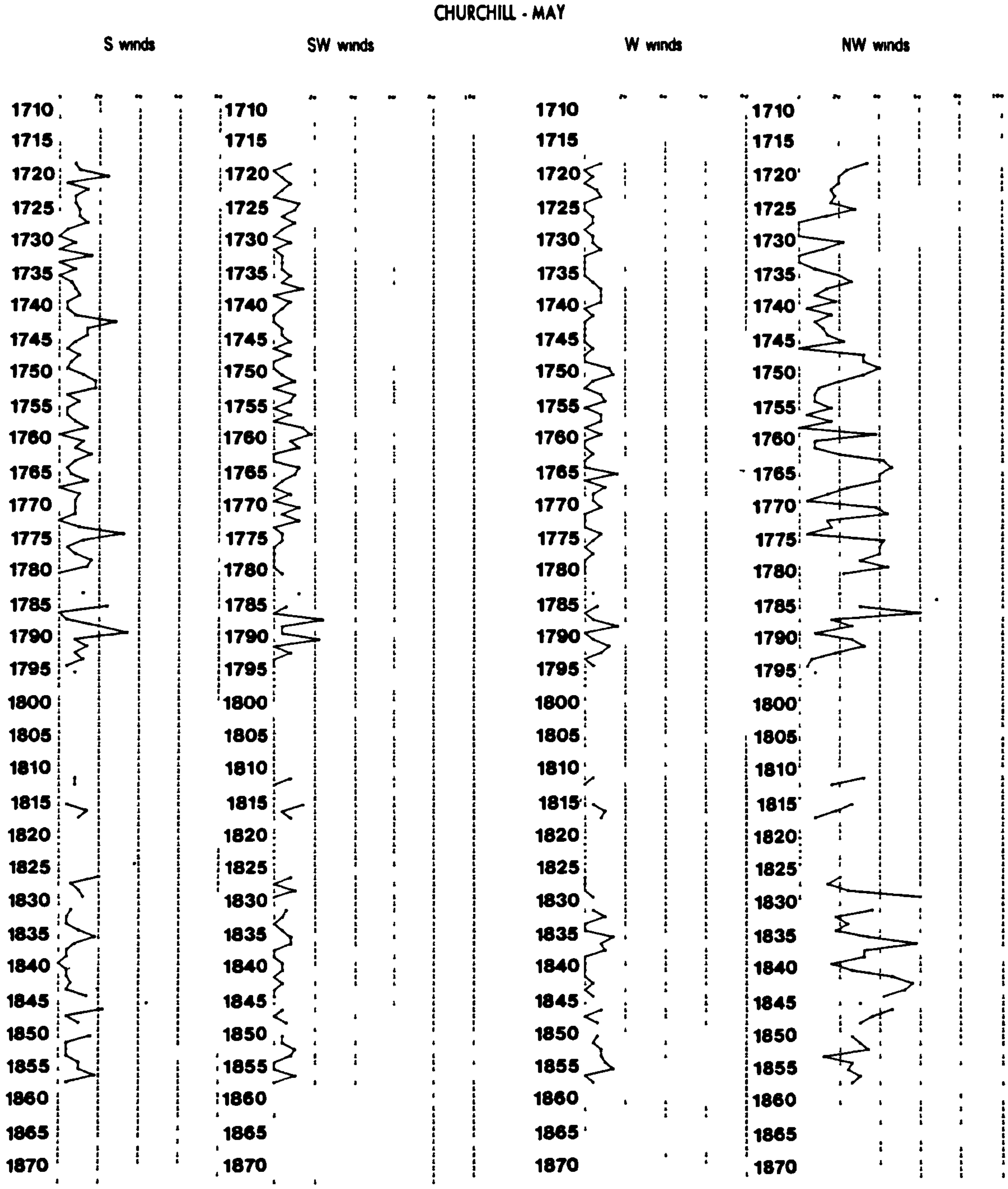


Figure 58: Percentage frequency of winds, Churchill - May

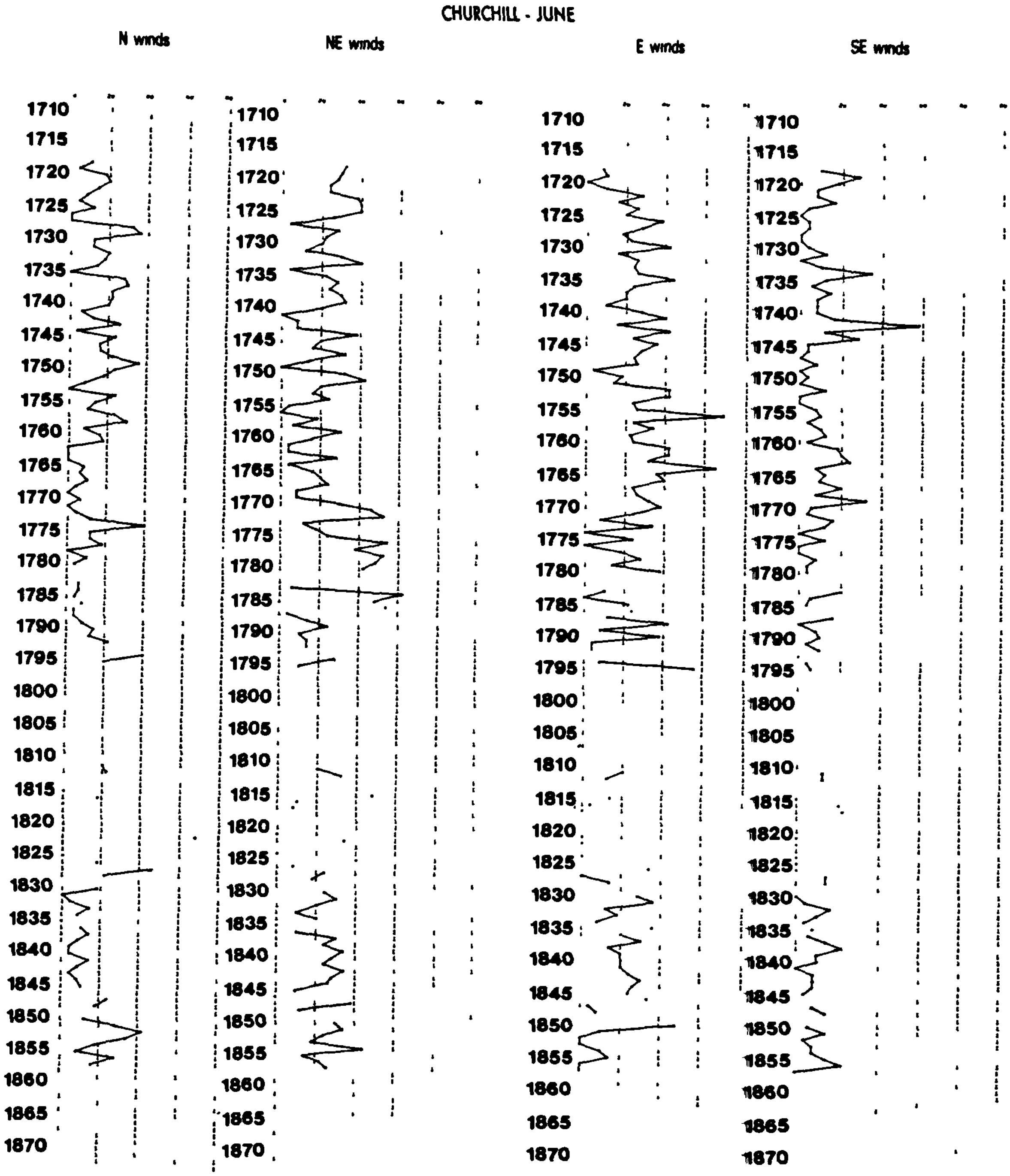


Figure 59: Percentage frequency of winds, Churchill - June

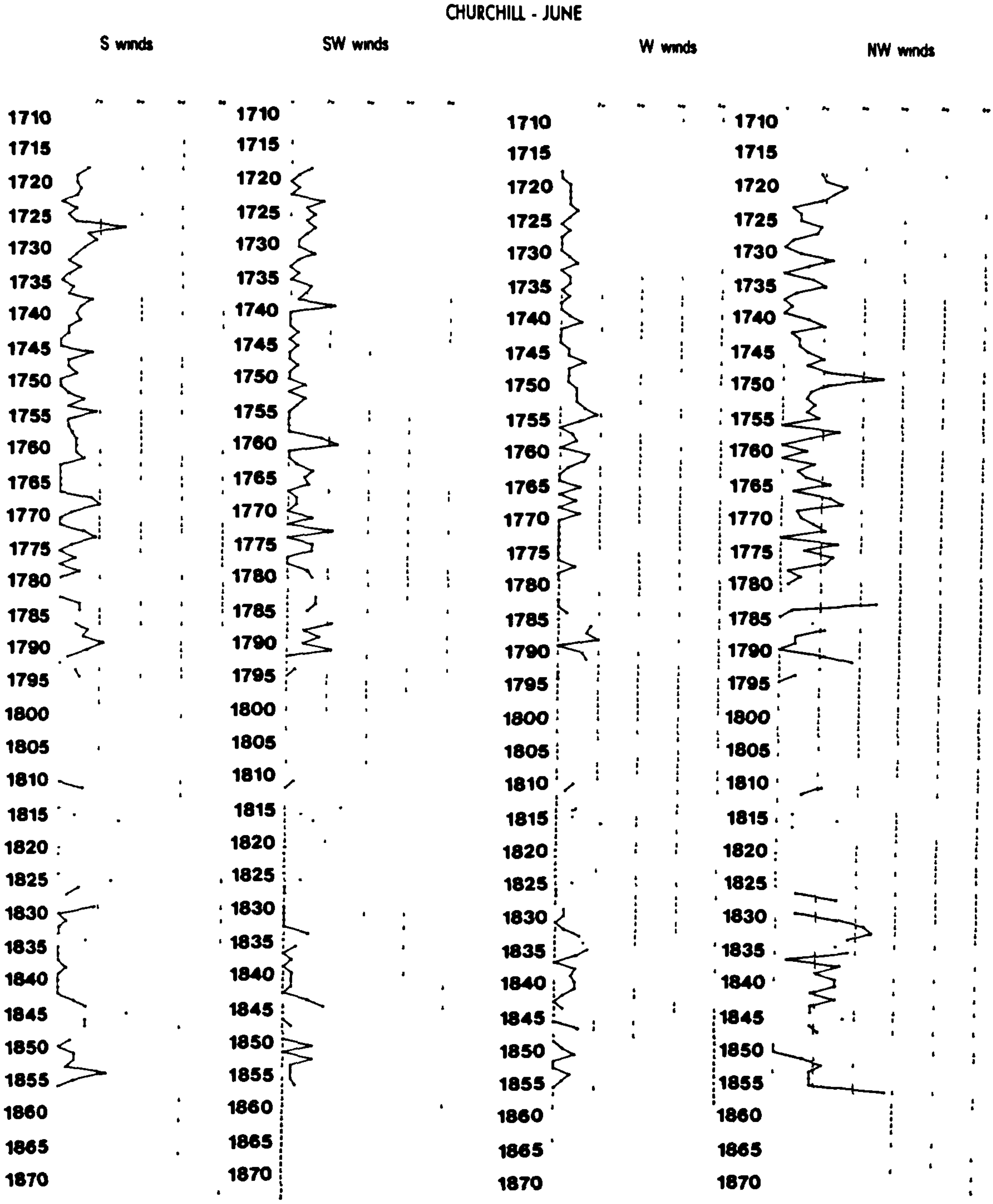


Figure 60: Percentage frequency of winds, Churchill - June

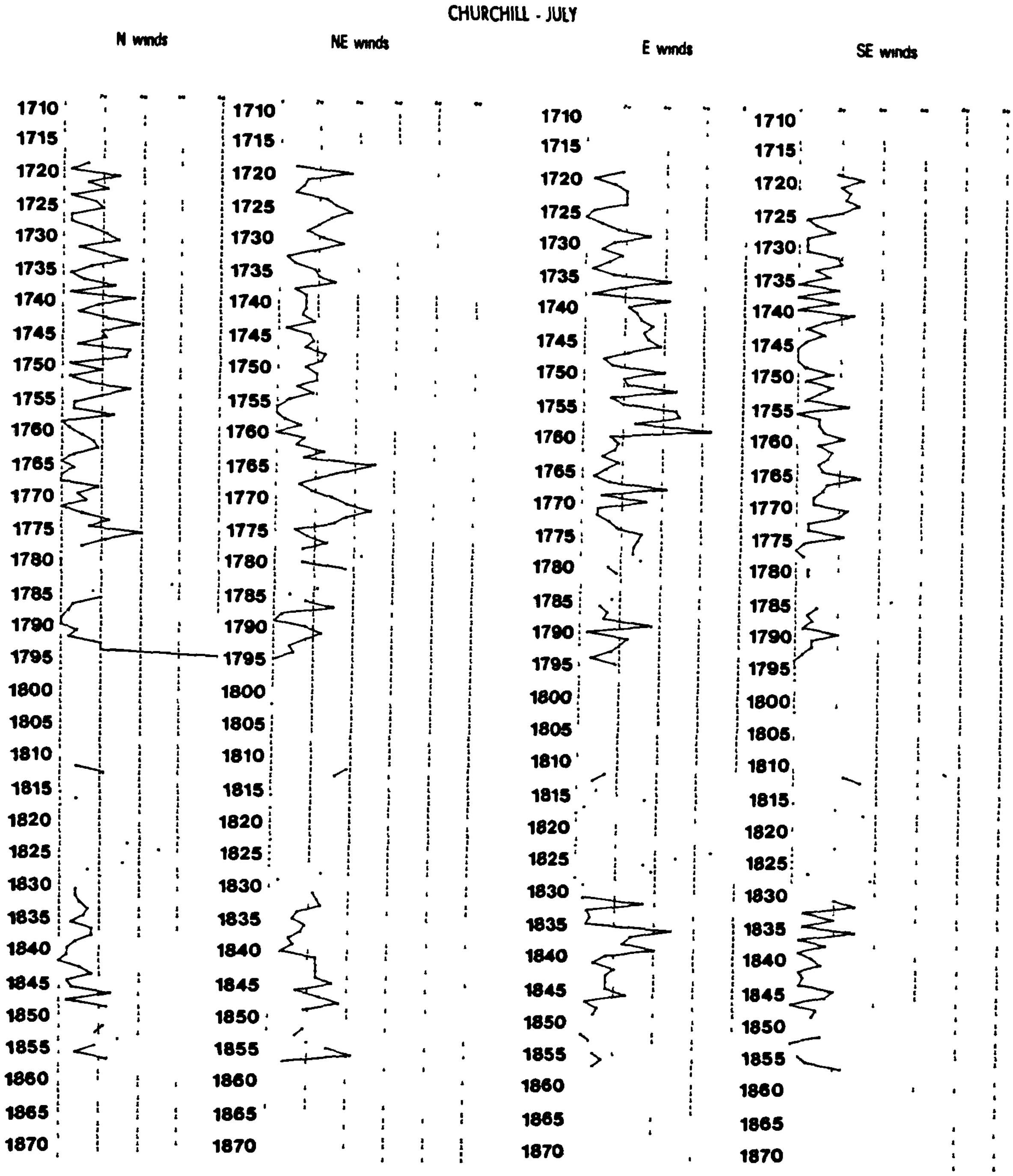


Figure 61: Percentage frequency of winds, Churchill - July

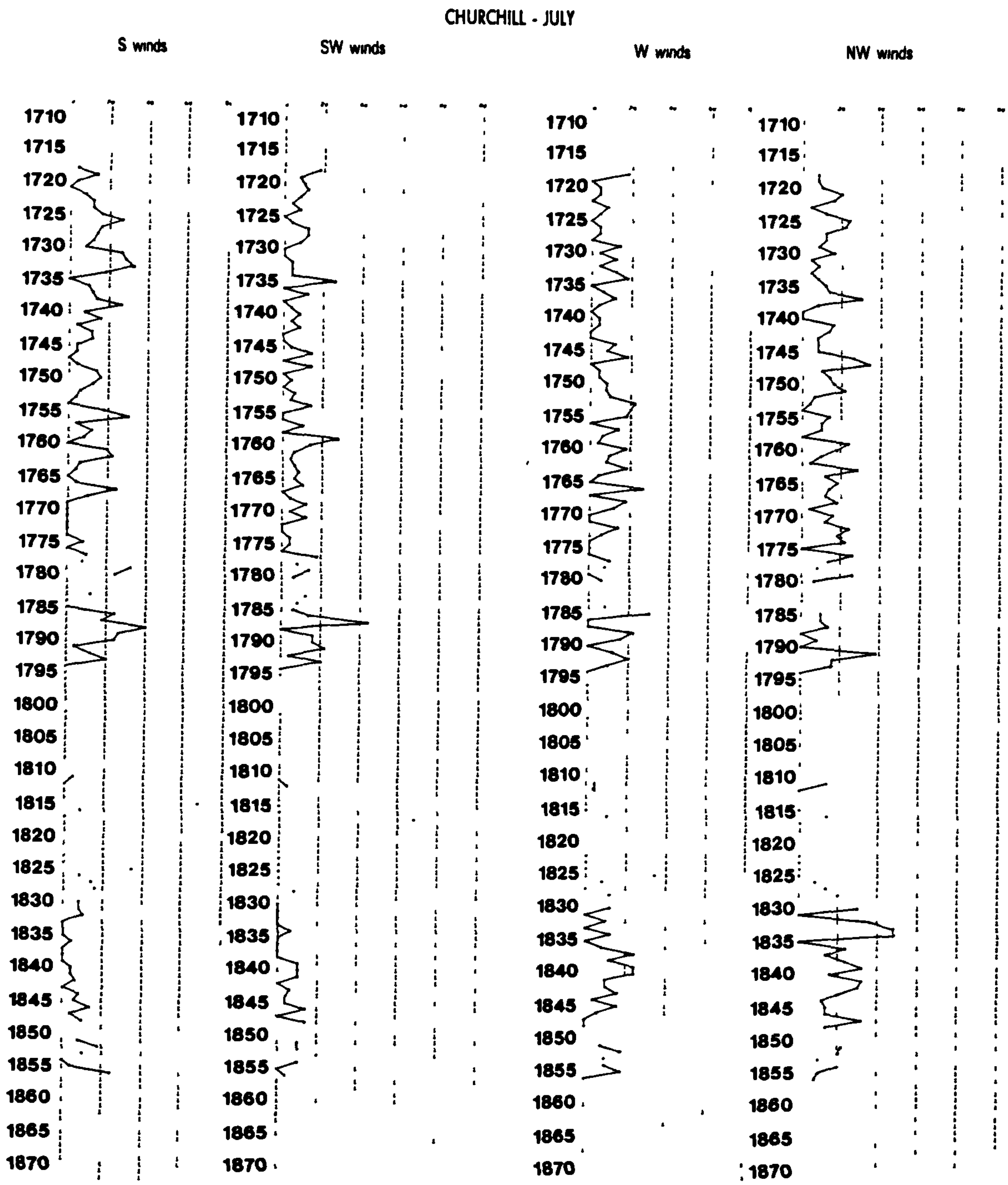


Figure 62: Percentage frequency of winds, Churchill - July

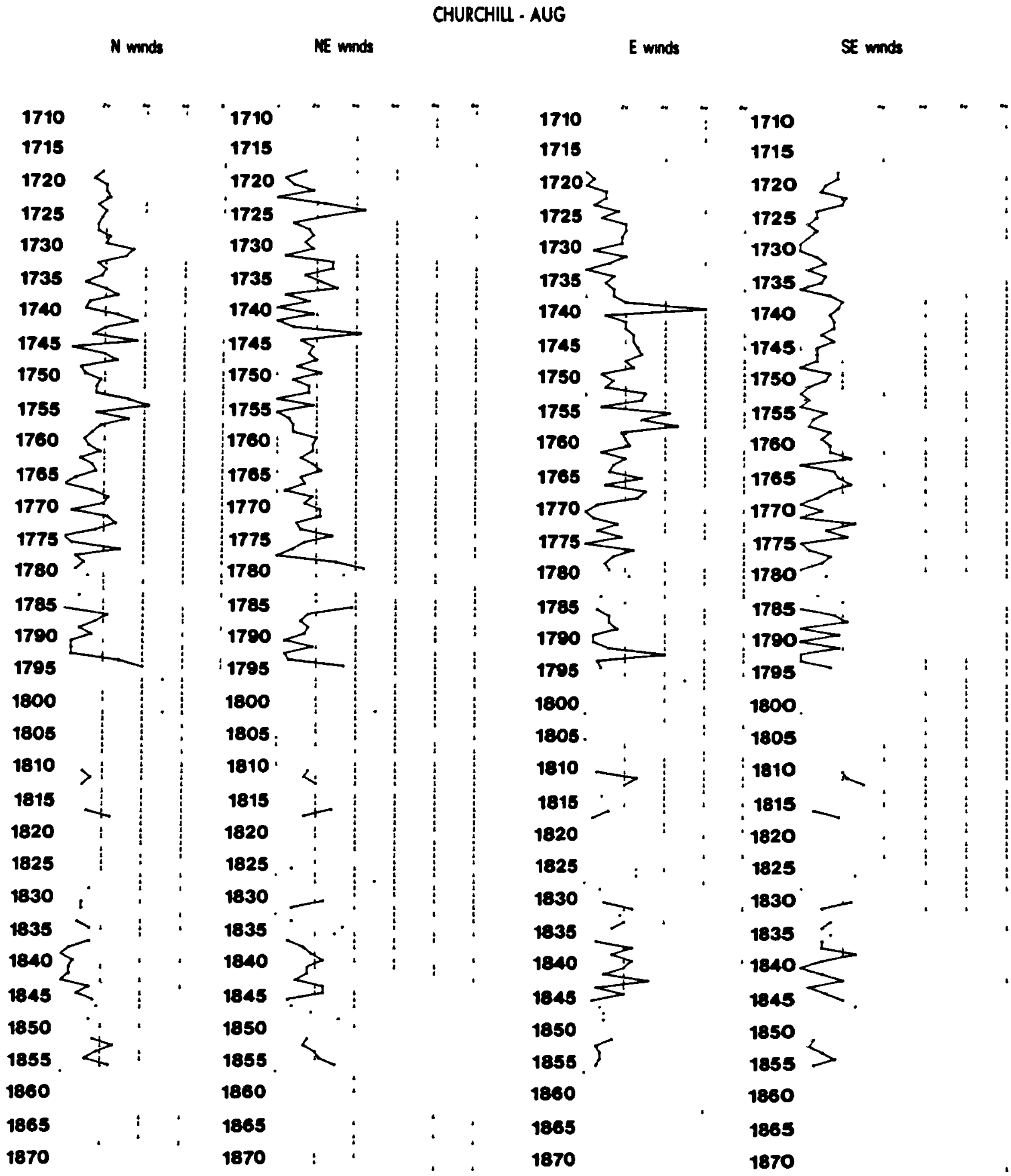


Figure 63: Percentage frequency of winds, Churchill - August

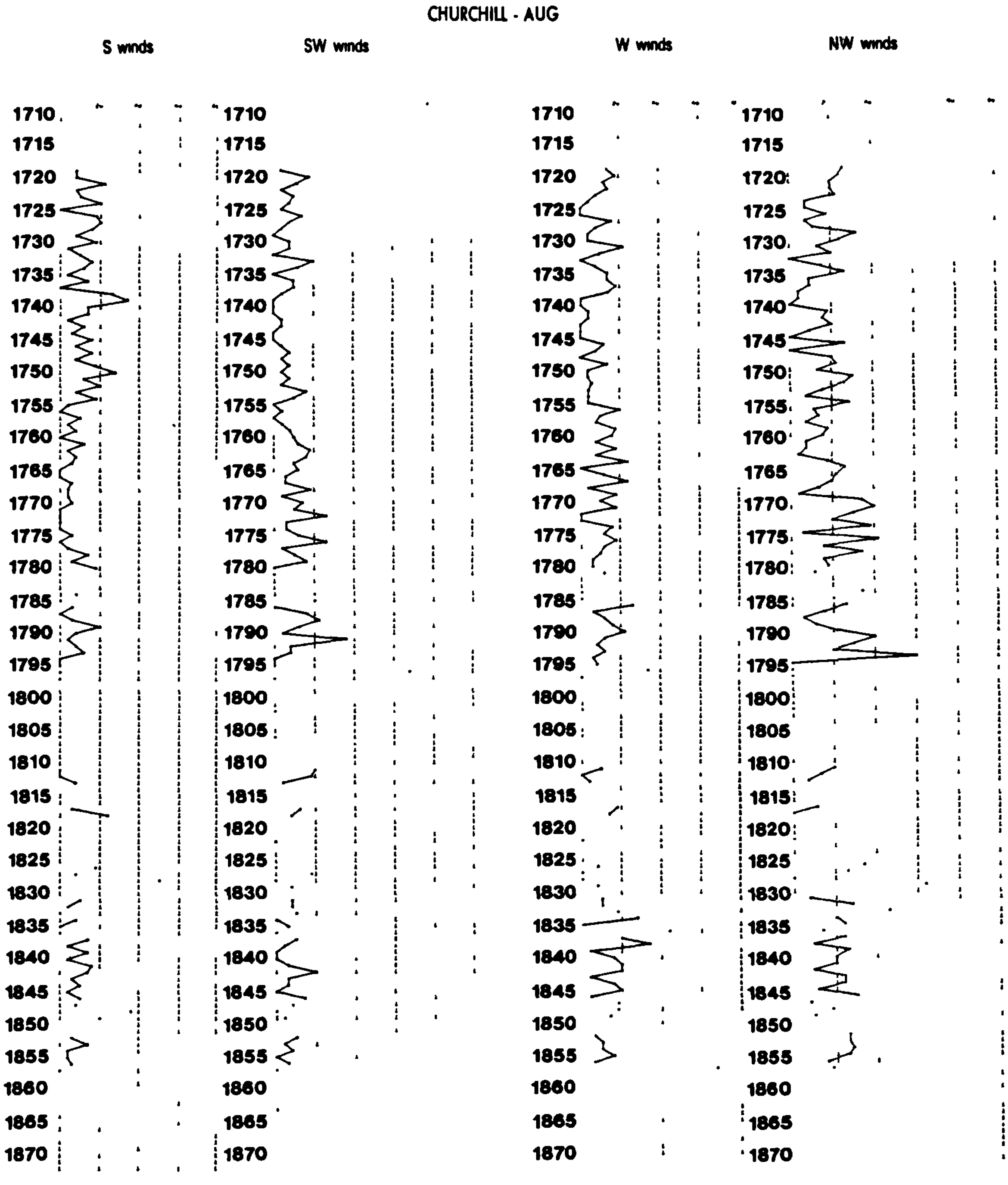


Figure 64: Percentagae frequency of winds, Churchill - August

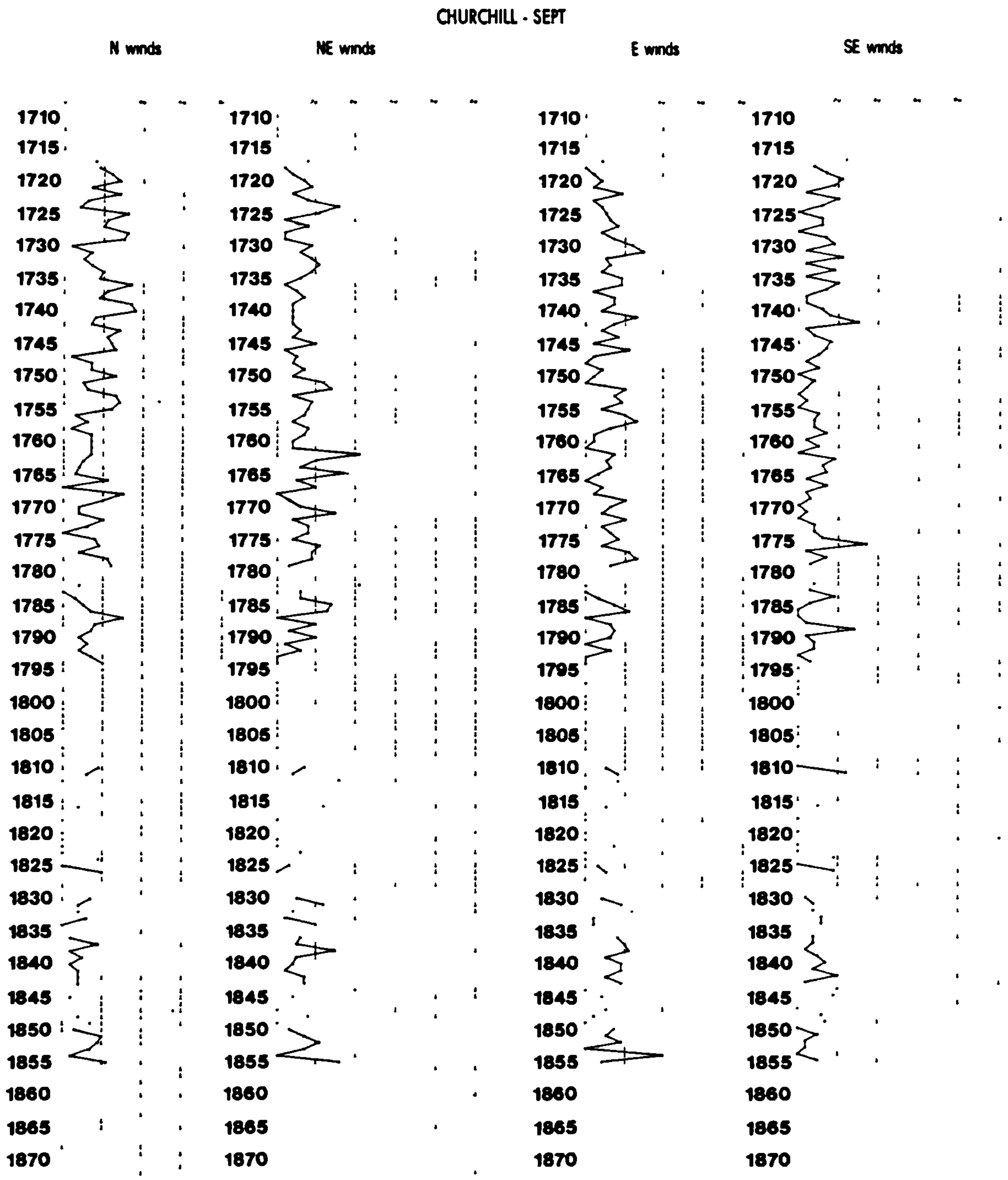


Figure 65: Percentage frequency of winds, Churchill - September

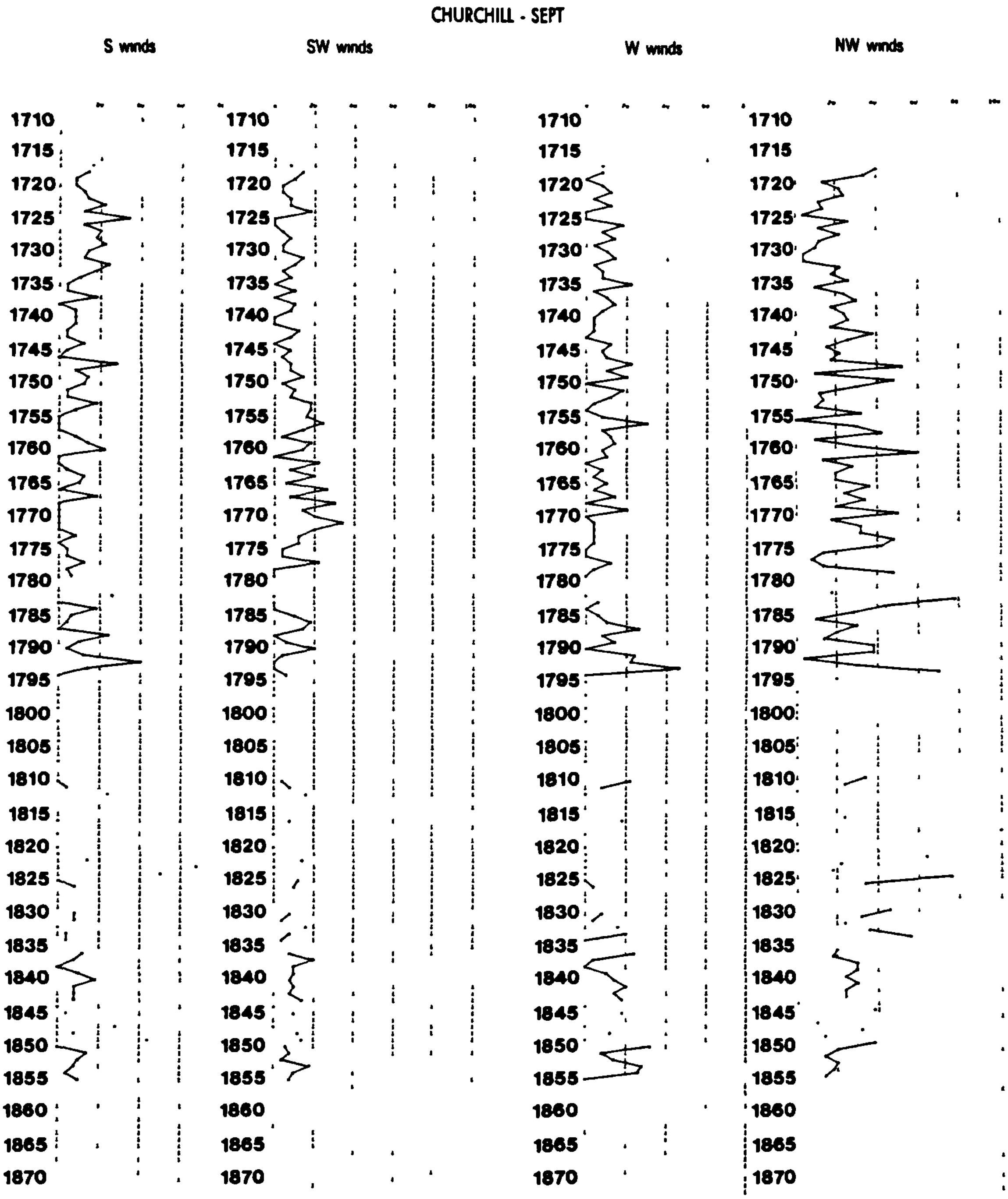


Figure 66: Percentage frequency of winds, Churchill - September

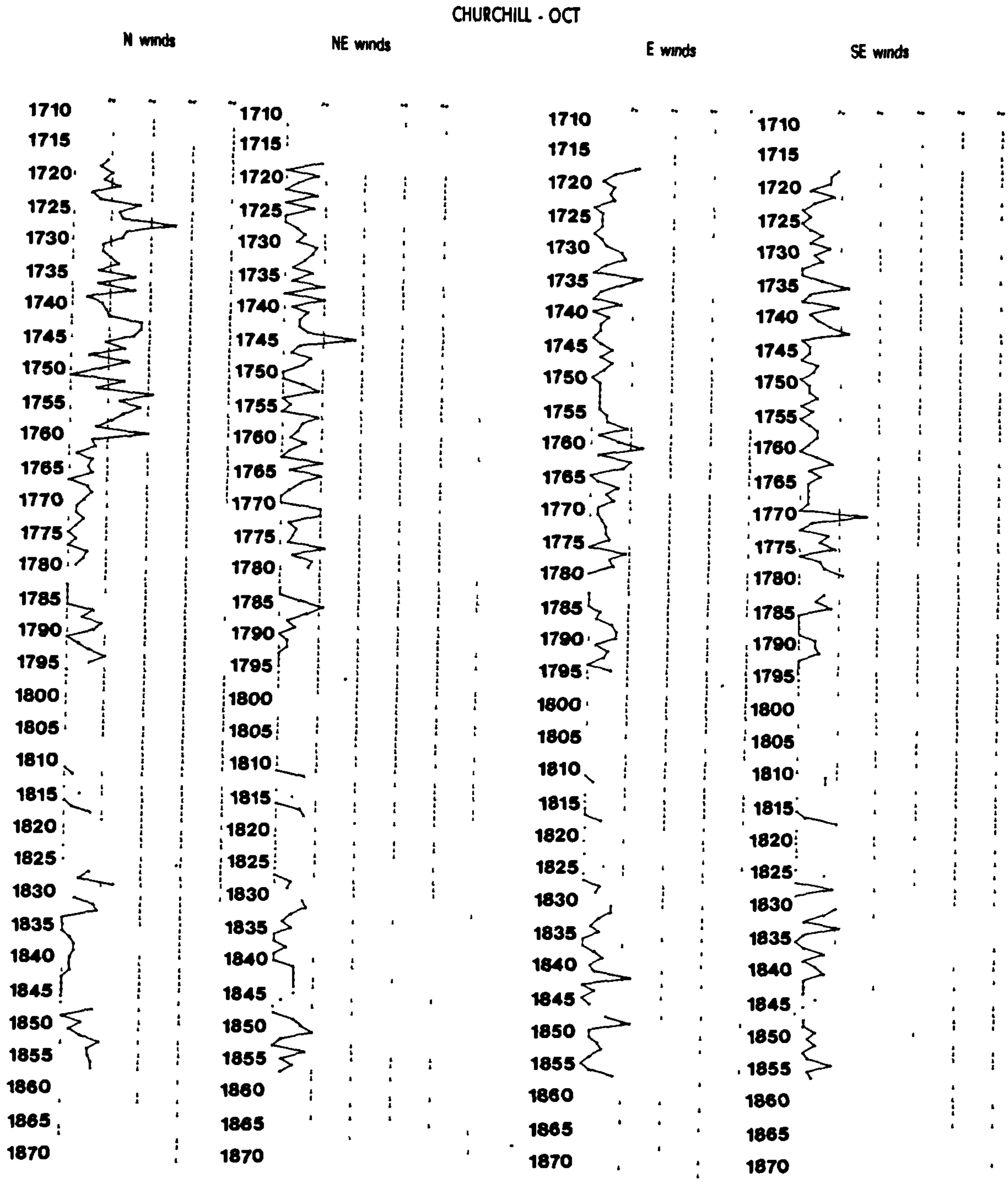


Figure 67: Percentage frequency of winds, Churchill - October

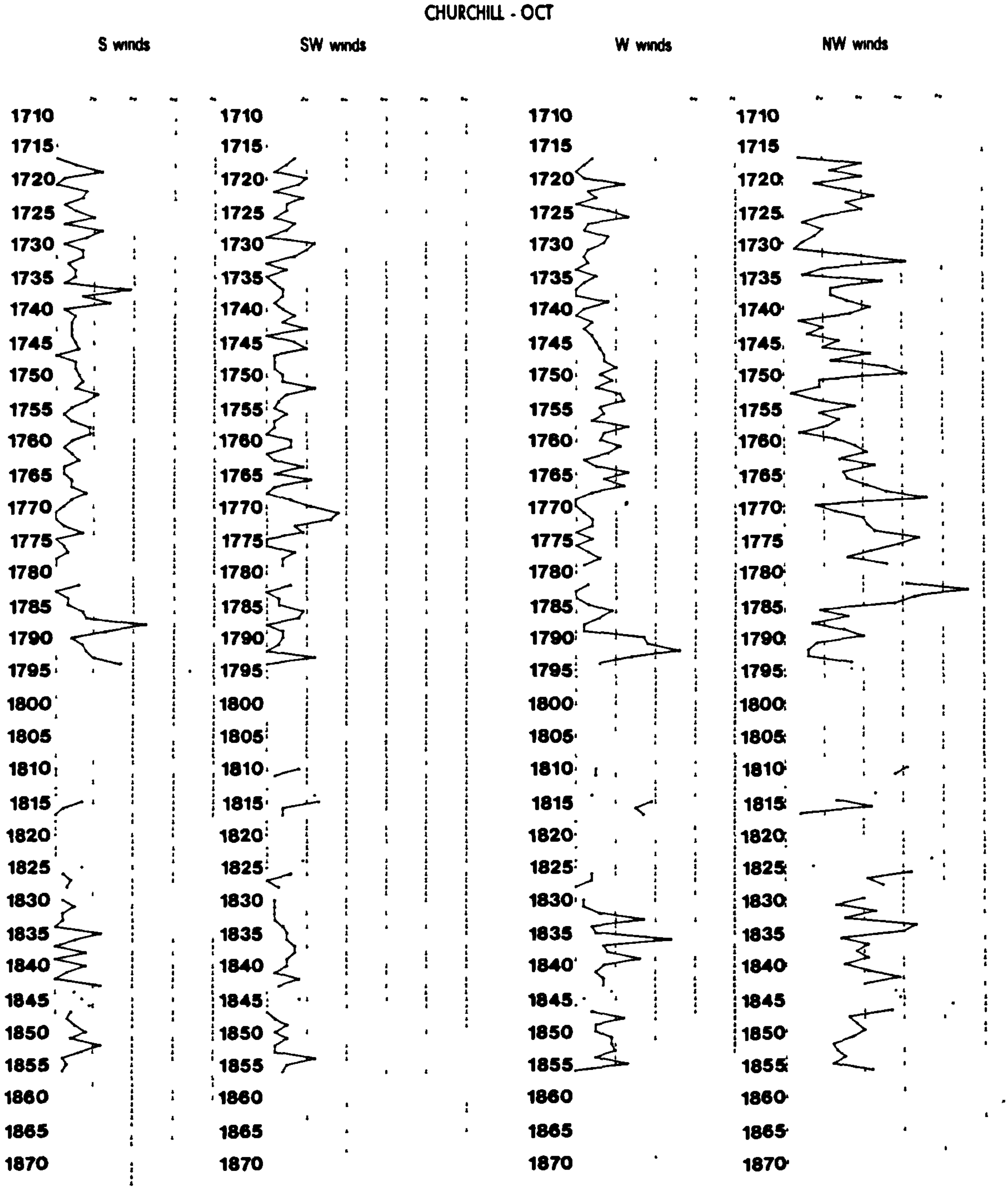


Figure 68: Percentage frequency of winds, Churchill - October

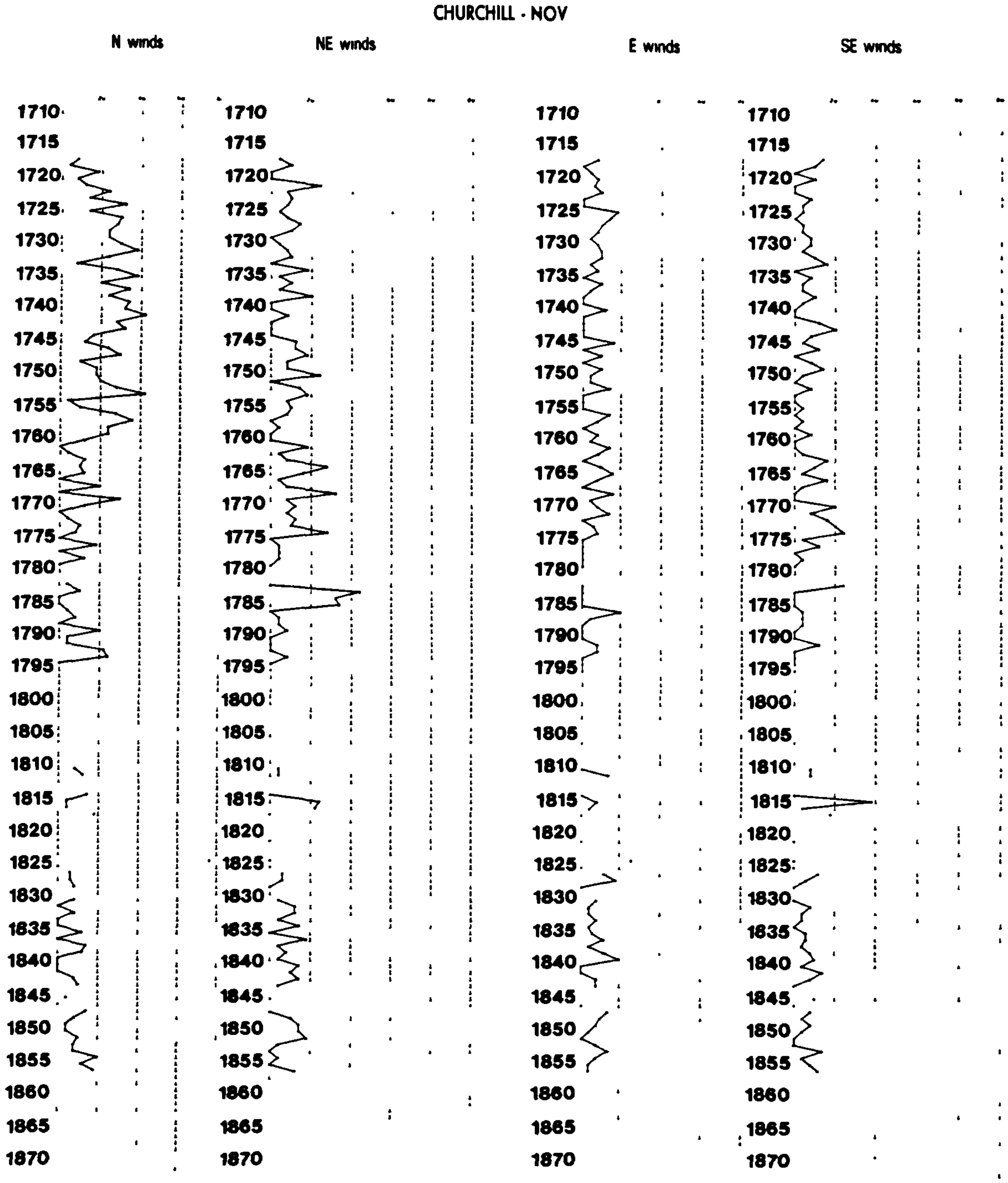


Figure 69: Percentage frequency of winds, Churchill - November

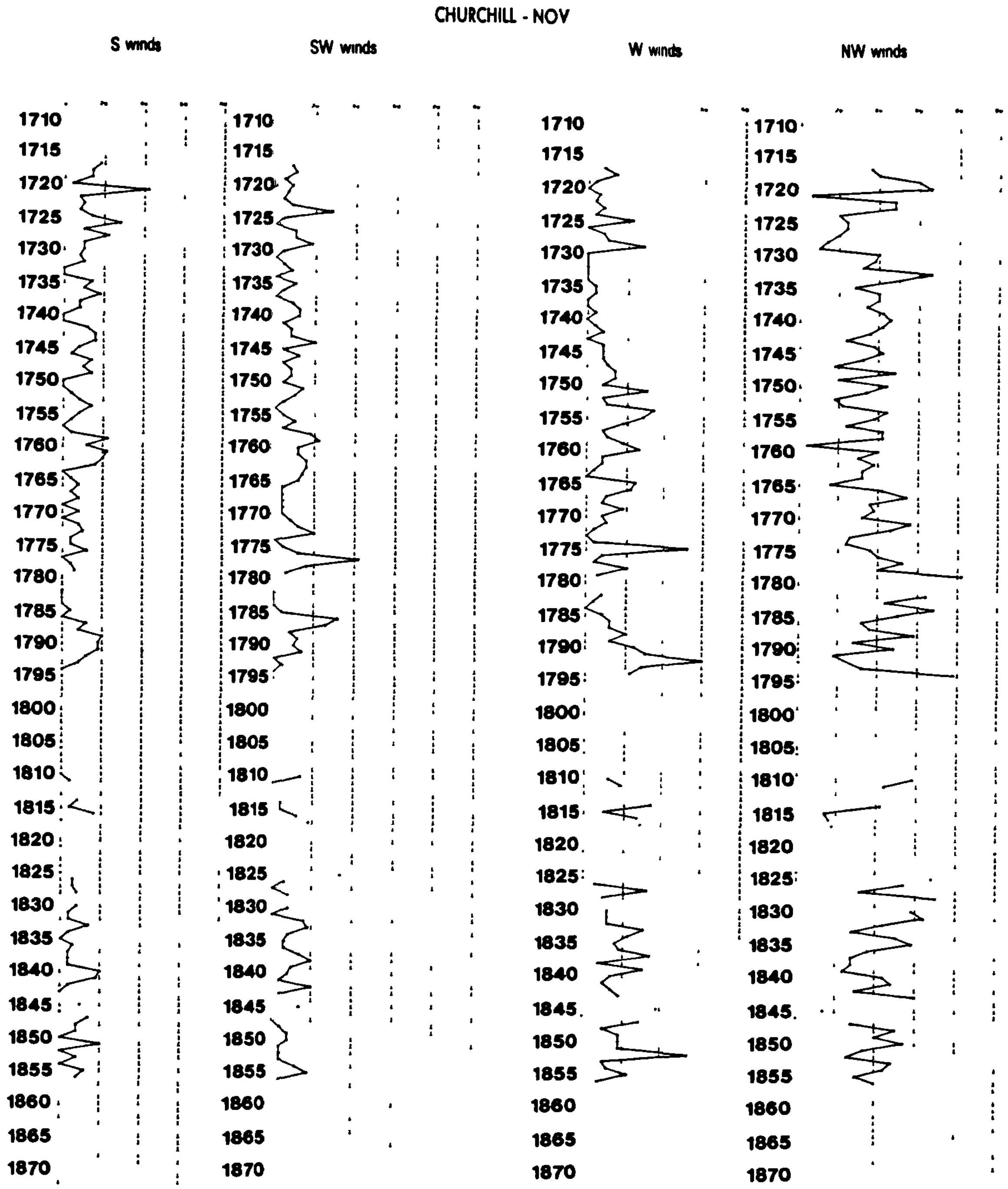


Figure 70: Percentage frequency of winds, Churchill - November

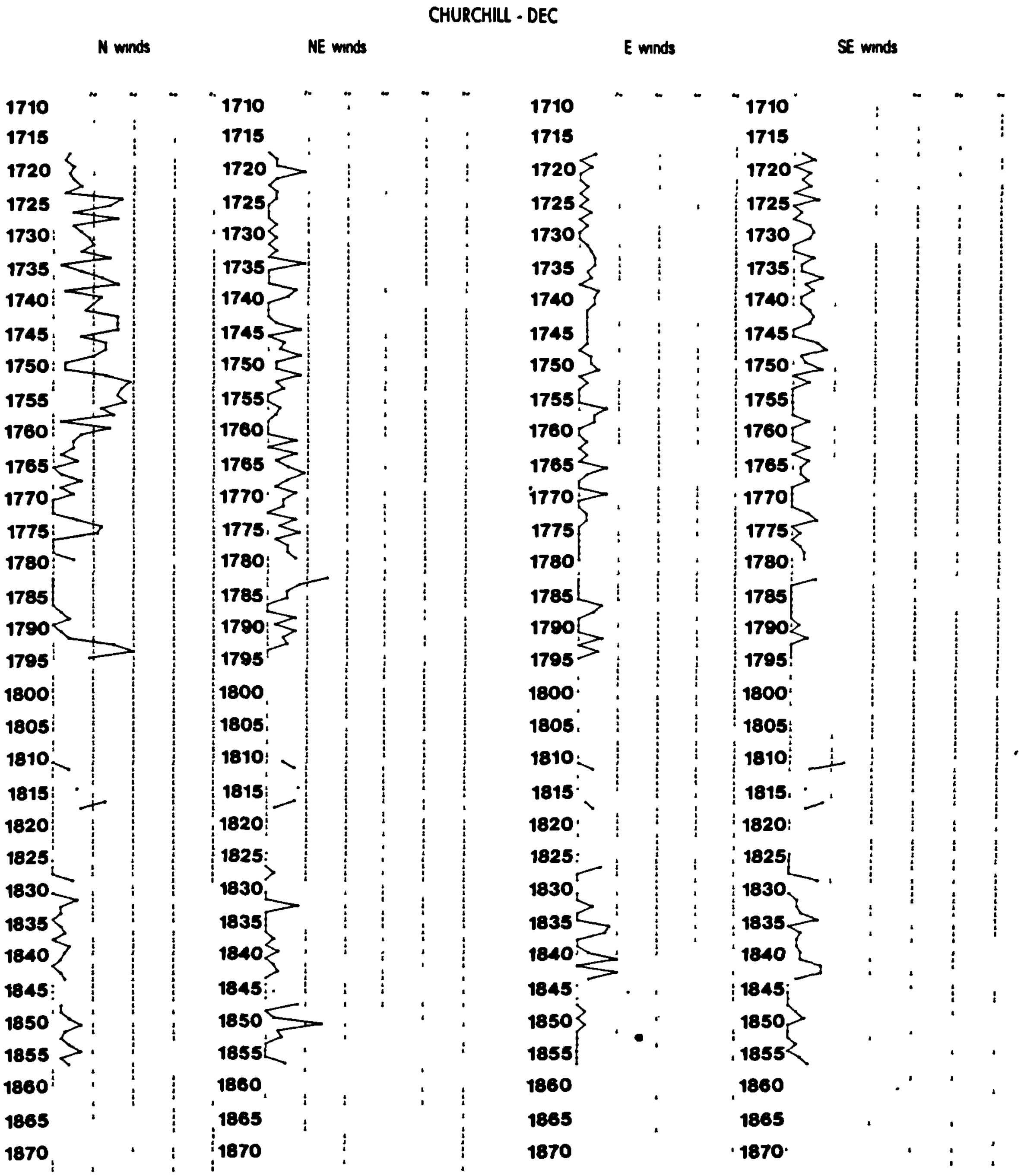


Figure 71: Percentage frequency of winds, Churchill - December

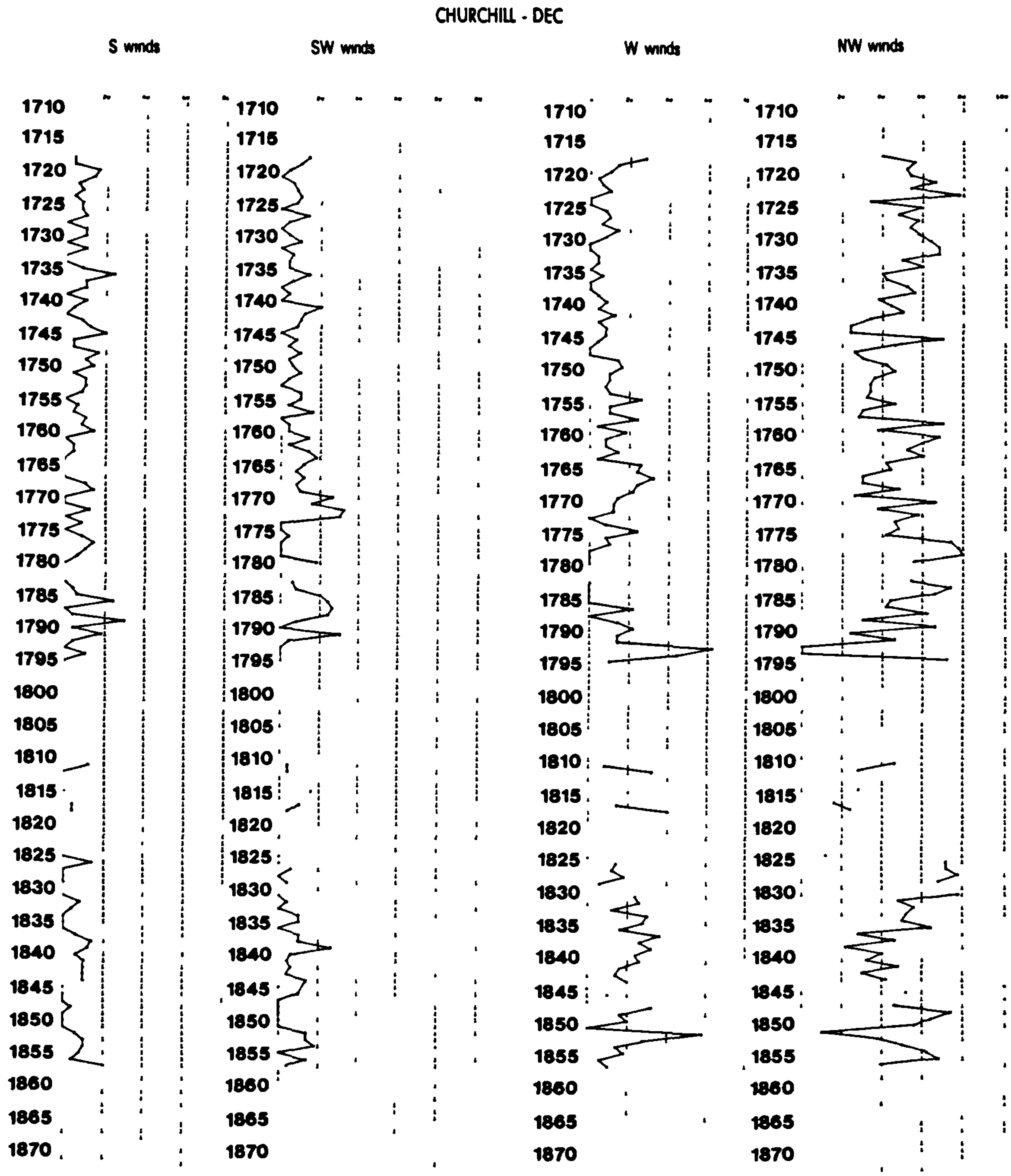


Figure 72: Percentage frequency of winds, Churchill - December

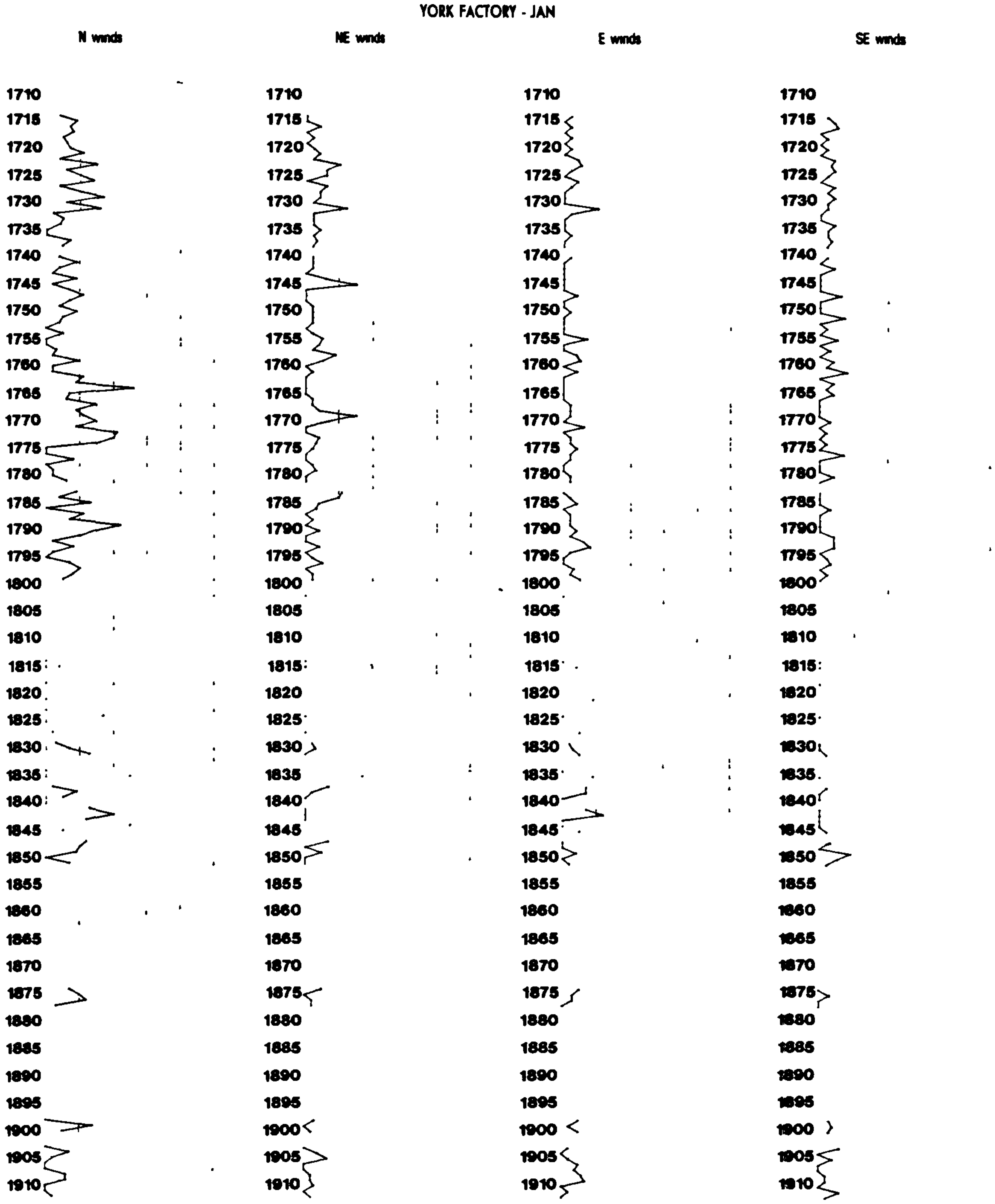


Figure 73: Percentage frequency of winds, York - January

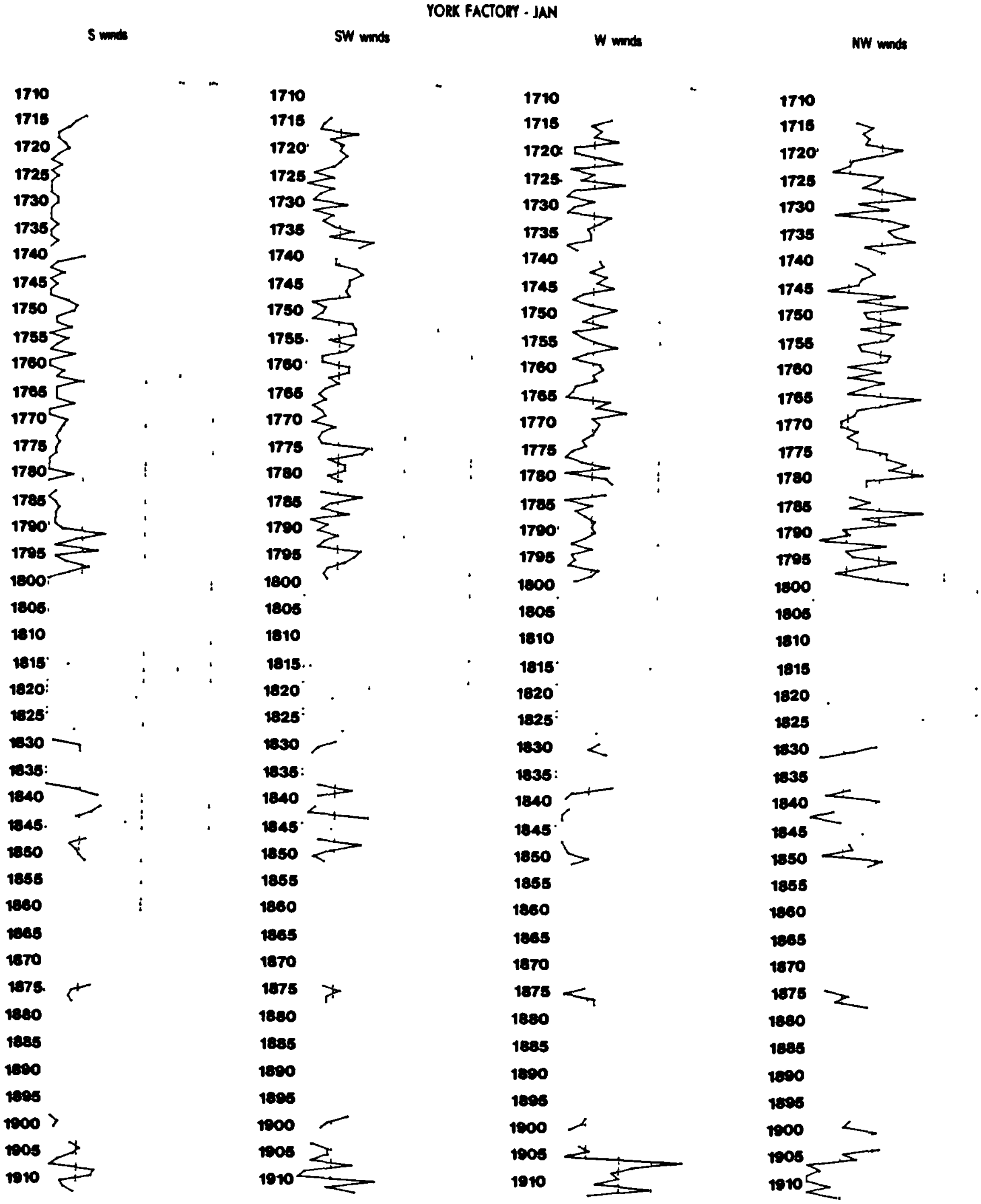


Figure 74: Percentage frequency of winds, York - January

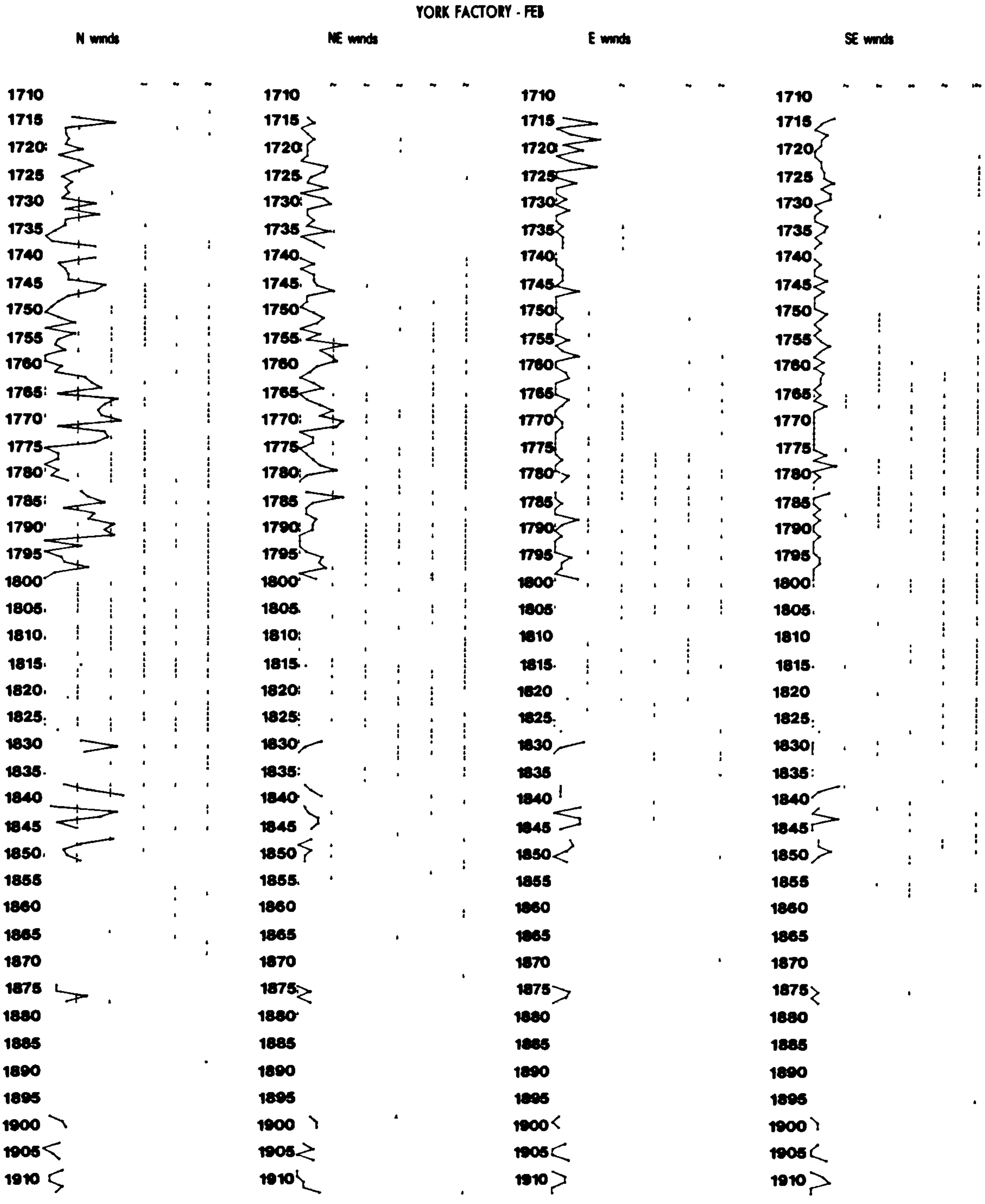


Figure 75: Percentage frequency of winds, York - February

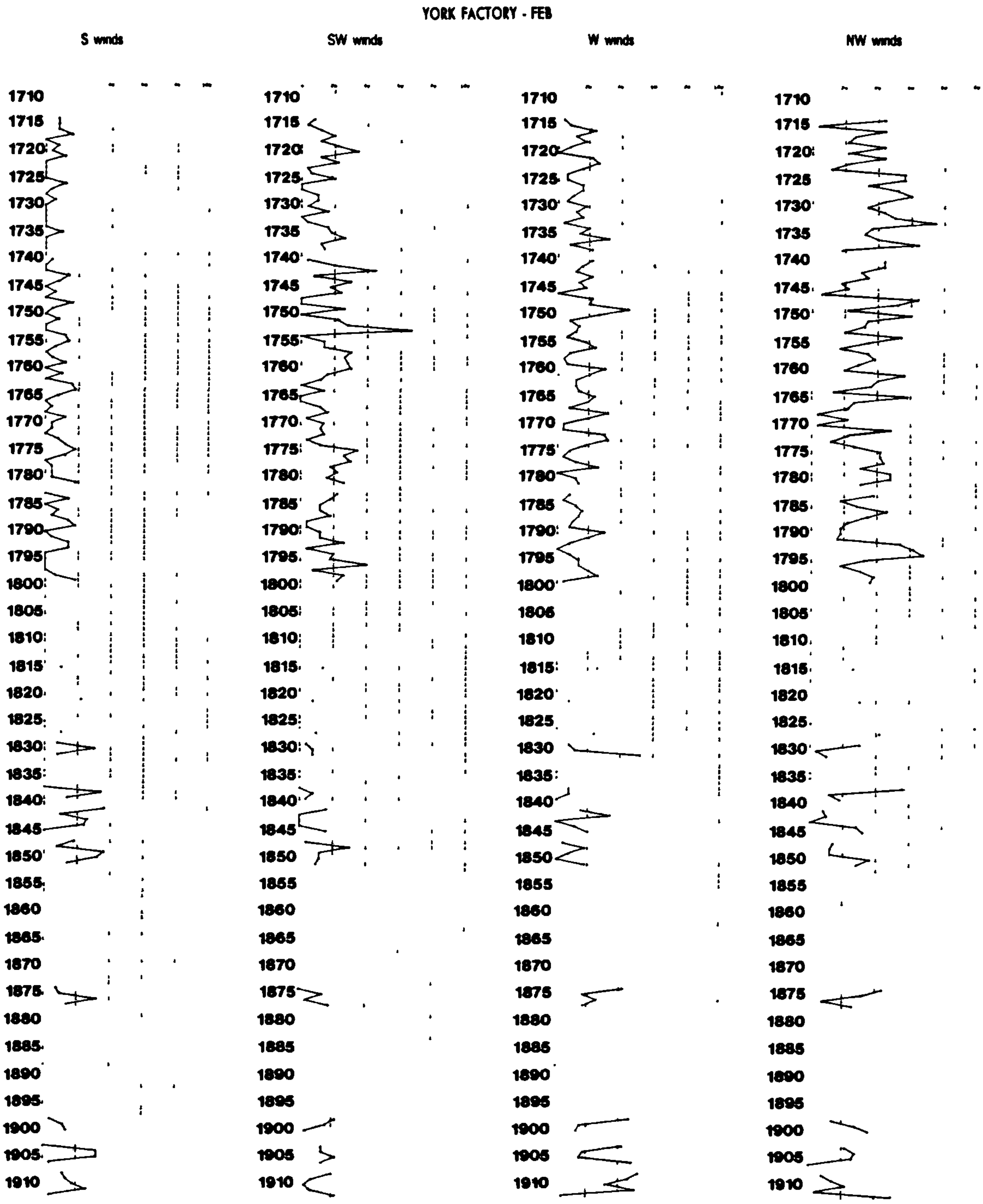


Figure 76: Percentage frequency of winds, York - February

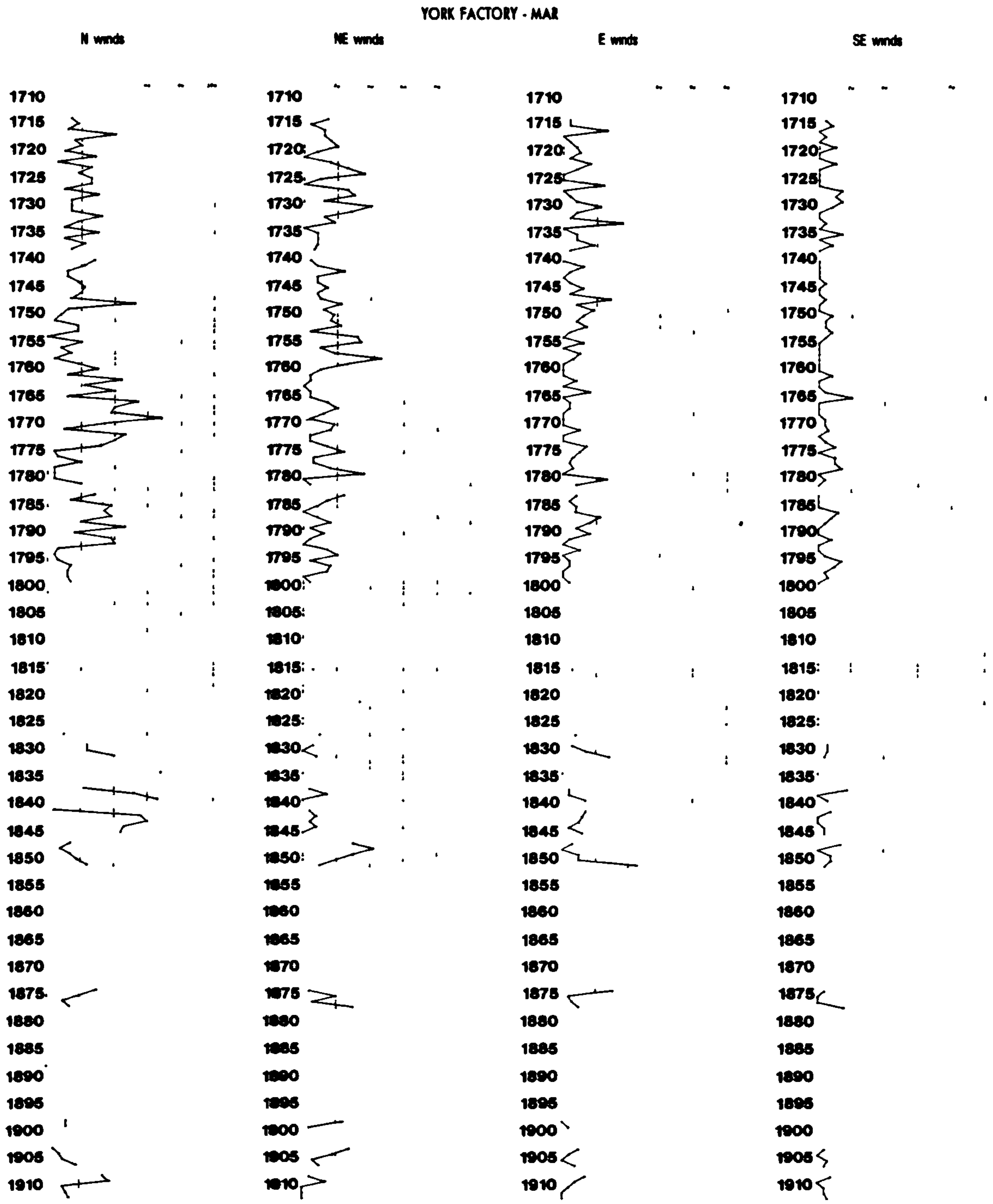


Figure 77: Percentage frequency of winds, York - March

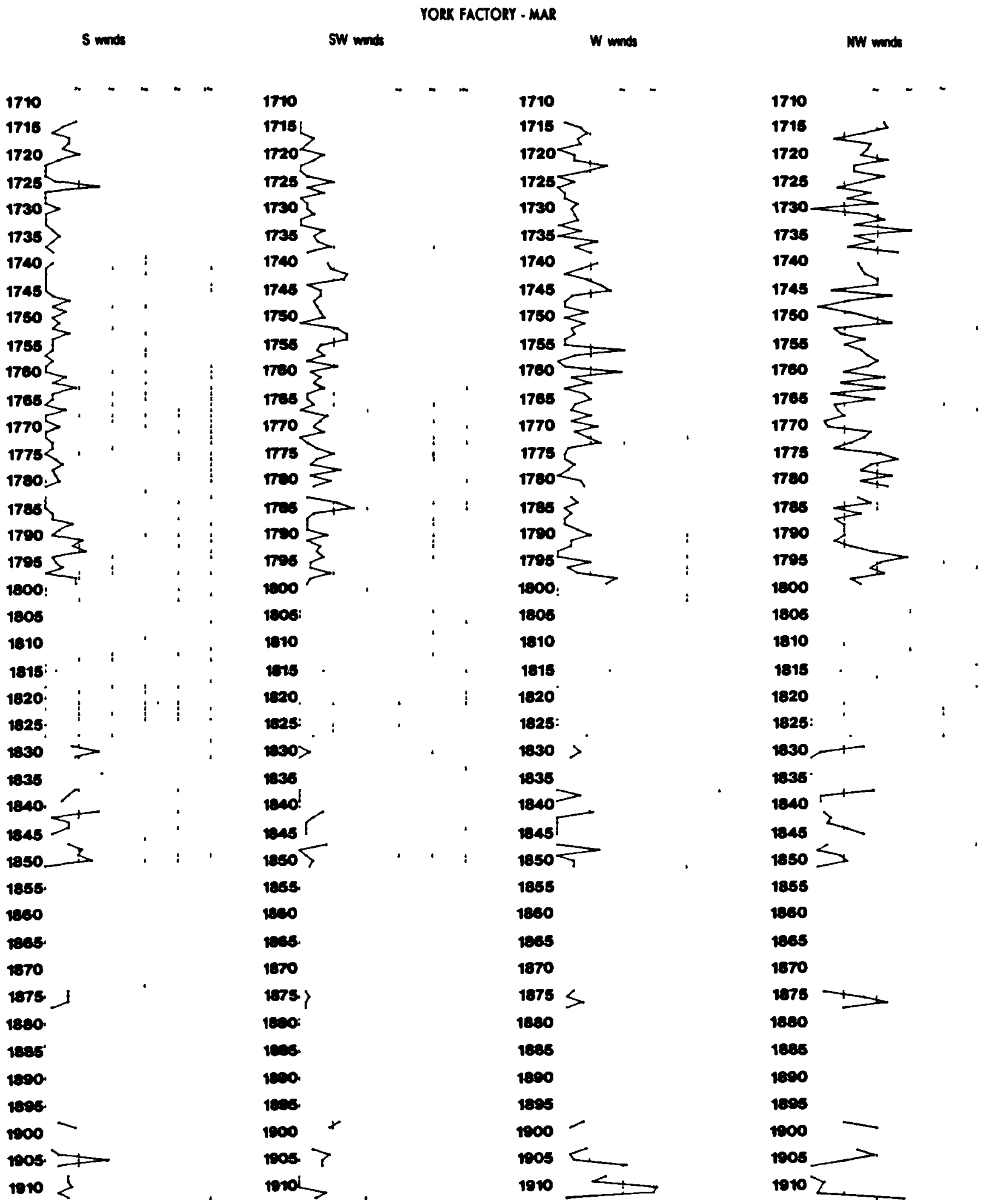


Figure 78: Percentage frequency of winds, York - March

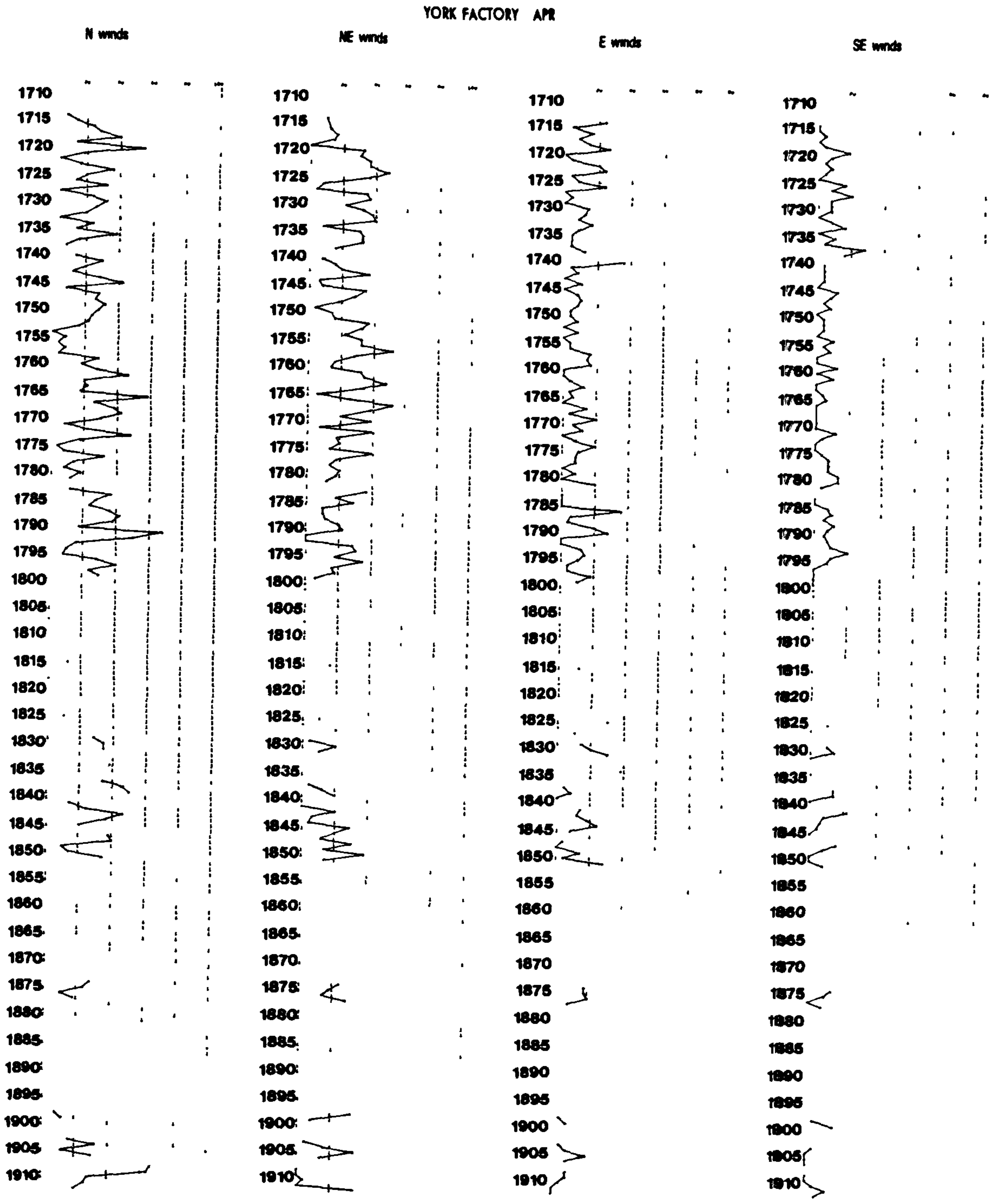


Figure 79: Percentage frequency of winds, York - April

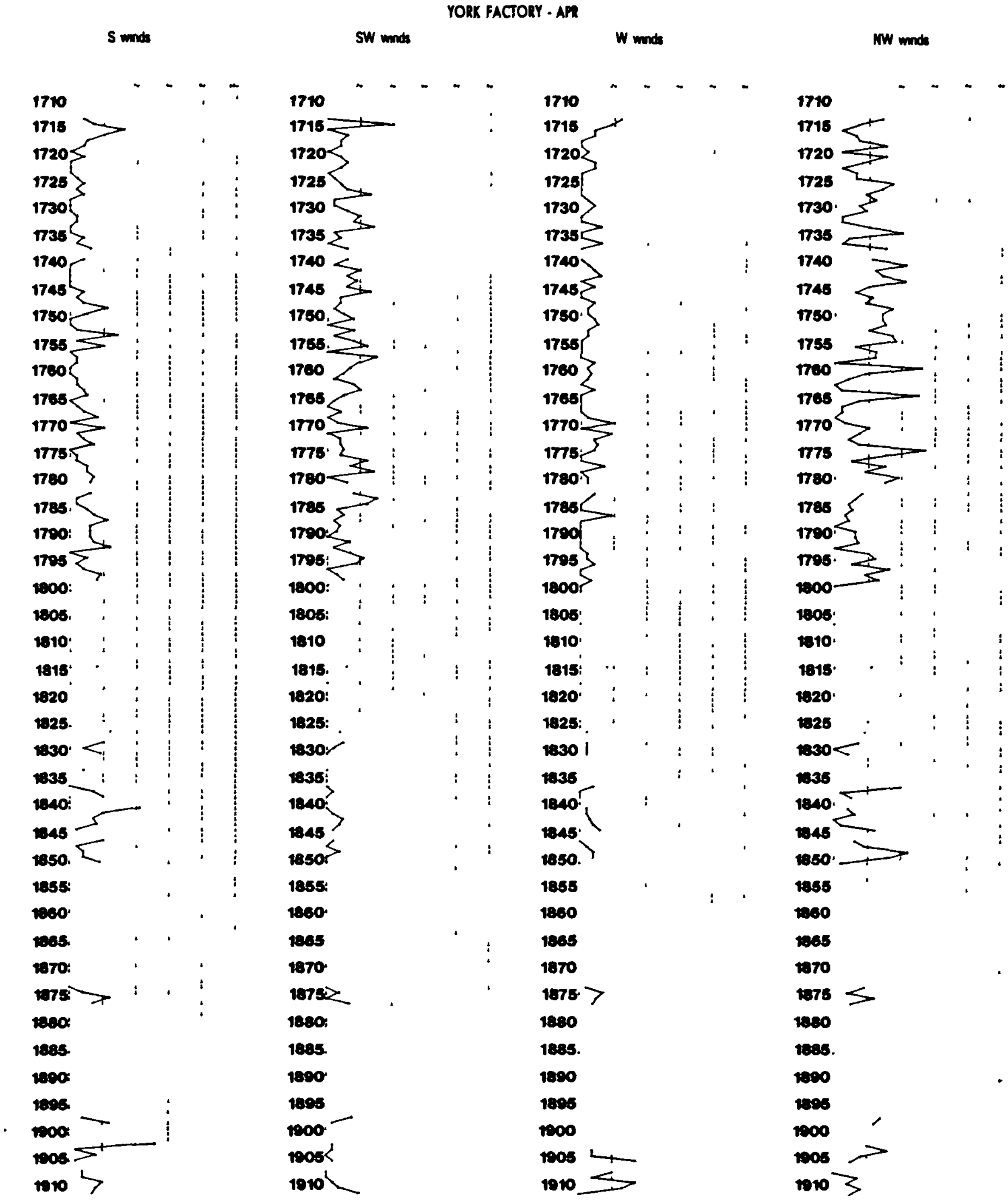


Figure 80: Percentage frequency of winds, York - April

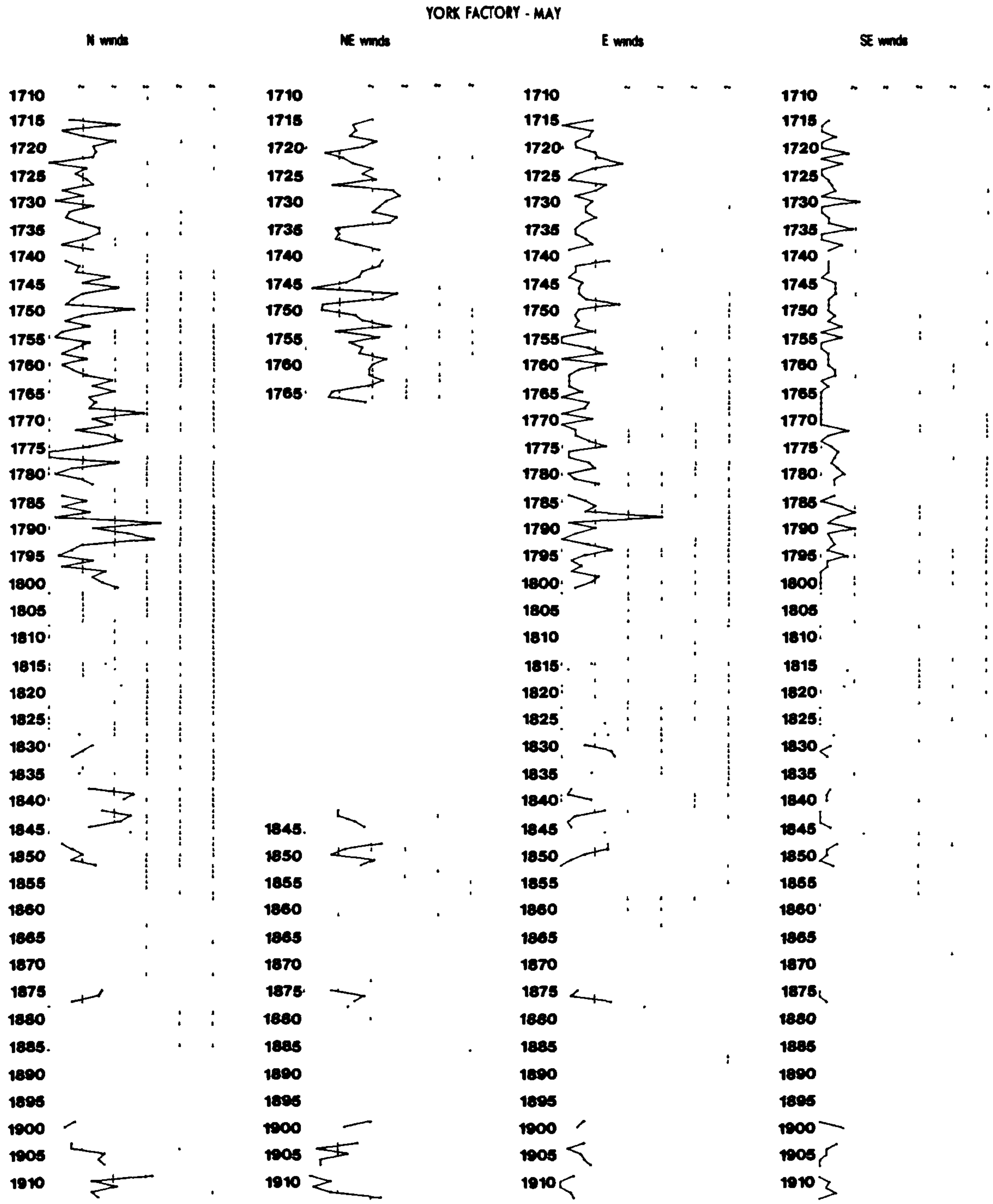


Figure 81: Percentage frequency of winds, York - May

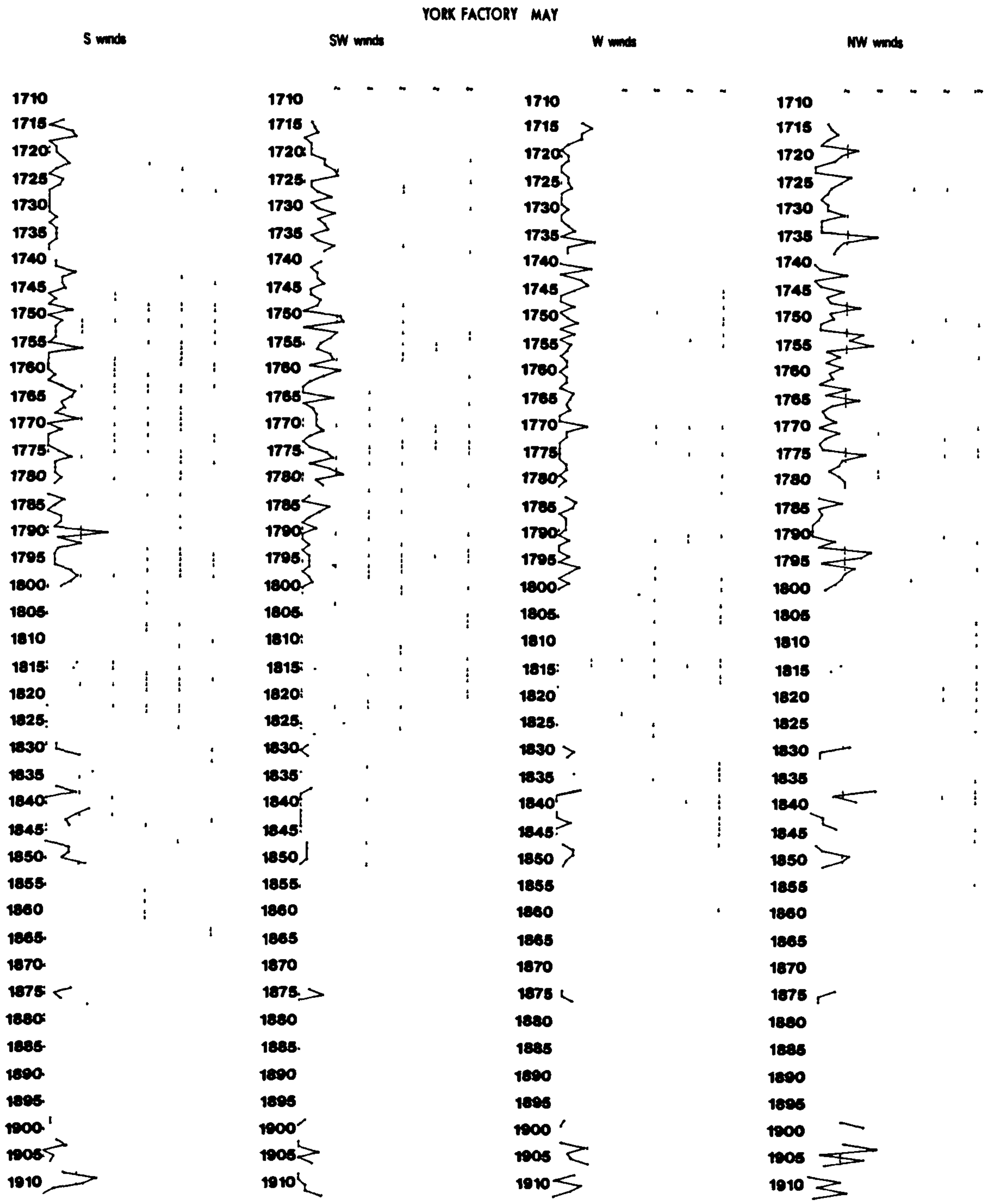


Figure 82: Percentage frequency of winds, York - May

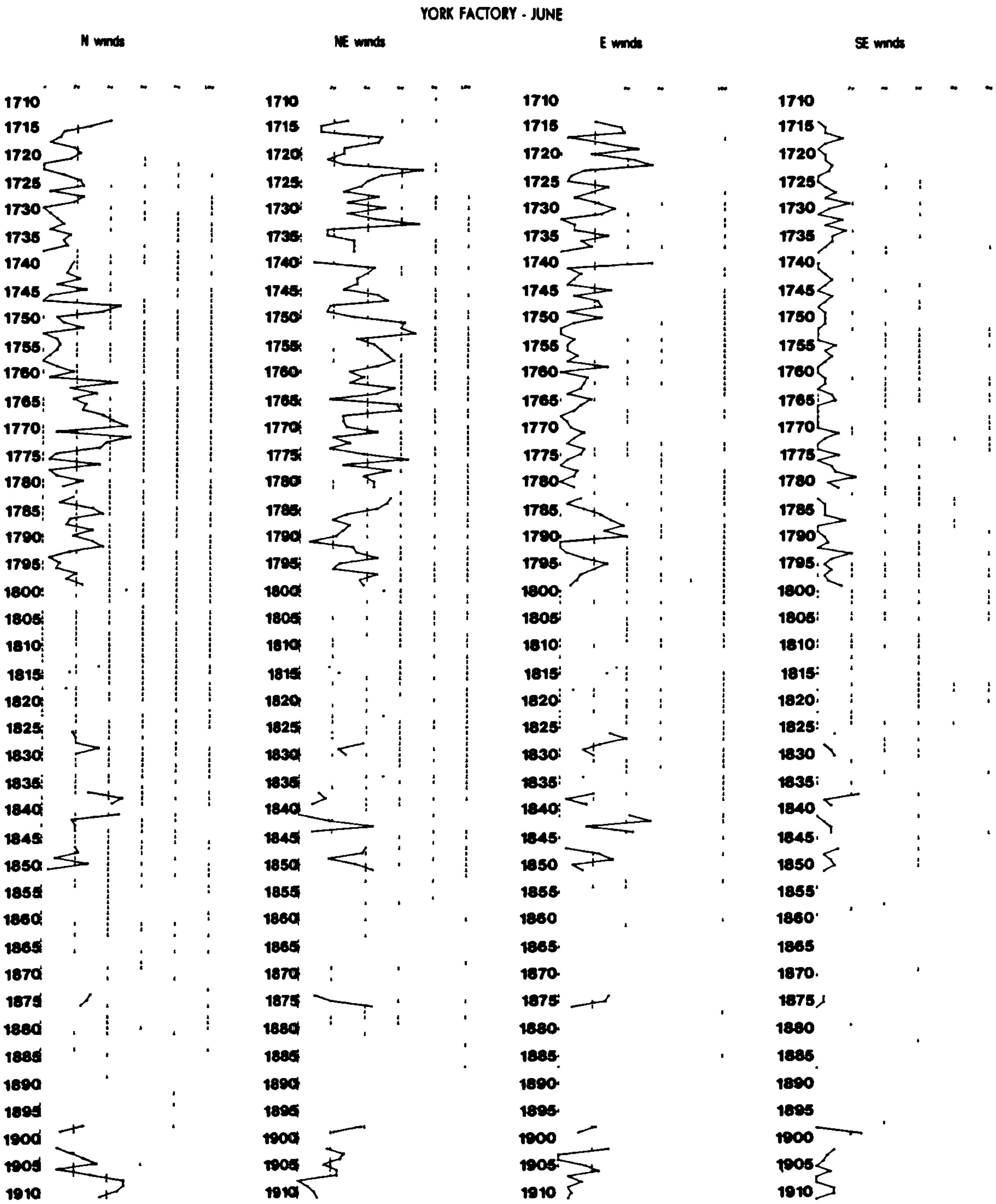


Figure 83: Percentage frequency of winds, York - June

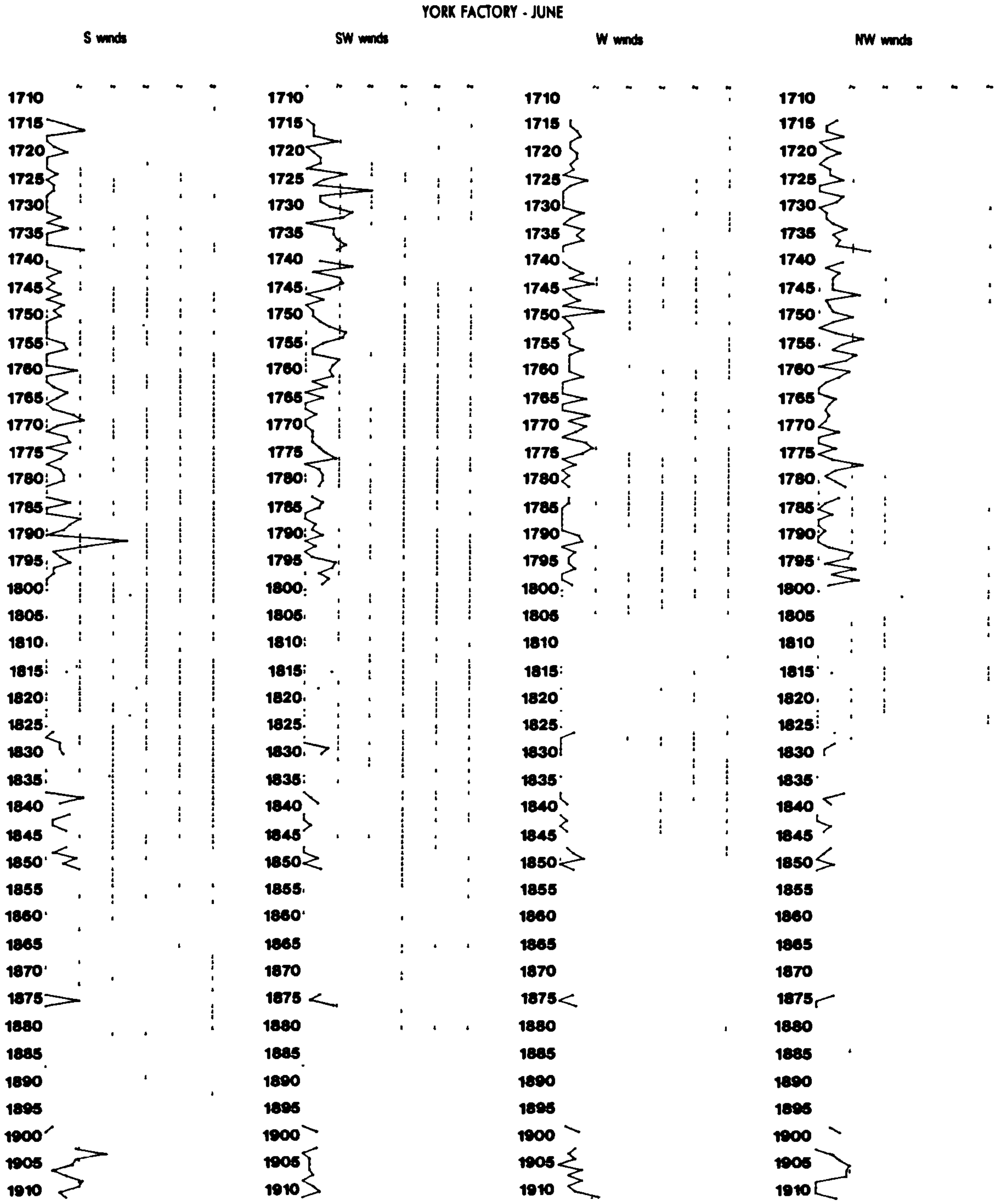


Figure 84: Percentage frequency of winds, York - June

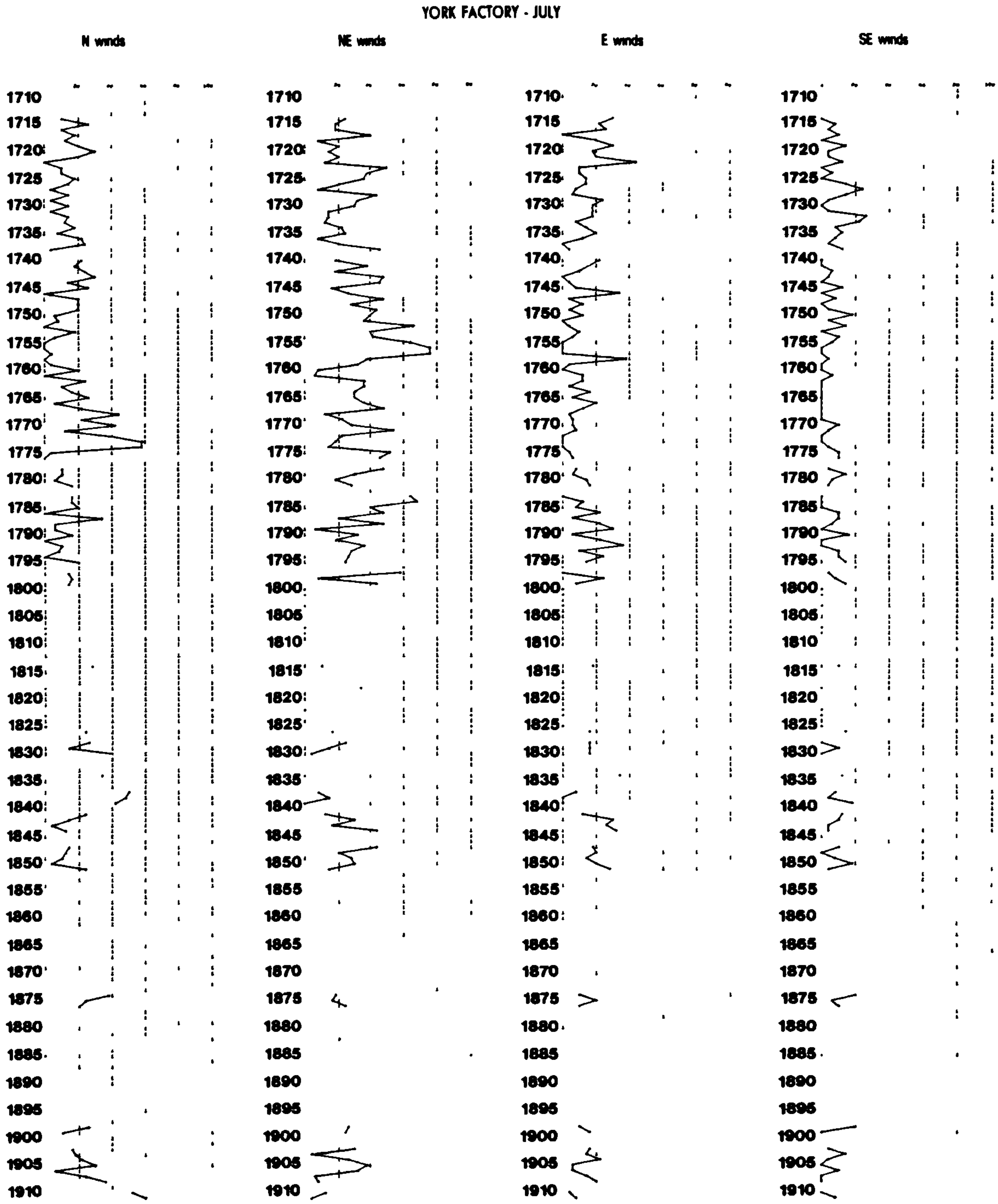


Figure 85: Percentage frequency of winds, York - July

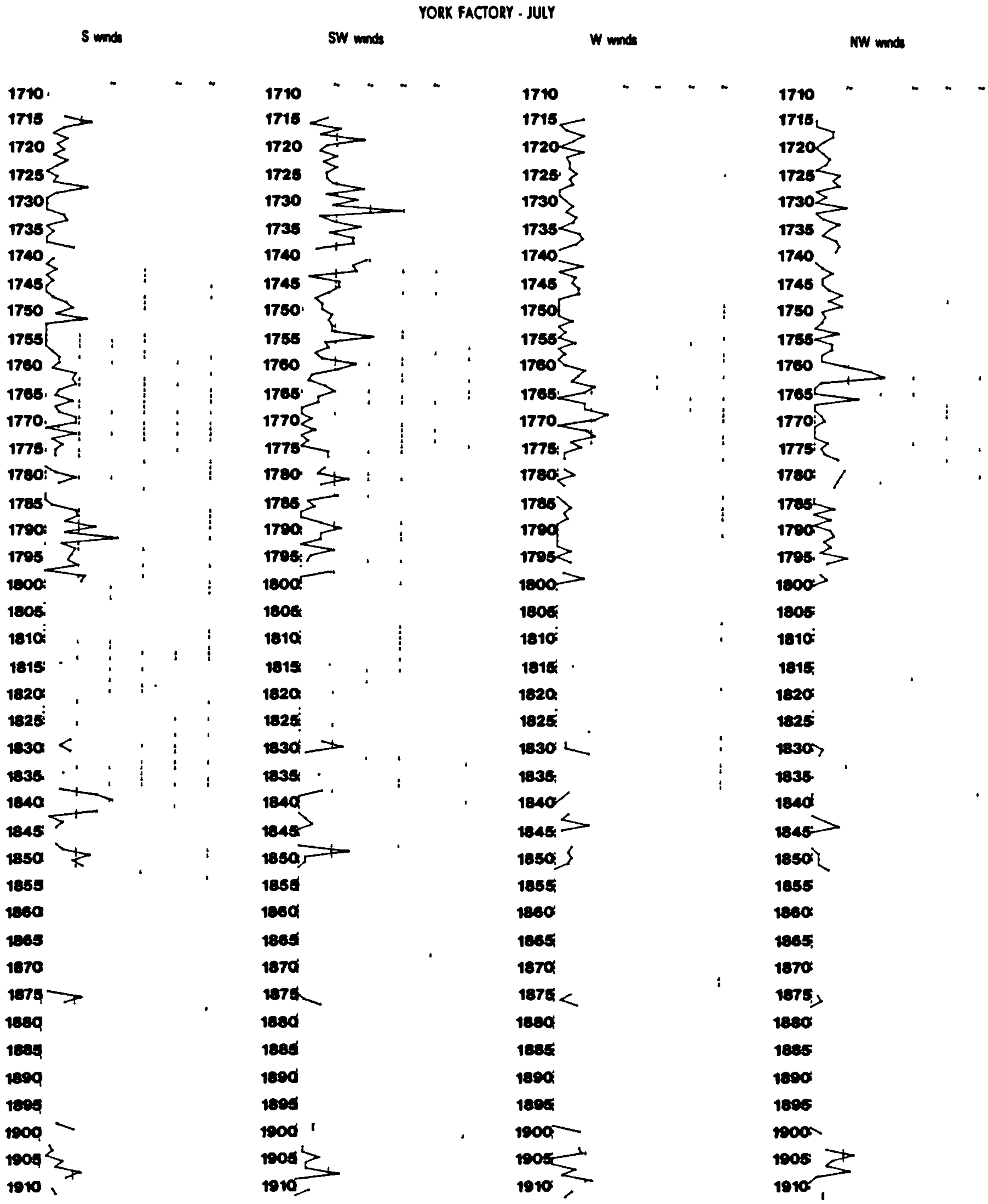


Figure 86: Percentage frequency of winds, York - July

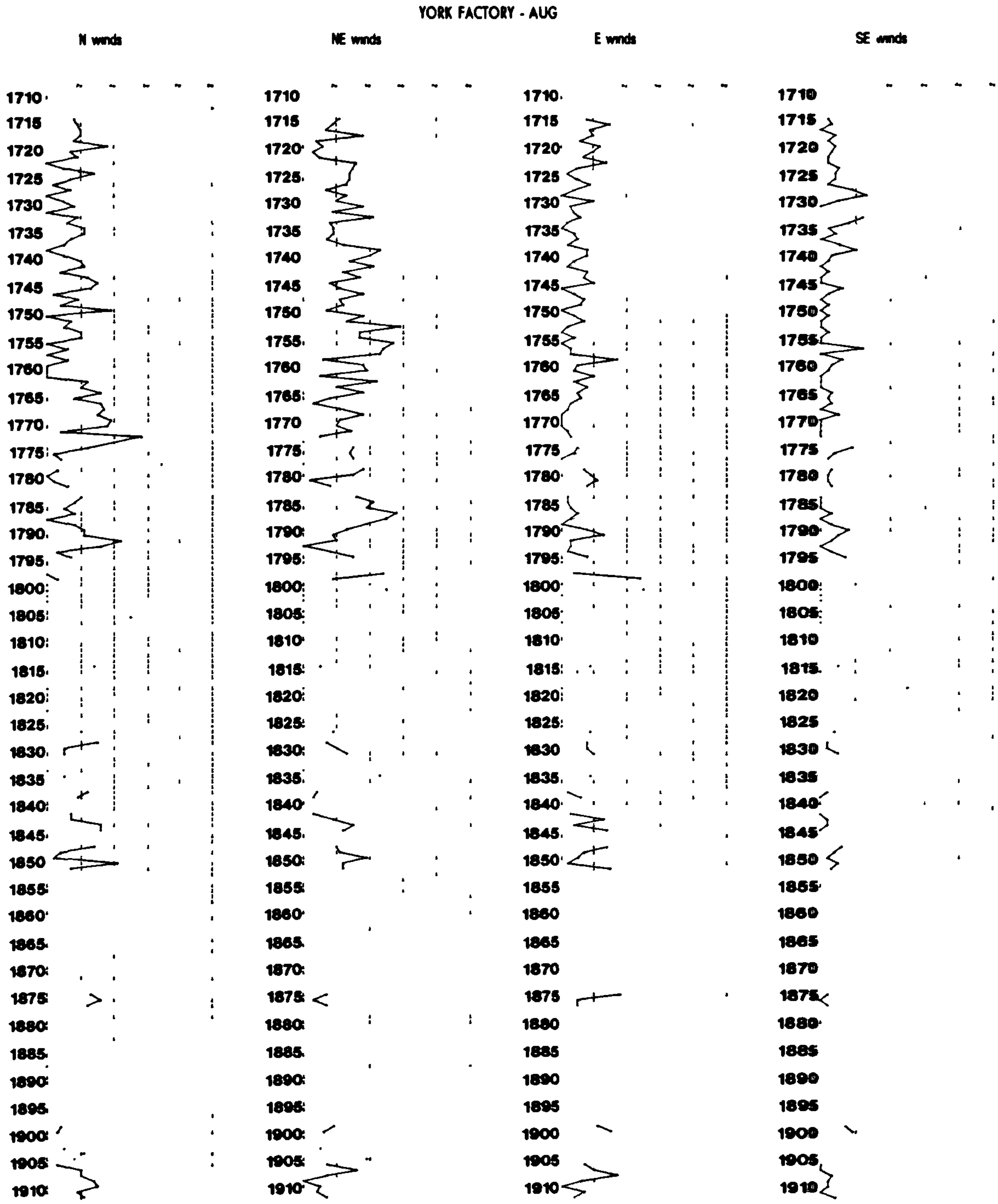


Figure 87: Percentage frequency of winds, York - August

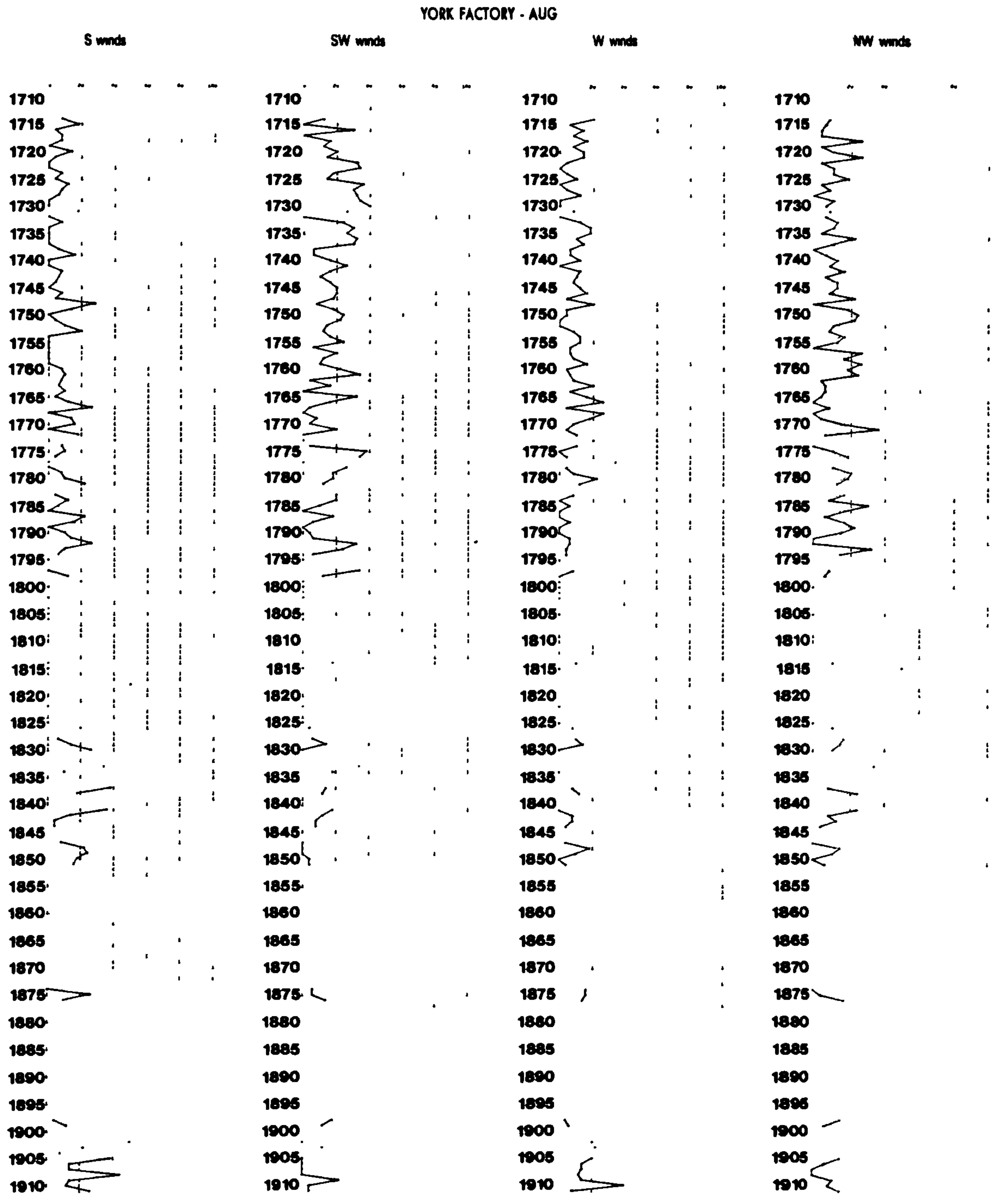


Figure 88: Percentage frequency of winds, York - August

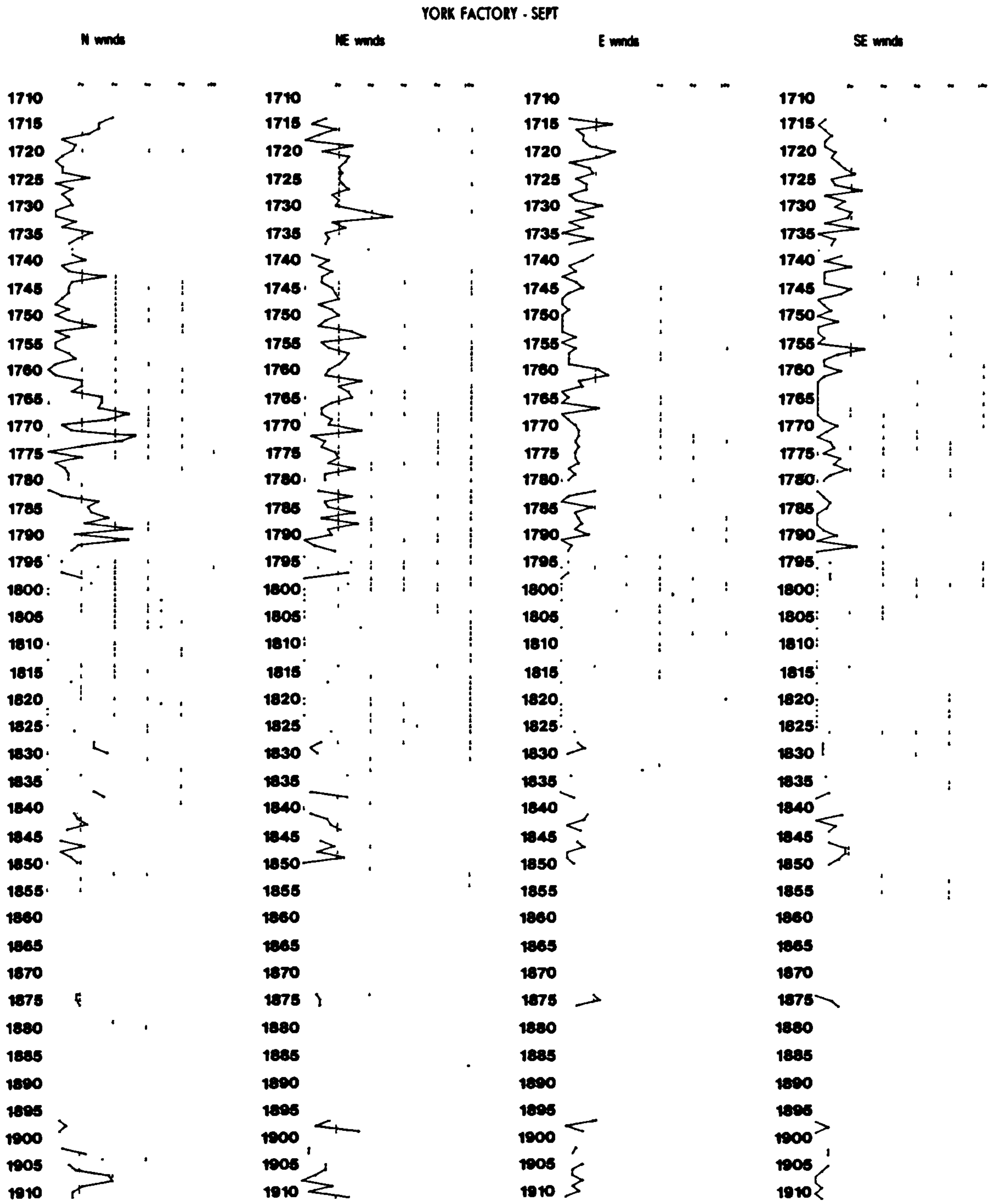


Figure 89: Percentage frequency of winds, York - September

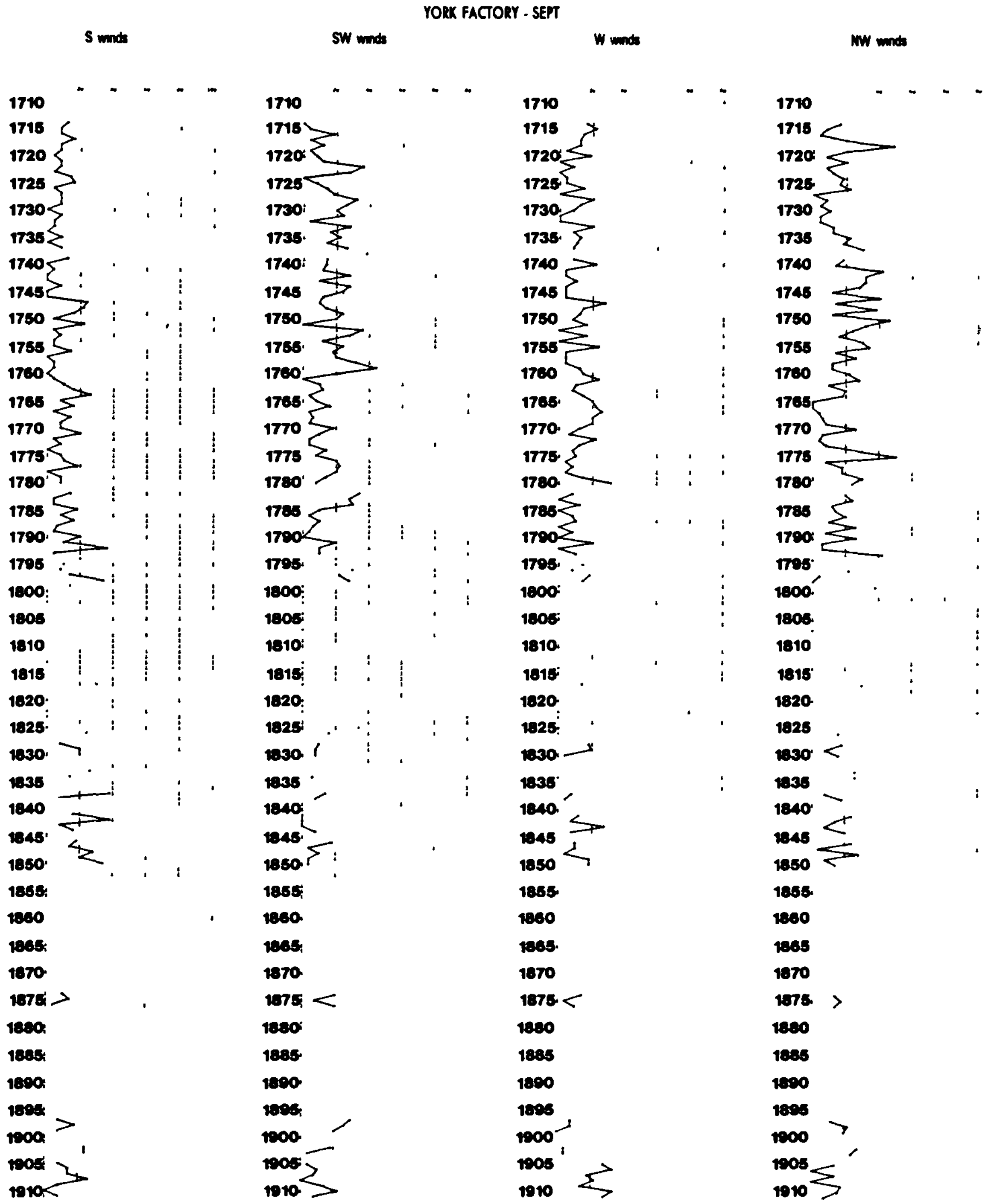


Figure 90: Percentage frequency of winds, York - September

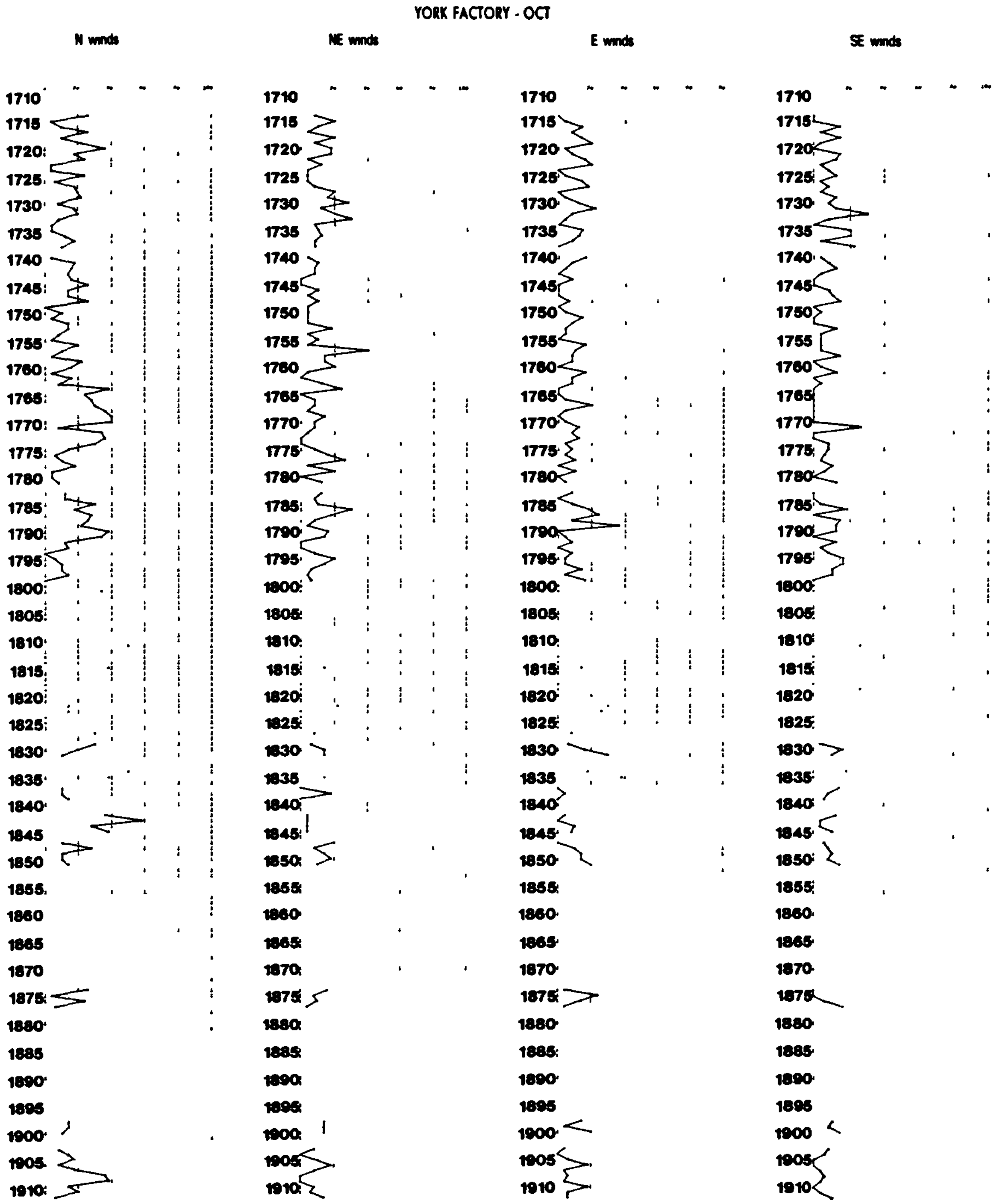


Figure 91: Percentage frequency of winds, York - October

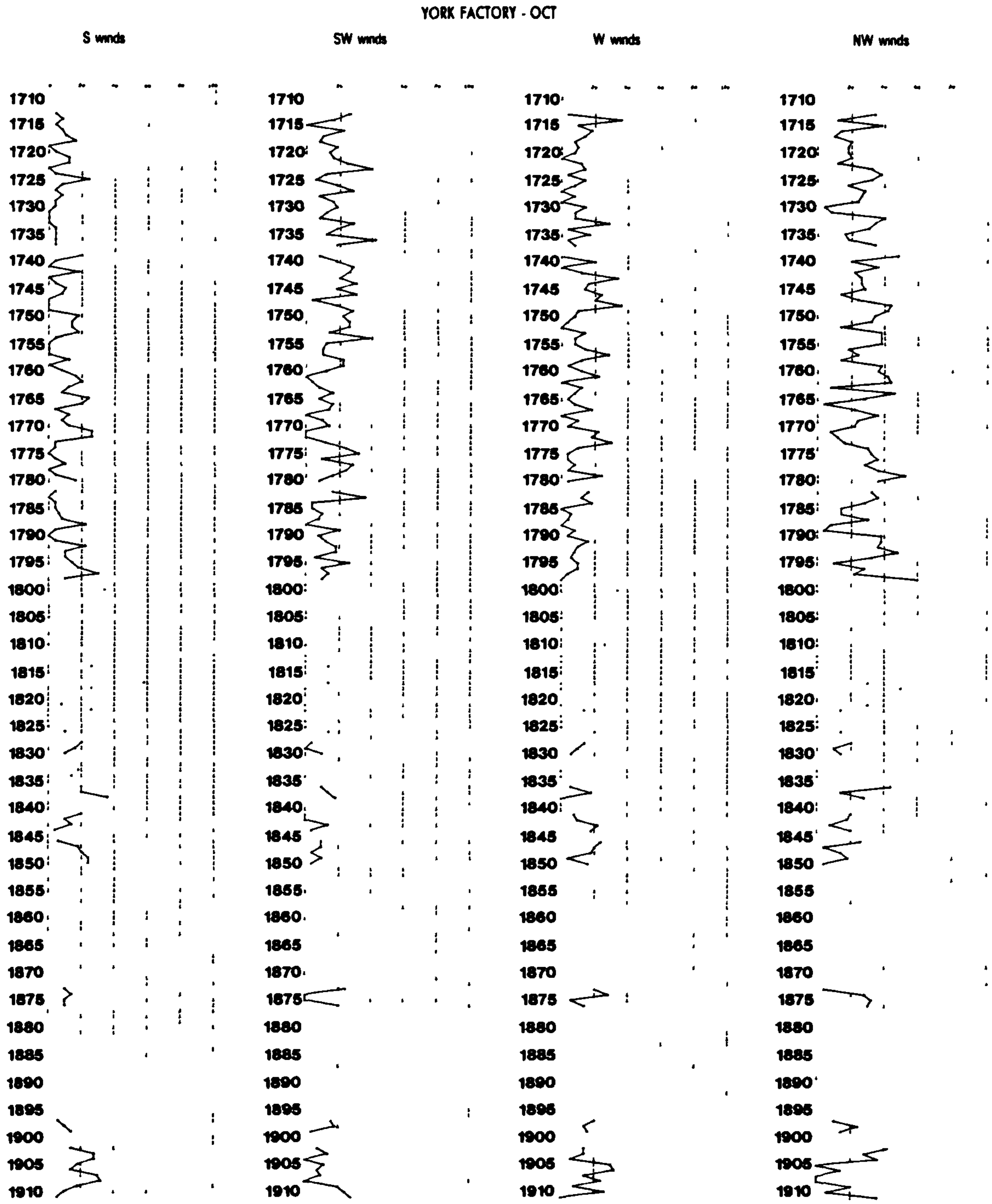


Figure 92: Percentage frequency of winds, York - October

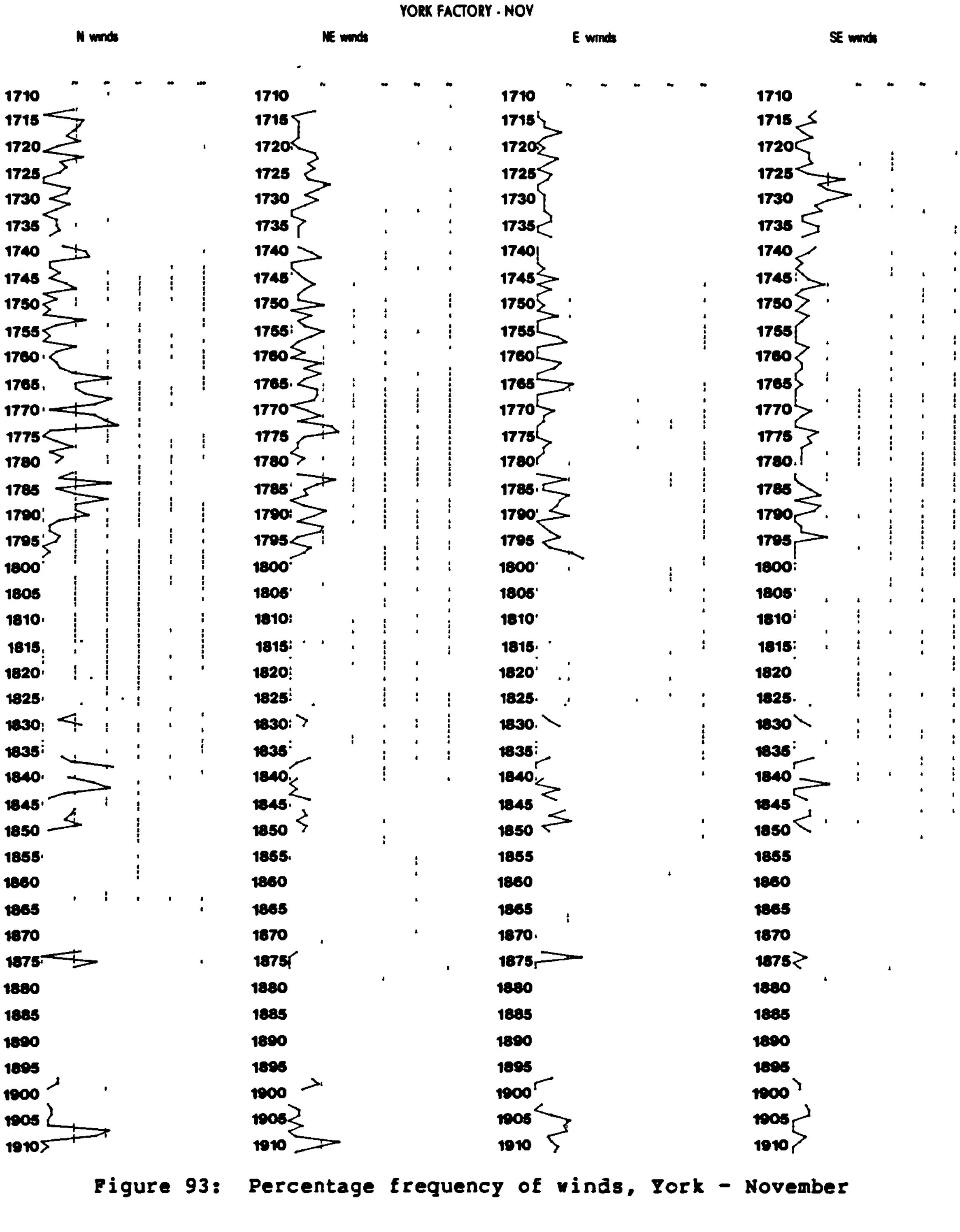


Figure 93: Percentage frequency of winds, York - November

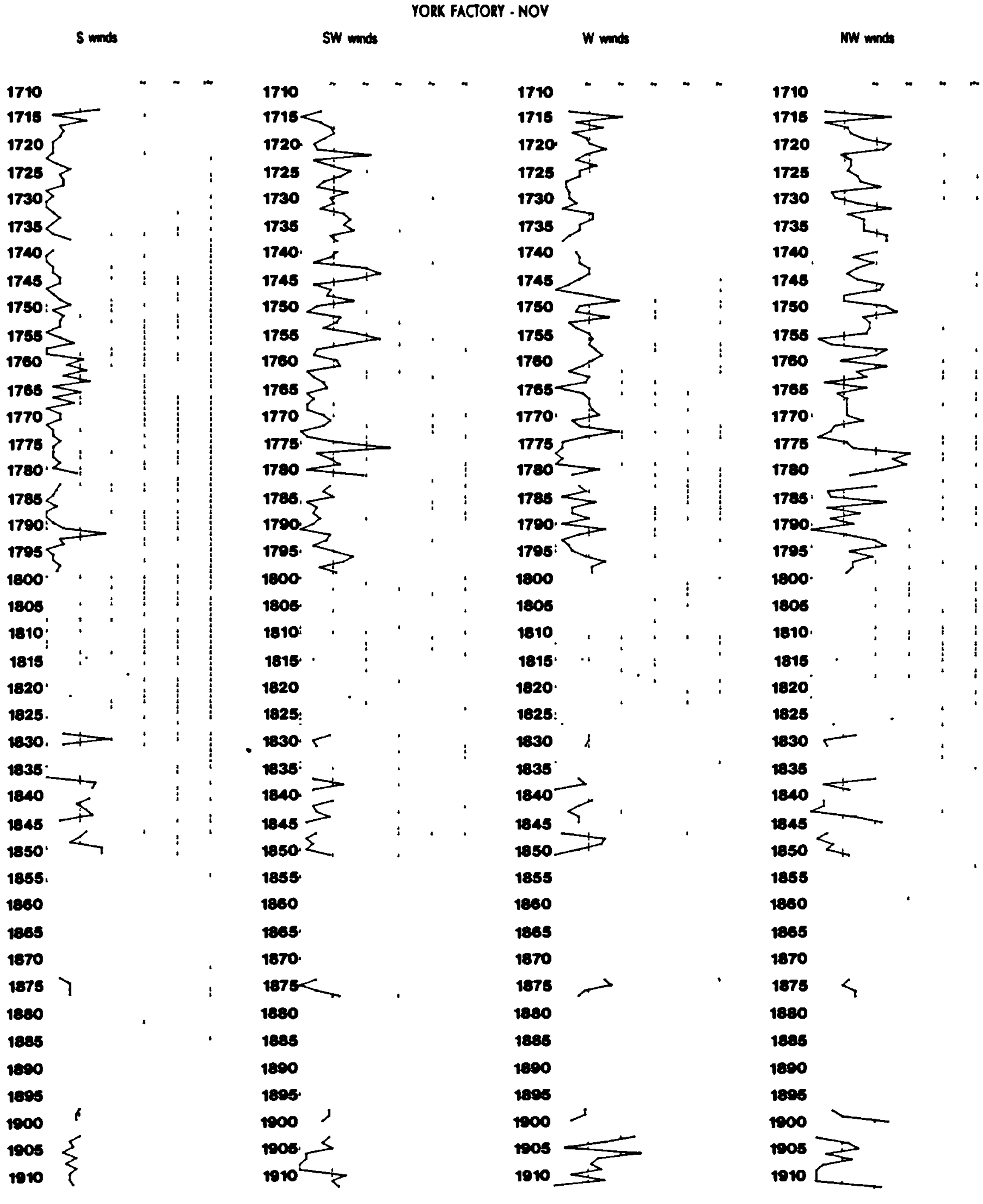


Figure 94: Percentage frequency of winds, York - November

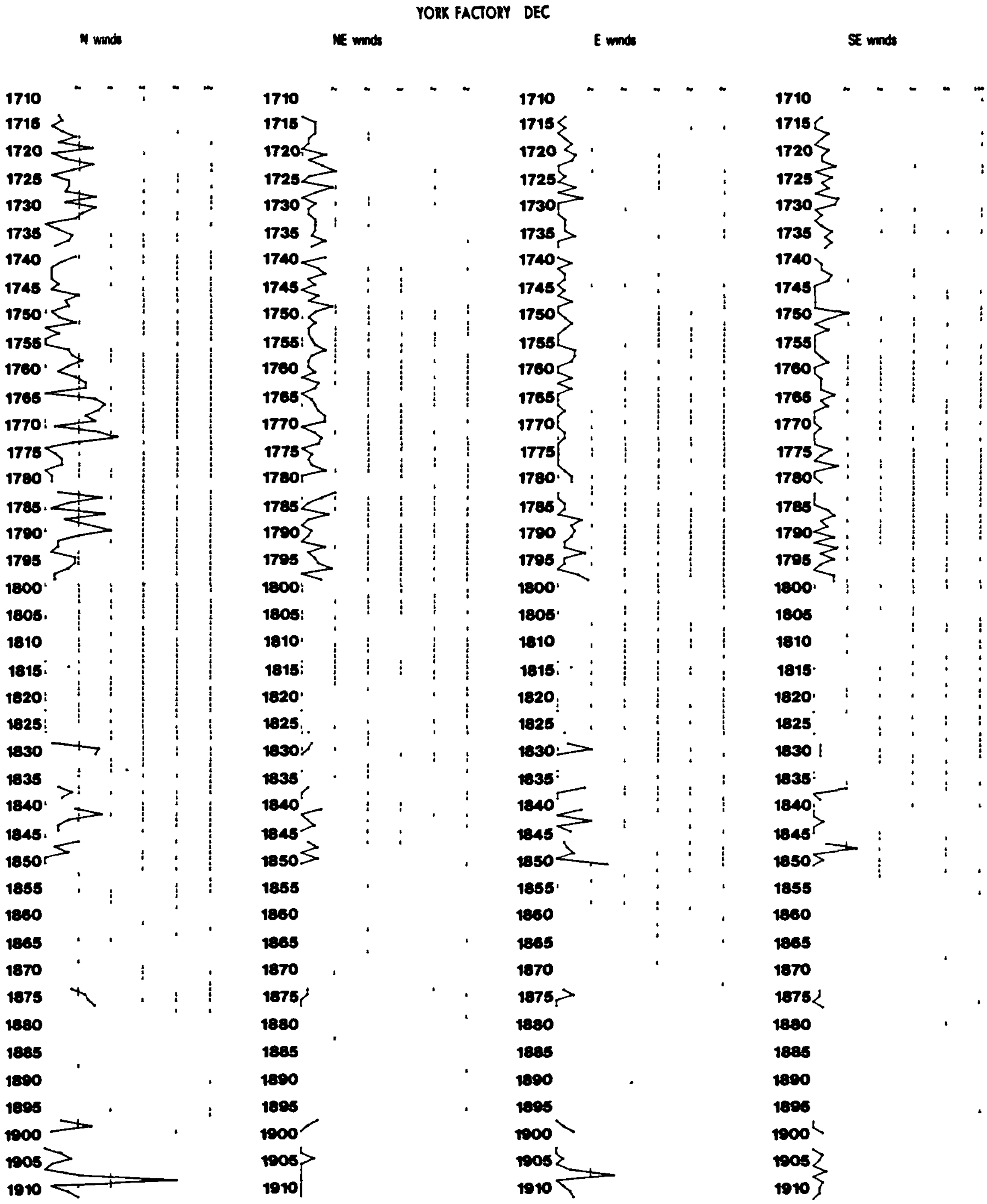


Figure 95: Percentage frequency of winds, York - December

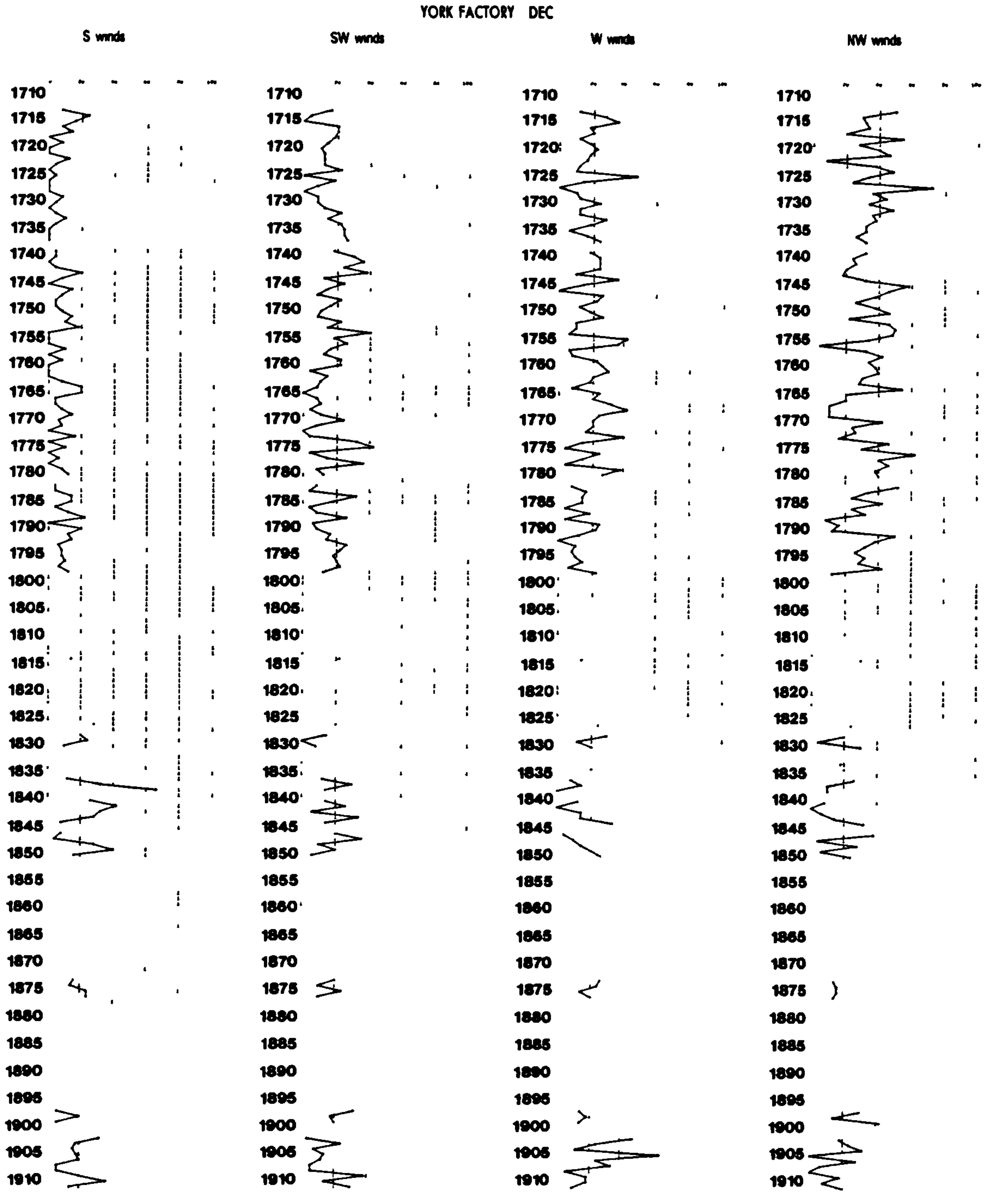


Figure 96: Percentage frequency of winds, York - December

data is to be carried out it would be more accurate to compare modern daytime records as it is assumed that wind directions of the evening are valid only until midnight at which time the subsequent day's winds become valid. It is important to note that there is nothing in the literature that deals with this problem that must have been confronted by other researchers who have used historical weather diaries or instrumental records. Kington (1975a, p. 104) notes that observations were usually made thrice daily at 07h, 14h, and 21h, but on the very next page shows a record kept at Lambhus, Iceland with readings taken twice a day at 06h and 12h.

Generally it would seem reasonable to assume that because the records indicated significant wind shifts during normal waking hours the record effectively covers at least 16 to 18 of the 24 hours. Also, as there was a watch maintained through the night dramatic weather events were observed and noted in the journal entry of the subsequent day. Finally because of the size and rate of movement of pressure systems it is unlikely that any significant pressure system could pass the station completely unrecorded in a period of 6 to 8 hours.

Regardless of the type of pressure pattern involved our stations experience wind directions that over the course of the years will reflect changes in their frequency as a function of any variations in global circulations. In this case any attempt at deduction of these variations can only come after the pattern of changes at the local stations have been defined. The previous section on wind examined annual variations in wind direction to determine large scale changes but it is variations in the seasonal patterns that are liable to be more sensitive and more significant in detecting changes of shorter time periods and lower amplitudes.

It was mentionned previously that the lengths of seasons in this region of the world are better defined as a function of climatological factors rather than by the traditional use of critical points in the earth's annual orbit around the sun, which are suitable at lower latitudes but due to the delay in the heating and cooling of the atmosphere have diminished relevance as one moves towards the poles. Winter has already been defined as the period from November to April inclusive when snow is almost always on the ground. The other three seasons are more difficult to delineate as there are no physical evidences as there are in winter. Probably the safest approach, particularly for studying changes in seasonal wind patterns is to identify the stormy transitional months of May and June as spring and September and October as autumn. This leaves July and August as the summer months, which is appropriate because they are the only two months at either location that are almost completely without recorded snow. There are one or two years of recorded snow in July at Churchill but August is without recorded snow at either site for the period of record, and in the modern record for that matter.

The following analysis uses these seasonal groupings as a basis for examining the shifts in monthly wind patterns for eight points of the compass.

6.3.24 Winter. (November to April inclusive)

A comparison of the percentage frequency of north winds at York Factory and Churchill for the month of November (Figures 71 and 95) shows two distictly different patterns. At Churchill the frequency is high at the beginning but shows a dramatic decrease that can be pinpointed to the year 1762 when the reading was zero. York Factory shows exactly the opposite with the percentages being low up until 1761 after which they increase. South winds also show a gradual decline in percentage frequency although no clear cut date can be assigned. At Churchill the decline in north and south winds is offset by increases in northwest, west and southwest winds. At York Factory south winds show an increase with 1760 appearing to be the point of change. The increase in north and south winds over the period of record is offset by a decline in southwest, west and northwest winds.

Although these trends have been described for the month of November they apply to every month from November through April at both York Factory and Churchill. It would appear, at least in the period from 1715 to 1800 that major changes occurred. The changes which occurred at both stations resulted in different wind direction percentage frequencies being affected. Those changes can possibly be attributed to two factors, the first being that the mean position of the Arctic Front moved from a position to the south of York Factory to lie between the two stations. This possibly resulted in the frequency of cyclonic systems associated with the Front taking different tracks and thus changing the pattern of winds. Very basically one can see that if a cyclonic system passes to the north of a station in the northern hemisphere its sequence of winds will be southerly, westerly and then northerly component winds. If the cyclone passes to the south the sequence is southerly, easterly and finally northerly thus on an eight point compass different winds and different frequency percentages of wind would be observed.

6.3.25 Autumn. (September and October)

Although these months have been placed together to represent a transitional season, and the modern record tends to support this decision, the historic record seems to suggest that a change occurs. (IFigures 65, 66, 67, 68, 89, 90, 91, 92). During the early part of the period under study the month of September shows wind direction percentage frequencies that are similar to those of the summer months, in the later portion it is similar to the patterns of October.

At Churchill in September north winds fluctuate in frequency but over the period from 1715 to 1800 show a gradual decline. In October the change is much more dramatic with the percentage frequency of north winds showing a dramatic decline from approximatetly 20% before 1761 to less than 10% after. Both September and October show an increase of northwest winds over the same period.

York Factory records for September appear to show less dramatic changes, although north and northwest winds gradually increase while southwest and east winds show very gradual decreases. Less obvious, but possibly of equal significance, is a very gradual increase in south winds, that is marked by a noticeable change in 1748 after which the percentage is higher than for the years prior to that date. A similar pattern for south winds occurs in October, but southwest winds show a slight decrease after 1760. North and northwest winds also show a gradual increase.

6.3.26 Spring. (May and June)

Once again north winds show changes.(Figures 57, 58, 59, 60, 81, 82, 83, 84). At Churchill there is a gradual decrease of north winds in May and June, however in June the overall percentage is slightly lower. At York Factory north winds show a very slight increase for both months. Northwest winds also show a very slight increase at Churchill however the overall percentage is lower than for other months of the year.

Unlike other months of the year neither station has one wind direction that is dominant for either May or June. East winds, although not dominant do show an interesting pattern. During May at Churchill east winds show a gradual decline over the period of record, while in June the percentage frequency increases to 1755 it then levels off until 1770 after which it declines. York Factory shows a very different pattern. In May east winds show no change in frequency, while in June they are above average until 1753 after which they return to a normal frequency.

6.3.27 Summer. (July and August)

Northerly component winds are at a minimum in July at Churchill as would be expected in the summer.(Figures 61, 62, 63, 64, 85, 85, 86, 87, 88). The northeast and east winds are the only two that show distinct variations in their patterns. It appears that shifts in the frequency percentage of these two directions are complimentary, that is as the percentage of east winds increases the northeast winds decrease. From 1719 to 1760 northeast winds decrease in frequency while east winds increase. After 1760 east and northeast winds are approximately the same frequency percentage.

August at Churchill has no dominant wind direction and although easterly winds show a very gradual increase to 1759 followed by a gradual decline to 1795 there are no dramatic changes. Again there are complementary changes in winds from adjoining quadrants; as north winds show a slight decrease northwest winds show a slight increase between 1719 and 1795. Similarly south winds have a higher frequency between 1719 and 1756 and lower frequency from 1756 to 1795, while southwest winds are lower in frequency for the former period and higher for the latter.

At York Factory in July there are some interesting patterns that do not reflect the changes seen at Churchill. East winds are a good example because at York Factory they show a decline in frequency from 1715 to 1756 and then a gradual increase to 1800, the opposite of the sequence at Churchill. North winds show an increase from 1760 to 1776 but it is northeast winds that show the great variations.

Overall there is a large swing in the percentage frequency from year to year with a peak of over 75% in 1758 and a nadir of about 5% in 1770. Figure 62 appears to show no increase in frequency from 1715 to 1739, after which there is a fairly rapid increase to a peak in 1758. After that year the frequency drops dramatically and then remains relatively constant to the end of the record.

Northeast winds in August again have the highest percentage frequency overall but do not show the amplitude variations seen in July. None of the directions show any great variations in frequency possibly because there is no dominant direction.

It is necessary to mention one small variation in the percentage frequency of east winds at York Factory for the month of August. In 1715 the percentage is approximately 20% however this gradually declines until 1736 when the percentage is less than 10%. It never rises above that level for the balance of the record. This type of shift has been labelled a gradual change in this broad analysis, which makes no attempt to imply significance, however it is possible that it represents a relatively significant change in the circulation patterns influencing the location.

6.4 GENERAL SYNOPSIS OF WIND DIRECTIONS

Even with this broad analysis of changes in percentage frequencies it is difficult to determine any correlated or broad scale changes between the two sites, but some patterns can be noted.

1. Seasonal patterns compatible with those delineated by the modern record are visible.
2. Changes that occur at Churchill do not always occur at York Factory, in many instances the inverse occurs. For example while southwest winds show a decrease in frequency after 1761 at York Factory for September they show an increase at Churchill over the same period.
3. There are two types of change occurring, one being variations in the annual amplitude of frequencies which change from month to month. Compare north winds at Churchill for the months of July and August (Figures 62 and 63). These annual amplitudes also vary for one direction in one month over the period of record, as can be seen with northwest winds during the month of September at Churchill.

   The other type of change being those discussed for each season where the percentage frequencies either increase or decrease over short (20-30 years), medium (30-50 years), and long (50 or longer) periods.
4. In several of the records a change in percentage frequencies seems to occur around 1761. That is, this year seems to be a point of major change in the overall record.
5. Changes that occur in one of the percentage frequency of direction of wind is usually reflected by a change in the percentage frequency of a neighbouring quadrant. For example at Churchill in July when northeast winds decrease east winds increase and vice ver-

sa. This shift between northeast and east quadrants rather than between east and northeast quadrants is important, because it indicates whether the overall pattern is veering or backing. This might serve to indicate exactly how the general circulation is changing. It is also important to note that a shift from one quadrant to another represents a change of a full 45 degrees in the wind directions which is a dramatic shift, but this will require further study with a new methodology. This comment refers to the fact that virtually all wind techniques require direction and speed and use a vector approach. Unfortunately very few historical climate records include wind speed.

Despite the general similarity between prevalent monthly wind directions of the modern record and those presented here, there are sufficient differences that appear to indicate shifts in the general circulation patterns.

It is beyond the scope of this study to provide any detailed analysis of the monthly wind direction percentages. There do appear to be some trends visually apparent, however these would require confirmation. The reader is referred to the year by year analysis in Appendix 1 in which the significant changes in annual percentages are presented.

This study does not intend to provide a more detailed analysis of the synoptic patterns along the southern shores of Hudson Bay. There are several reasons for this omission not the least of which is the complete lack of any detailed analysis of modern synoptic patterns for this region. Peripheral studies are available some of which have been discussed in the section reviewing previous literature. Ironically there have been quite extensive studies done of the Arctic Islands and particularly Baffin Island, for example the work's of Locke and Locke(1977); Barry, Bradley, and Jacobs (1975); Brinkmann and Barry(1972); and Alt (1978) to name a few. These have evolved because of the availability of brief but detailed modern records. In contrast the shoreline of Hudson Bay has few recording stations, while the Bay itself has no weather vessels or even remote recording stations. Hopefully this work will lead to an intensification of effort to establish a network of recording stations to fill the void in this critical region.

The lack of synoptic information forces the adoption of the studies of Minns (1970) in conjunction with the peripheral works listed above. Minns' work is based on the air mass and frontal climatology of Bryson which evolves from air mass trajectories and presences as a function of temperature. The contention is that it is possible to estimate the probability of the presence of an air mass type at a given location given a particular temperature. This temperature is seen as conditionally dependent upon the wind, precipitation and cloud conditions and therefore itself can be estimated by knowledge of these meteorological elements. Using these probabilities a stochastic model was created that reached the conclusion that a weakened westerly vortex led to an increased intrusion of Arctic air during the nineteenth century.

> Consider the example of Arctic air and the north wind. An increase in the frequency of Arctic air would presumably represent an increase in frequency of the north wind-there appears to be no reason to suppose that the degree of association between the north wind and Arctic air should alter radically without some sort of catastrophic alteration in the major determinants of the atmospheric circulation,...
>
> (Minns, 1970, p. 27)

Certainly north winds experienced along the southern shores of Hudson Bay would be bringing air from Arctic latitudes and most probably this would result in cooler conditions than exist with winds from other directions. The difficulty is that north winds can be the result of a variety of pressure patterns, each of which can result from varying atmospheric conditions.

Barry et al. (1975) identified twelve synoptic conditions as they affected different regions of the Arctic Archipelago and central Canada. The diagrams they present clearly show that northerly component winds occur under several of these situations in the southern Hudson Bay region.

A similar attempt at synopsis was carried out by Alt for the same region although only for the months of June through August (Alt, 1978, p. 65). Considering the more detailed nature of the Alt study the degree of agreement is encouraging. It is surprising however that the Alt paper makes no reference to the work of Barry et al.

Alt concludes that increased glacier melting (a high negative mass balance) occurs "...when fully developed anti-cyclonic conditions dominate and the warm sector of tracking cyclonic systems intrude as far north as Devon Island" (Alt, 1978, p. 65). Cool conditions and summer snowfall are associated with a dominance of the Baffin Bay cyclone or when tracking cyclonic systems pass through the region.

Barry et al. attribute cooler summers and increased passage of cyclonic systems "...with a westward displacement of the mean 700 mb trough over eastern North America,..."(Barry et al., 1975, p. 89) These results are interestingly linked with the results of Locke and Locke who note that

> The depression of glaciation thresholds and equilibrium- line altitudes of about 400 m along the coast of Baffin Bay may indicate increased precipitation during the Little Ice Age due to an increase in the frequency of low pressure centered over Davis Strait and Baffin Bay.
> (Locke and Locke, 1977, p. 299)

Extrapolating from the maps presented by Brinkmann and Barry to the precipitation patterns associated with various locations of the 700 mb trough yields the following pattern for our locations at York Factory and Churchill.

Location of 700 mb Trough.	Precipitation
Winter:	
1. Westward in winter, Shallower trough	Normal precipitation
2. Westward in winter Normal trough	Below normal precipitation Low temperatures over western Canada
3. Eastward location of trough (Labrador-Ungava)	Well above normal precipitation
Deeper than normal	Warmer temperature in western Canada

Summer:

4. Deep trough: over eastern Hudson Bay	Normal to low precipitation
5. Westward location	Normal to low precipitation
Normal trough	Temperatures slightly below average
6. Eastward location (Labrador-Ungava)	Normal to low precipitation
Deeper than normal	

The westward shift of the 700 mb trough is associated with a shorter wavelength of the stationary long-wave pattern that may result in a low zonal index and associated meridional conditions. Conversely an eastward shift may result in a longer wavelength, high zonal index, and more latitudinal flow.

Dey (1973) examined a different region, the Canadian prairies, and for a different reason, to determine the synoptic conditions that occur during summer dry spells. His results represent another peripheral example that contribute to the lack of synoptic analysis in the southern Hudson Bay region. He concludes that,

> "...there was a general eastward migration of all pressure systems and that the north Pacific high and the north Atlantic high tended to extend north eastward from their normal positions, whereas the Hudson Bay low moved southeastward during dry spells.
>
> (Dey, 1973, p. 169)

At the 700 mb level he observed an eastward displacement of the high pressure ridge that formed on the lee side of the

Rocky Mountains. This would probably result in an eastward displacement of the 700 mb trough that normally is located in eastern North America. Putting the two studies together brings the common denominator that eastward movement of the north Pacific high and eastward movement of the 700 mb trough of eastern North America result in below normal precipitation in prairie Canada and above average precipitation in the southern region of Hudson Bay. The cause of this increased precipitation would seem to be the location of the Rossby waves in a low zonal index, meridional flow, thus increasing the frequency of cyclonic systems tracking through the western and southern portion of Hudson Bay.

There has been considerable debate over the date that most accurately determines the end of the Little Ice Age. The most popular dates are as Lamb (1977, p. 463) points out, 1700, 1850, and 1900. Obviously it is not logical to assume that any one year can be selected as the most critical. Lamb has suggested that all can agree on the main phase spanning from 1550 to 1700. This epoch was followed by distinct periods of glacial advance that Lamb attributes to increased precipitation rather than cooler temperatures that were evident during the main phase.

One of the main arguments put forward to define the onset of the main phase of the Little Ice Age comes from the meteorological diaries of Tycho Brahe which showed different percentage frequencies for various wind directions when compared with those of the twentieth century. This study attempts to detect similar shifts in percentage frequency of wind directions as indicators of changes in the general circulation. If these shifts can be determined to be more latitudinal or more meridional it would be of some significance; however, a correlation with variations in precipitation would be of even more value.

This section will attempt to compare some of the general patterns of weather events discovered in this study with those occurring in Europe. Manley comments that climatic fluctuations "...should not be expected to occur at the same time or with the same intensity in all longitudes in either the North American or the Eurasian continent, even in those critical latitudes from 45 degrees north to 60 degrees north in which such changes may have their maximum effect" (Manley, 1974, p. 173). However in discussing climatic changes in England as a function of its location Lamb writes "It is not contradicted by the observation that the cooling of climates setting in after the 1940s took effect almost a decade sooner in the Arctic - and in tongues extending from the Arctic towards the heart of the northern continents - than it did in much of Europe and the U.S.A. Its amplitude was also much greater in the Arctic and in northern parts of the continental interiors than elsewhere." (Lamb, 1977, p. 477). Churchill and York Factory located in the heart of the North American continent and at approximately 56 degrees north latitude are obviously affected by the situations described by Lamb and Manley. The Arctic tongues that Lamb mentions relate to the outbreaks of air associated with continentalism and the southward push of the Arctic Front.

It is difficult to compare regions when there are no specific measurements such as temperature or precipitation. As a result some of the methods used to analyse climate change in Europe have been applied to the data. When these comparisons are coupled with general commentary from the diaries it should be possible to see whether changes are similar in time and amplitude.

C. Easton (1928) provided a rating of the winters of western Europe based upon a subjective index value that ranged from warm through very severe. Although Easton examined each century from the first century A.D. to the 19th century only the date that relates to the period of coverage in this study are shown in Table 18. Lamb (1977, p.567) points out that although Easton's data have been superceded the extreme years, those that are exceptionally warm or cold, will remain valid in any system of classification because they are so different. The subjective classification that Easton used is placed in brackets opposite the year.

Easton identified the year by the January in which the winter fell, therefore using the same approach, a classification of winters was carried out based upon diary comentary and the frequency of reference to extremely cold or extremely mild conditions (Table 19).

The most immediate thing to notice when Tables 18 and 19 are compared is that there are no years in which either mild or cold winters in North America are matched by those in western Europe. Ironically the year 1716 was very mild at both North American stations, Easton lists it as a severe winter. Similarly 1838 was recorded as a mild winter at York Factory but severe in western Europe.

TABLE 18

Subjective Rating of Winters in Western Europe

Mildest Winters	Coldest Winters	
1717 (Warm)	1716 (Severe)	1729 (Severe)
1725 (Warm)	1740 (Very Severe)	1742 (Severe)
1764 (Mild)	1757 (Severe)	1763 (Severe)
1796 (Warm)	1784 (Very Severe)	1789 (Very Severe)
1807 (Warm)	1795 (Very Severe)	1799 (Severe)
1822 (Warm)	1823 (Severe)	1830 (Very Severe)
1834 (Extremely Warm)	1838 (Severe)	1841 (Severe)
1846 (Warm)	1845 (Severe)	--------

TABLE 19

Subjective Rating of the Winters at York and Churchill

Mild Winters		Cold Winters	
York Factory	Churchill	York Factory	Churchill
1716	1716	----	1733
----	1723	1741	1741
1744	1744	1748	1748
1753	1753	1749	1749
1777	1777	1772	1772
1807	1807	1786	1786
1818	----	1787	1787
1825	1825	1791	1791
1831	----	1792	1792
----	1835	1793	1793
1838	----	1796	1796
1849	----	1799	1799
1850	----	1801	1801
		----	1803
		----	1804
		1805	1805
		1806	1806
		1822	1822
		----	1826
		1839	----

There does not appear to be any delay factor as Lamb suggested between the onset of very severe winters at the study sites and the general region of western Europe. In fact it does not appear that there is any connection between singular years in either region whether it is a warm or a cold winter.

Features that do seem worthy of note are as follows.

1. The decade of the 1790s was apparently the most extreme at both York Factory and Churchill.
2. The period from 1786 to 1806 appears to have been extremely cold except for one or two intervening normal years.
3. A similar period from 1784 to 1795 seems to have occurred in western Europe.
4. After 1807 the number of mild years seems to increase at York Factory while they decline at Churchill.

The daily journals support the general conclusion of extremely bad weather between 1786 and 1806 as there are constant references to extremely unusual conditions.

The comments relate to a wide range of situations which include very cold temperatures and distinct shortages of snow all of which lead to a lack of game for food. The natives suffered from shortages of food and Joseph Colen makes many references to their hardships while Colen's men themselves suffered from scurvy. There is an irony that there were very few journals maintained from 1800 through 1820 and this is possibly attributable to the extremely poor weather conditions. The comments about conditions during this time are listed in Appendix A.

A failure to find correlations between individual years between two regions so far apart is not surprising. Some years, such as 1816, in which universal or hemispheric effects of a catastrophic event might create a cold winter or summer over widely separated regions are to be expected. Consistent atmospheric and wave patterns that would result in consistent correlation between only two regions would certainly simplify things but it would not appear to be the situation.

It does appear that although single years do not correlate there are periods of a few years or more that do. For example the period from approximately 1780 to 1820 was one of very great extremes, particularly of cold winters both in the southern region of Hudson Bay and western Europe. This correlation can probably be attributed to large scale influences affecting the winter months. For example, a slight reduction in the amount of solar radiation resulting in a more southerly location of the Arctic Front.

Written references to hot and cold summers are far less frequent in the daily journals; in fact there are only 4 comments about exceptionally hot summers, Table 20. The summer of 1781 is unique as it is the only one that is mentionned as being hot at both York Factory and Churchill. Coincidentally 1781 is shown to be hot according to the temperatures for central England calculated by Manley (1974). In this case a hot summer is one in which the mean temperature for June, July and August was 16 degrees Celsius or over. Neither 1768 or 1813, the other two years listed in Table 20 are classified as hot from Manley's data. There are far more cold summers noted than hot ones. All of them are recorded at both Churchill and York Factory up to 1801 after which they are never noted coincidently.

TABLE 20

Subjective Temperature Rating of the Summers at York and Churchill

Hot Summers		Cold Summers	
York Factory	Churchill	York Factory	Churchill
----	1768	1730	1730
1781	1781	1734	1734
----	1813	1759	1759
		1770	1770
		1777	1777
		1778	1778
		1801	1801
		1808	----
			1812
			1823
			1824
			1828
		1842	
		1848	

As was noted earlier the only measure we have of precipitation is the number of precipitation events that occurred and the nature of that event. There are a few references to snowfall depths in the journals, but there are no references to rainfall amounts and as a result it is difficult to make comparisons. A classic approach to the problem has beeen the summer wetness/dryness index. In this technique months that are very dry are assigned a value of zero, normal months a value of one-half and exceptionally wet months a value of one. Lamb (1977, p. 562) presents data of the wetness/dryness index totals for each decade from 1100 A.D. to 1960 observed in England, Germany and Russia. These values were established for 50 degrees North latitude in all three countries from a variety of sources including modern rainfall records. It is not clear exactly how the various sources were interpreted and integrated to achieve the results obtained, a portion of which are shown in Table 21.

TABLE 21

High Summer Wetness/Dryness Index

Decade	Eng	Germ	Russia	Churchill	York
1710-19	10.0	8.5	10.5	-----	----
1720-29	11.5	8.0	13.5	11.0	11.5
1730-39	10.0	10.5	13.5	11.5	10.5
1740-49	7.0	6.5	10.5	11.5	9.5
1750-59	13.5	12.0	10.0	12.0	9.0
1760-69	11.5	12.0	9.0	6.0	8.0
1770-79	11.5	11.0	6.0	11.0	13.0
1780-89	12.0	10.0	10.0	11.0	12.0
1790-99	10.5	12.5	10.0	7.5	14.5
1800-09	10.0	12.0	11.0	----	----
1810-19	10.0	14.5	8.0	----	----
1820-29	12.0	16.5	9.0	----	----
1830-39	11.5	15.5	9.0	9.5	----
1840-49	10.5	14.5	10.0	15.5	----
1850-59	12.5	12.5	10.5	----	----
1860-69	9.0	10.5	10.0	----	----

Europe 50 Degrees North (Lamb, 1977, p. 562-3)

Only the months of July and August were used to determine the values given and therefore these months were used to obtain a wetness/dryness index for Churchill and York Factory. The designation of a particular month as wet, dry or average, was based primarily upon the recorded number of days with precipitation, but this was reinforced with any written comments in the journals. Table 22 also shows the annual and decadal index values obtained for Churchill and York factory. It must be noted that these stations are at 56 degrees North latitude whereas the three European stations are referred to by Lamb (1977, p. 564) as being near to 50 degrees North latitude. The Russian station is at 35 degrees East longitude and probably would reflect a degree of continentality, closer to the two North American stations.

There are two distinctly dry decades at Churchill, the 1760s and the 1790s. At York Factory the 1750s and again the 1760s are the dry decades. The only distinctly wet decade at Churchill during the period of record was the 1840s while at York Factory the 1770s and the 1790s were well above average.

Table 21 shows that approximately the same period of record England was dry in the 1740s; Germany in the 1740s; and Russia in the 1770s. England was wet in the 1750s; Germany in the 1820s and 1830s; and Russia in the 1720s and 1730s.

It does not appear that there are correlations between any of the events in Europe and those in North America. The difference in latitude and continentality might be a reason for the lack of correlation. It was felt that a more likely reason is the fact that August and September tend to be the months of heavier rainfall at York Factory and Churchill and therefore might be a better measure of high summer wetness and dryness. Table 22 shows the indices obtained when August and September values were used for the calculations. As can be seen there are surprisingly few changes thus suggesting that this might not be a factor in the lack of correlation between the two regions.

Temperature Data

The nature of the instrumental temperature data was outlined in Chapter 3, in which it was shown that the most apparent problem was the freezing of mercury at approximately -39 degrees Celsius. For the purposes of this analysis it was assumed that the data was totally acceptable and that any errors would be within tolerable limits. All the evidence is that the thermometers were kept in appropriate shaded external locations; used standard Fahrenheit scale;

TABLE 22

Summer Wetness/Dryness Index for August and September

Decade	York Factory	Churchill
1720-29	10.0	11.0
1730-39	11.5	10.5
1740-49	11.5	9.5
1750-59	11.5	9.0
1760-69	12.0	8.0
1770-79	6.5	13.0
1780-89	9.0	12.0
1790-99	7.5	14.5
1800-09	----	----
1810-19	----	----
1820-29	----	----
1830-39	9.5	----
1840-49	15.0	----

and followed the scientific procedures outlined by the Royal Society. Certainly when compared with the problems Manley (1953) faced in determining the mean temperature of central England, these records are almost comparable to modern records.

The longest period of modern record at Churchill runs from 1953 to 1979. It was decided that although this was an unusual length of time to serve as a base for comparison it was preferable to have as long and continuous a record as possible. A comparison of the range of temperature observations on each day of the year for the historic and modern records are displayed in Figure 97. The highest and lowest reading for each day of the year during the period of record serves to illustrate the variation in the range of temperatures. It is interesting to note that the two records are similar in their pattern adding validity to the historical data. More importantly they both show a wider range in the summer and winter with a definite narrowing in the spring and fall. This is in keeping with the observations of Catchpole (1969) in reference to the Canadian Arctic and sub-Arctic.

> The major minimum of mean TR (daily range of temperature) occurs in autumn or early winter, and the minor minimum occurs in spring. Summer emerges, by inference, as a season of strongly cyclical diurnal temperature variations. Irregular variations appear to predominate in winter.
> (Catchpole, 1969, p. 256)

The autumn and spring minima are attributed to the depressing effects of freeze and thaw, which release and absorb latent heat of fusion. Later in the same paper Catchpole states that "...the net effect of the occurrence of the freeze-thaw process over snow or ice-covered surfaces is the reduction of the daily temperature range" (Catchpole, 1969, p. 266). Longley (1949), in a study of daily regimes at Quebec City, puts an approximate value of 1.1 degrees Celsius reduction in daytime maxima and 0.6 degrees Celsius increase in minima due to freeze-thaw. It would be interesting to see if the absence or presence of snow cover could be detected from temperature data if that event was not recorded. Another point of significance is the relatively small variability of minimum temperatures compared with the greater range maximum temperatures.

The historic record was studied to determine the various combinations of hourly readings that existed because unlike the modern record the sequence of hours on which observations were made could vary from one observer to the next and occasionally from one day to the next. In order to ensure that the average daily temperature calculated from the his-

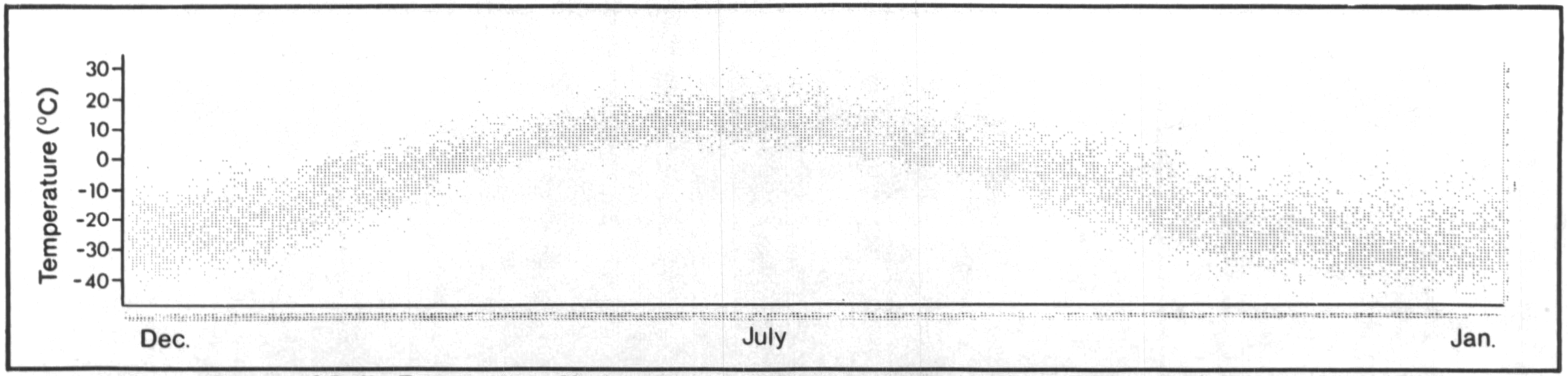


FIGURE 97a **Range of Daily Temperature Observations for the Historic Record at Churchill Factory**

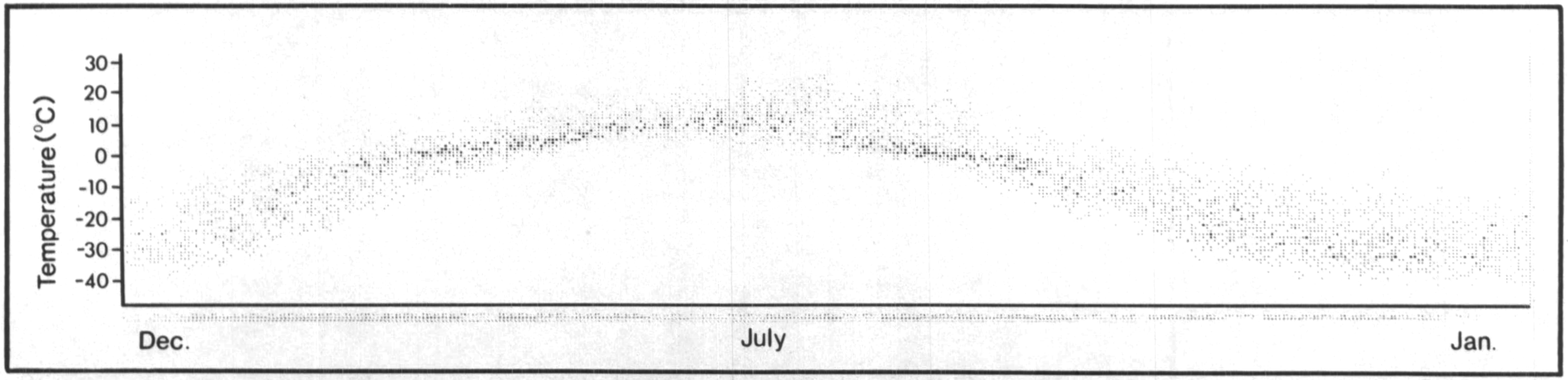


FIGURE 97b **Range of Daily Temperature Observations for the Modern Record at Churchill**

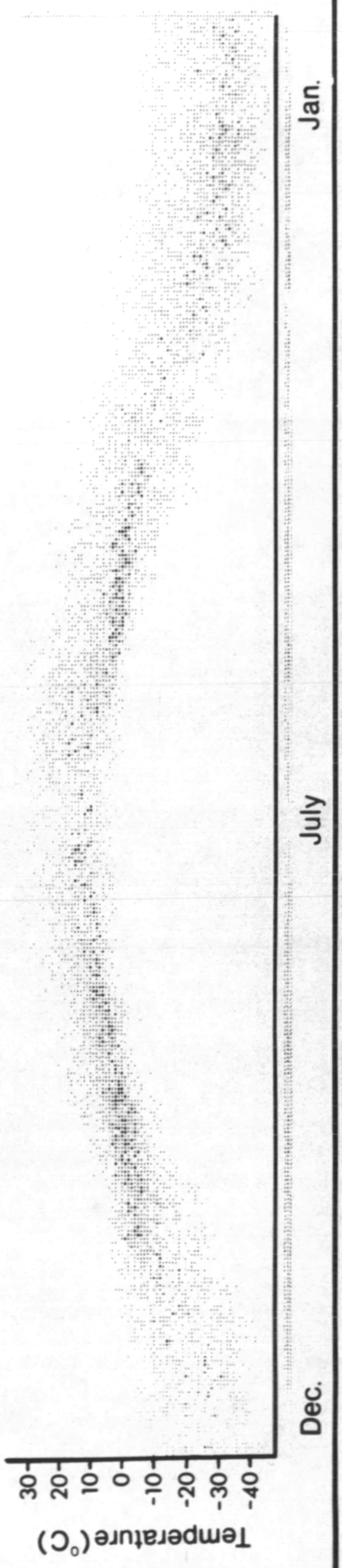


FIGURE 98 Range of Daily Temperature Observations for the Historic Record at York Factory

Figure 98: Range of daily temp. observations, historic, York

toric data would be the best approximation, the following procedure was followed.

From the modern record

$$T = \frac{T_1 + T_2 + \ldots + T_{24}}{24}$$

was computed for all days.

Notation: T = average daily temperature
T_1 = temperature at 0100
T_2 = temperature at 0200
$\ldots T_{24}$ = temperature at 2400

Once the daily averages had been calculated using the 24 hourly readings it was possible to determine what weighting factor would be necessary if less readings were available. Consider for example a day on which three readings were taken, at times a, b, and c.

1) A regression was run on the modern record, using the estimate
$$T' = aT_a + bT_b + cT_c + K$$
This gave the weights a, b, c and the adjustment K

2) The estimate T' was applied to all historic records for which were taken at the times a, b, and c.

This procedure was applied to all different combinations of readings which occurred in the historic record. An exception; readings of unknown time, one per day, were recorded having occurred at 2400 hours, since there were no recorded midnight readings in the historic record. In these cases, the single available reading was taken for T'.

It was assumed that the correction factor calculated from the modern Churchill record would be applicable to the historic record of both Churchill and York Factory. If Catchpole's (1969) observations of the differences between snow covered and snow free surfaces, and the transition time between these conditions is correct then the preceding assumption would appear valid.

Daily temperature time series are a result of the combined influences of seasonality, warm and cold air masses, a day to day persistence effect, and the diurnal temperature ranges. Because of similarities in latitude, low coastal plain location, and extent of snow cover (see Figure 18; Date of First Recorded Snow) these factors tend to be the same at both sites.

Figures 99 and 100 show the plots of monthly mean temperatures for York Factory and Churchill for each of those months when there were sufficient daily readings to make the monthly mean an accurate estimate of the true mean. At Churchill the summer maximum temperatures, usually occurring in July, are very consistent with the modern record. It must be kept in mind that these are monthly means therefore a distinctly cold period of a week or two in duration would not show as being distinctly different from an average value. An example of this type of problem can be seen in the record for the year 1813 when the monthly temperature was recorded as 11.7 degrees Celsius, a journal entry indicates that it was the warmest July for three years and yet this figure is 1.3 degrees Celsius cooler than the modern monthly mean for the period from 1956 to 1972 at the same location.

It appears that the winter temperatures at Churchill for 1768, 1811, and 1812 are well below the winter average temp-

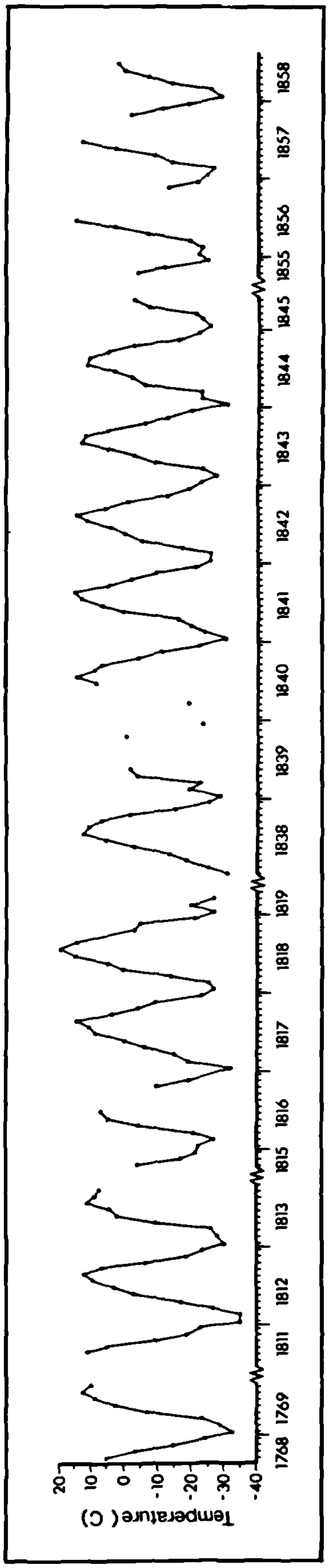


FIGURE 99 Plot of the Monthly Mean Temperatures for Churchill Factory

Figure 99: Plot of monthly mean temperatures for Churchill

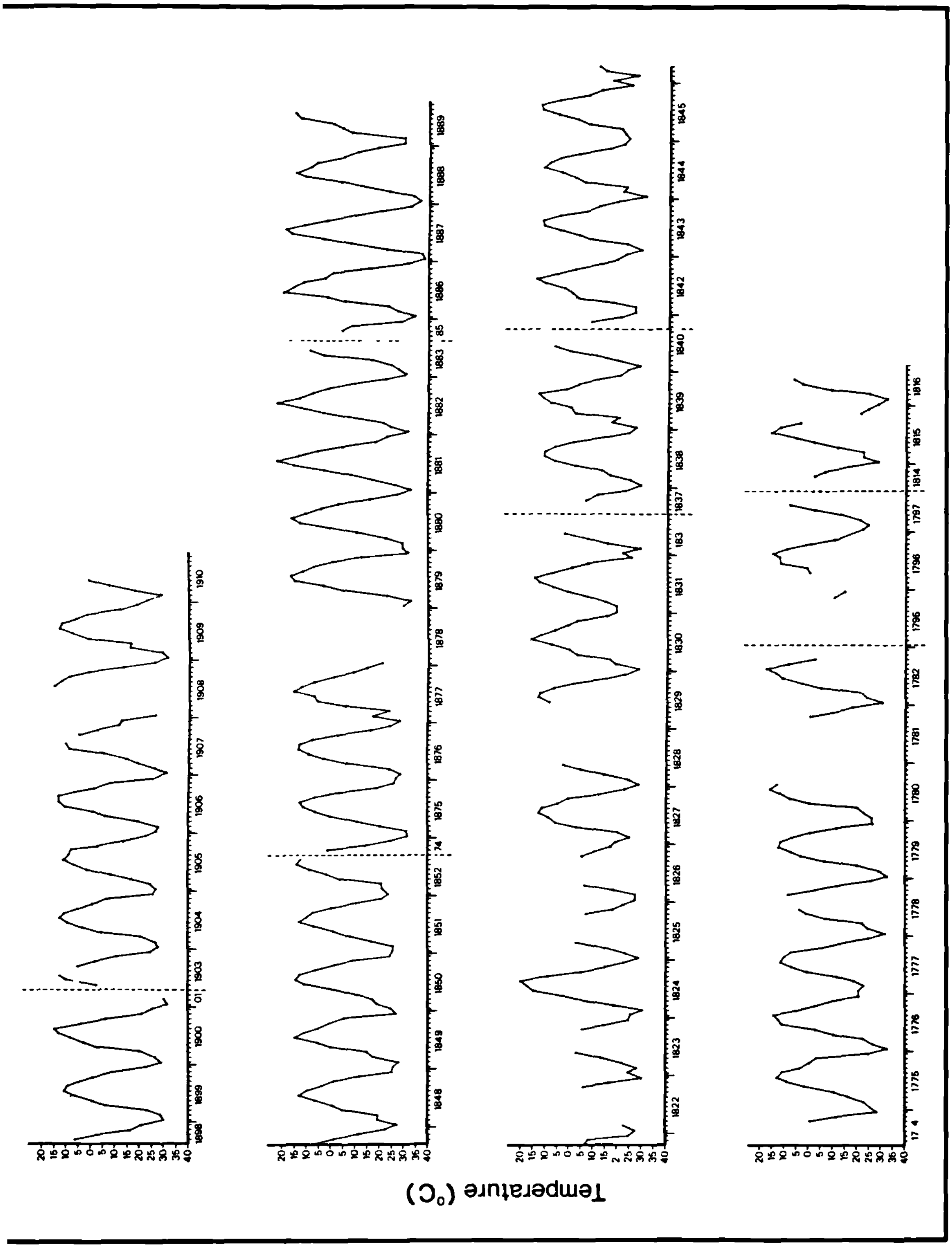


FIGURE 100 Plot of the Monthly Mean Temperatures for York Factory

Figure 100: Plot of monthly mean temperatures for York Factory

eratures of the modern record. Unfortunately this is an insufficient sample to draw any definitive conclusions, but it does seem indicative of the lower temperature one would expect to find at the end of the Little Ice Age. This is reinforced by the fact that the remainder of the records show most winters at or even slightly warmer than the average temperature for January in the modern record. The only exception to this is the January mean temperature in the year 1817 when the average was -30 degrees Celsius (modern Churchill average for January -27.4 degrees Celsius), this might be the result of the decreased temperatures that occurred after the Tambora eruption in 1815, which resulted in the subsequent year of 1816 being referred to as the year with no summer.

Other significant features in the Churchill record include the following (The modern mean, 1953-1979, for Churchill are given in brackets);

1. Written comments in the Churchill journals for 1812 note that there was a late spring, May was cold and July had bad weather.These are supported by the temperature data which show monthly averages of April -17.8 degrees Celsius (-11.9 degrees Celsius), May -3.2 degrees Celsius (-2 degrees Celsius), June 3.0 degrees Celsius (5.8 degrees Celsius) and July 9.7 degrees Celsius (12.6 degrees Celsius).An indication of cool summers during this time period is provided by the comment that July 1813 with a mean temperature of 11.7 degrees Celsius (12.6 degrees Celsius) was the warmest for 3 years.This period will be referred to again in the analysis of the York Factory record.

2. There are no comments about the temperature at Churchill in 1818 but the York journal notes that "November very mild, mildest for 30 years or more".The reading was -4.7 degrees Celsius (-12.4 degrees Celsius).
3. 1841, which is noted in the journal as having the latest spring since 1822, has an April mean of -15.9 degrees Celsius (-11.9 degrees Celsius).
4. June 1842 is commented upon as being cold and is recorded as 4.2 degrees Celsius (5.8 degrees Celsius).
5. As a general observation the summer mean temperatures are quite consistent or the period of record as seen in Figure 99 while the winter temperatures vary considerably.

The York Factory record is much more extensive than that maintained at Churchill Factory because it was the headquarters of Hudson's Bay Company operations on the Bay. The graph for the York Factory data is shown in Figure 100. Because the latitudes and sites of The two Factories are very similar it was decided that it would be reasonable to combine the two graphs as seen in Figure 101. Where there are data avalable at both sites for the same period of time, as in the period between 1840 and 1845, the similarity between the curves is evident. It would seem to indicate the validity of the data and the decision to combine the two records. It has been argued that the stations are on opposite sides of the Arctic Front and therefore one would expect quite different temperatures. In fact the temperatures are different, however they fluctuate in phase.

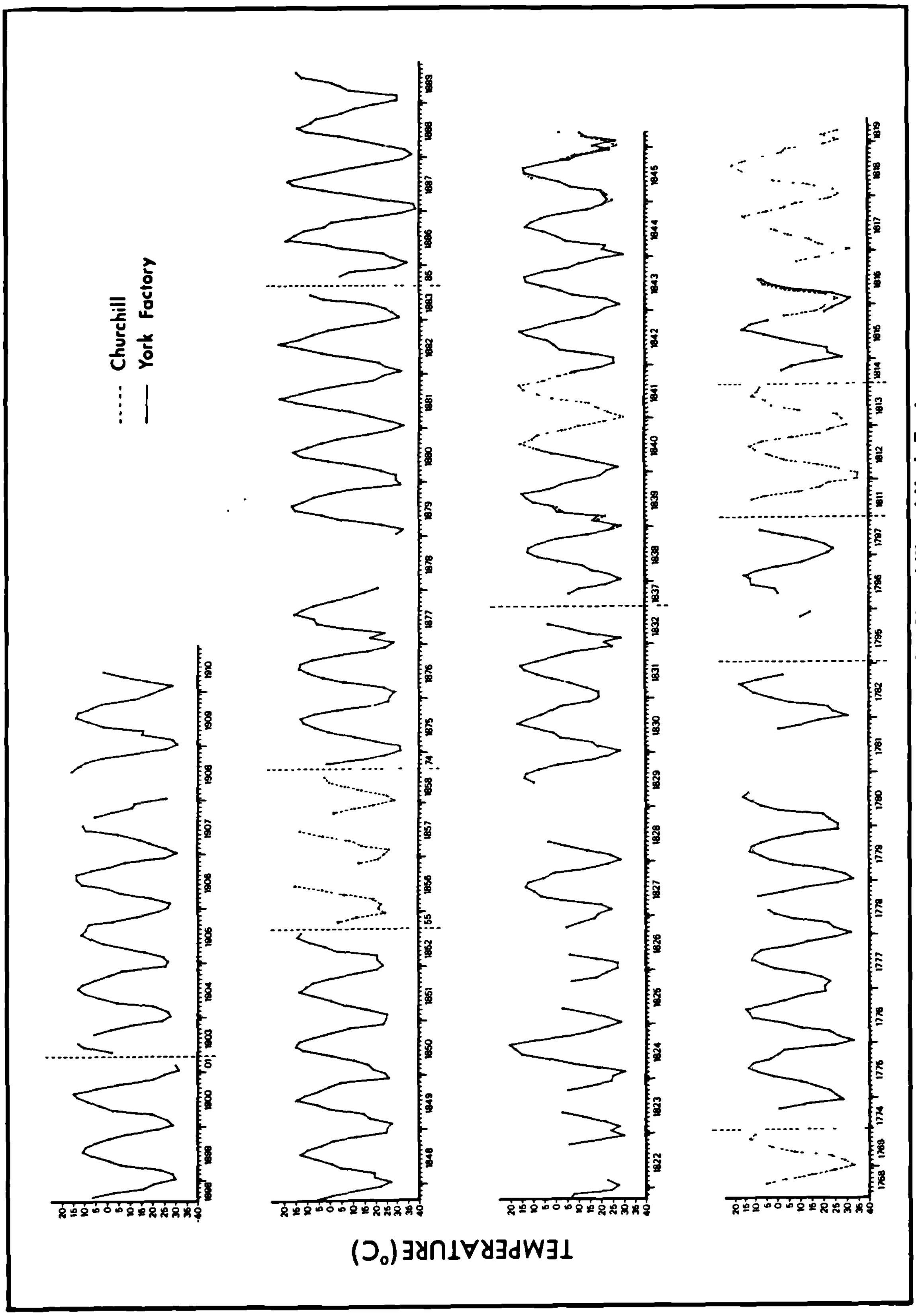


FIGURE 101 Combined Plot of the Monthly Mean Temperature for Churchill and York Factory

Figure 101: Combined plot of monthly mean temps. for both sites

The most notable feature of the York Factory graph is the distinctly larger amplitude of the curves for the decade 1879 to 1889. This period of colder temperatures is coincident with similar colder temperatures being recorded at Winnipeg in southern Manitoba for the same decade. Records were maintained in Winnipeg commencing in 1874. By 1898 the amplitude has decreased and in the period from 1898 through 1909 the curves resemble those for the periods 1775 to 1780 and 1837 to 1852.

Other significant features of the York Factory record are as follows (the modern monthly means for Churchill are shown in brackets);

1. The period from 1775 to 1779 has below average summer temperatures.Other records presented in this thesis show that each of these summers had above average rainfall typified by a journal comment for July 1777 noting the wet July and lousy summer. In the same year the Churchill journals remark on the mild winter and late heavy snowfall, conditions that are confirmed by the monthly means for York Factory which were, November (1776) -10.6 degrees Celsius (-12.4 degrees Celsius), December (1776) -21.2 degrees Celsius (-22.8 degrees Celsius), January (1777) -21 degrees Celsius (-27.4 degrees Celsius), February -22.7 degrees Celsius (-27 degrees Celsius), March -19.4 degrees Celsius (-20 degrees Celsius), April -12.2 degrees Celsius (-11.9 degrees Celsius) and May 0.0 degrees Celsius (-2 degrees Celsius).January and February are considerably above the average a condition

apparently related to the shift in wind patterns, most notably a dramatic decrease in the percentage of north and west winds.

2. The winter of 1797 was warmer than the average but it also had an above average number of days with snowfall, with snow being recorded on 16 days in the month of May.
3. From 1774 onward there are two periods without temperature records, 1783 to 1795 and 1798 to 1821 (except for very short records in 1814 and 1816).The irony of these gaps is that they are possibly due to extremely bad weather which resulted in harsh conditions for man and animal alike so that survival was more important than record keeping.It is also possible that there are some records in private possessions in England, particularly those maintained during the tenure of Joseph Colen who suffered such difficult climatic conditions that there was a dramatic decline in the number of furs taken, while scurvey and illness increased due to lack of game. Comments from the journals of Colen for this period are listed in Appendix C.
4. A written comment for 1825 says that there was rain and it was mild in February, the record indicates the mildness with an average temperature of -23 degrees Celsius (-27 degrees Celsius).
5. 1828 is noted as being mild in May but cold in June at Churchill. The York record has only 6 days of temperatures for June, but May is distinctly above average 2.4 degrees Celsius (-2 degrees Celsius).

6. February 1831 was reported as mild this was probably due to a high percentage of south winds (30%). The mean monthly temperature was -19.5 degrees Celsius (-27 degrees Celsius).

7. June 1842 is mentionned as being very cold in the written record. The measured average was 2.6 degrees Celsius (5.8 degrees Celsius).

8. Written comments for 1849 read " very late Fall.Interior rivers and lakes unfrozen until the 10th of December".The temperature record supports these comments, November average was -5.8 degrees Celsius (-12.4 degrees Celsius).

9. During the period from 1841 to 1852 summer temperatures remained consistent and close to the modern average (July 12.6 degrees Celsius).Winter temperatures show a gradual increase through the same time.

This section has examined one of the earliest and most extensive temperature records in North America and certainly the earliest in Central Canada. The accuracy of the records has been tested and an outline of the significant features provides insight into temperature trends in the latter half of the 18th century, and the 19th century.

Chapter VII

CONCLUSION

Although general attempts have been made to analyse the data presented in this study it is, for the most part, an unabashed attempt to fill a void in the field of descriptive climatological data. Several of the simple analytical techniques have been applied to determine the validity of the collection, coding and retrieval methods as much as for the conclusive results that they might yield.

In spite of these factors some general conclusions can be outlined.

1. The coding and storage method appeared to work well. It proved to be flexible and yet concise and precise. A vast quantity of material, both literary and numerical was included under a singular storage system. Statistical analysis, from the most simple frequency counts to the most complex spectral analysis could be carried out on raw data, modified data, or secondarily generated data. In short the system had all the benefits of computer technology.
2. By being able to cross reference between statistically generated results, such as the number of days of rainfall in the summer, and personal comments of the observer, reflecting on a dry summer it was possible to determine the accuracy of the frequency count. More important it was possible to determine what the

perceptions of the observer were with regard to a dry season. Generally, if there was a paucity of rainfall the observer would comment on the dry season, but this was not always the case. The discrepancies could usually be accounted for by careful examination of the record. It would appear that the observer's judgement is tempered by what affects human activities. For example a dry summer would only be commented upon if it resulted in a large number of forest fires, or low water in the rivers that made canoeing difficult. This does not necessarily mean that the whole summer was dry either as travel on the rivers might be concentrated at the beginning and end of the summer when men moved to the interior for trade and returned with the bounty, also the drought might be restricted to only one portion of the drainage basin of a river with the net result being an overall reduction of flow. This is more easily understood when the extent of the Churchill and Nelson River drainage basins are considered. (Churchill basin 109,100 square miles).

3. The journals have proved to be a reliable source of climatic information. Consistency of the observations and the methods of their notation proved themselves in all of the tests of homogeneity between: individual observers at a single location; observers at two different locations; and observers at two different locations over time.

This homogeneity existed in the comparison of the records of both stations thus allowing for valid statements to be made about the changes that are determined. It would appear that there is no evidence of local changes despite the relocation of the Factories at both York and Churchill.

In order to verify the data and the method several analytical techniques were used.

a) Phenological indicators.

b) Measures of frequencies or intensities of occurrence.

c) Spectral analysis

d) Correlation between biological events and climatic factors.

4. It is ironic that one of the conclusions resulting from this study is in apparent contradiction of one of the original assumptions. An assumption was made that the two stations chosen for comparison were close enough to justify claims for homogeneity of the records. This proved to be the case, however, it also has become apparent that the two stations are very different with regard to the climatic regimes that they occupy. Although this appears to be a situation where the hypothesis and the null hypothesis are both being deemed acceptable, in fact they reflect the nature of the regional climates and climatic change. The general similarity between the curves and the climatic events at the two stations are a reflection of the larger scale fluctuations of

climate modified by small scale local conditions, but in the longer time scale and slower response time of vegetation we see that distinctly different regimes are created. Bryson's (1966) contention that the Boreal forest/Tundra division occurs between the two stations seems to be supported. Bryson assumed that the northern and southern limits of the Boreal forest are a reflection of air mass and frontal zone locations. For this to be true the relationship between air mass characteristics and the flora must remain constant. This concept suggests that past locations of frontal zones and frequency of influence of air masses could be determined from pollen data. The difficulty is that the line separating the tundra region from the Boreal forest represents a vegetational response to climatic conditions, and as such would be unlikely to reflect changes of climate within the time frame of this study. The record as presented in this study seems to suggest that the mean summer location of the Arctic Front moves south of York Factory for considerable periods of time but rarely moves north of Churchill. It bears out the original contention that these stations serve as excellent indicators of the annual positions and migrations of the Arctic Front.

Additional information obtained by the study suggests that, as would be expected, there is a correlation between the various positions of the 700mb trough and seasonal conditions in the southwest side of Hudson Bay. Although not examined as part of this study it would appear that analysis of changes from zonal to meridional flow would yield valuable information about surface and subsequently upper air flow over the period of record. This need for further study is strongly supported by the fluctuations evident in the graphs of the percentage of monthly wind directions at the two sites.

The period from 1755 to 1765 appears to suggest that a major change in climatic conditions occurred. Evidence of this change is seen in a variety of factors presented in graph form such as; the number of days with heavy or continuous rainfall (Fig. 44); first days of thaw after March 1 (Fig.19); and the percentage frequency of north winds. Obviously meteorological dynamics dictate that there should be a correlation between these events. The fact that the graphs indicate this change lends credence to the accuracy of the observations and the viability of the method.

Where does this change fit into a general picture of climatic patterns and events established in other parts of the northern hemisphere? As was seen in the section that compared some of the patterns of climate observed in central Canada with patterns established in Europe there did not appear to be any similartities between the two regions, at least as far as the short term or local region dynamics are concerned. The change in the pattern between the stations is probably connected with a significant shift in the general circulation that has caused York Factory to change from a Tundra type climate to a Boreal forest climate. The relationship between the sunspot cycle and shifts in the general circulation of the middle latitudes have been written about by several authors, the most recent being Brown and John (1974).

The Icelandic Low persists year round and generally covers an area which includes Iceland, the southern tip of Greenland with an extension over Baffin Island in the Canadian Arctic. Mitchell (1965) recorded the secular migration of this low pressure centre using data generated by Lamb. Generally it has been shown that the centre of the Icelandic Low tends to lie further east during sunspot maximum in which case the general counterclockwise circulation would create different weather conditions in the Arctic and Sub-Arctic region of central Canada.

In conjunction with this shift, low-pressure storm systems which track along the guidelines established by the circumpolar jet, are altered in the general west to east movement. Helland-Hansen and Nansen (1920) followed by Kullmer (1933) and Brown and John (1974) all suggest that there is a southward shift of the storm tracks over the North Atlantic during high sunspot cycles. A correlation can also be drawn between a deeper and east of normal configuration of the Icelandic low with a high zonal index or latitudinal flow and a strong gradient for westerly winds. A west of normal position for the Icelandic Low is associated with a low zonal index and a meridional flow. Brown and John put a value of 3 degrees further south at sunspot maximum compared to sunspot minimum. When this concept is combined with the argument that the effect of sunspots varies according to the latitude, it is not unreasonable to conclude that the change observed in so many variables in this study in the 1755 to 1765 period is coincident with the end of the Maunder minimum.

Manley comments that "Climatic fluctuations... should not be expected to occur at the same time or with the same intensity in all longitudes, in either the North American or the Eurasian continent, even in those critical latitudes from 45-60 degrees North in which such changes may have their maximum effect" (Manley, 1971, p. 173). The written comments in the journals for the time period up to 1760 at both sites suggest that the weather was extremely variable up to that time with excessive cold periods, excessive warm periods and excessive precipitation being referred to in all seasons. Other evidence of this time being critical in this region is the reference to moraines formed circa A.D. 1750 in West Greenland (Ten Brink and Weidick, 1974, p. 436).

Possibly it might be concluded that in the critical region of 60 degrees North in central Canada the mean summer position of the Arctic Front was further south than at present up until approximately 1760. After that date the Front appears to have resumed a more normal pattern of cyclical movement. Generally cycles have not been sought other than in the cursory examination of the application of a power spectrum analysis to the frequency of precipitation data. Some other trends have been noted that seem to correspond to those detected in other parts of the northern hemisphere, but in most cases these are longer in nature. For example the brief but significant instrumental temperature record indicates that temperatures were cooler in the 1770's than at present but showed gradually warming in the middle of the nineteenth century, but then became very cold in the late nineteenth century. Despite this there are very clear local trends that appear to be responsible for individual months or even years not being comparable to those found in Europe. A good example of this would be the year 1816 which is not noticeably colder than the average as it was at many northern hemisphere locations. This was probably due to an unusual ridge of high pressure that extended from the region of Lake Superior north to central Hudson Bay. Dr. A.J.W. Catchpole (Pers. Comm) in an unpublished paper suggests that this pressure pattern would account for York Factory and Churchill having a moderate summer with above average southerly winds while stations on the southeast side of the Bay had an excess of northerly winds and a very cold summer.

The overall pattern of weather indicated by the records maintained at York Factory and Churchill indicate similar trends to those noted for several other regions of the northern hemisphere but individual years and individual seasons cannot be compared. It would appear that the sites are critically located with regard to changes in the mean summer position of the Arctic Front. With the variations between zonal and meridional flow that are associated with the Front it is not surprising that these stations do not have weather sequences comparable to those of Europe.

The amount of detailed information available from the two stations in the study should provide for extensive and detailed synoptic analysis. Future projects should include most, if not all, of the following:

1. Monthly weather reviews of each station using wind, temperature, barometric pressure, precipitation patterns and any extreme or unusual meteorological events.
2. A classification into weather types based upon the existing types defined by Alt (1978) for Devon Island region, Barry et al. (1975) for Baffin Island and Dey (1973) for the Prairie region of Canada would allow for studies similarly to those carried out by H.H. Lamb (1972a) for the British Isles.
3. By applying the method developed in this study all of the Hudson's Bay Company locations listed in Appendix B a more complete picture of regional variations should become apparent.
4. From (1) and (2) it should be possible to develop synoptic weather maps for extensive periods of time and over a large area of central North America.
5. Analysis and classification of the surface circulation patterns for central and western North America should follow from the synoptic maps.
6. Ultimately upper air patterns and locations of the known semi permanent features of the general circulation would be determined.
7. All of the foregoing will allow an extension westward of the work already created and in the progress of being done in the North Atlantic and European sectors of the Northern hemisphere.

In conclusion, the extensive and intensive nature of the Hudson's Bay Company records, particularly as a source of climatological information, require diligent and continued research. This study is presented as a preliminary stage to establish the extent of the record, the type and variablility of the data, the validity of the record, and a methodology that provides flexibility and scope for a voluminous amount of information. In depth climatological analysis of the results has not been attempted because it is felt that it is more important at this stage to establish a methodology that will ensure uniformity of data collection. The amount of information in these records will result in many climatological researchers being involved over a long period of time. Also it is felt that it is essential to move carefully to validate both the method and the data. Any misuse, misinterpretation or misrepresentation of the nature and form of the data could result in seriously reducing the credibility of the original material. There is no need to rush to judgement of trends based upon these two preliminary stations when a more complete picture with numberous spatial and temporal cross references will be available. All too often in historical climatology the researcher is forced to draw extensive and sweeping conclusions from a paucity of data. In this case one is fortunate to be able to say that this is not necessary.

Appendix A

ANNUAL ANALYSIS OF GENERAL CLIMATIC INDICATORS

This appendix is a year by year analysis achieved by combining annual and monthly counts of the number of snow and rainfall events at each station with the annual and monthly percentages of wind directions. Written comment by the original observer are included to illustrate the validity of their observations and the method of coding used on the data. These comments usually are generalizations, for example that the winter was mild, or notations on unusual climatic phenomena, for example thunder in April. The net result is an annual synopsis of the general climatic conditions.

1715 York - above average number of days with snowfall. Particularly high in March and April. Rain recorded on 16 Feb. Number of days with rain average. Greatest number in September. Comment that September was cold. Winds. Average for the year although September saw 38% of the winds from the North and 65% from northerly directions.

Churchill - No record

1716 York - Indications and comments of a mild winter. Below average snowfall days. Below average number of days of rainfall. Ice 2' less than previous year. In April 69% of winds from south and southwest. Thunder and lightning recorded in April and the ground thawed. Poor spring with extremely variable weather.

Churchill - No record

1717 York - Well below average number of snowfall days. February no snowfall days recorded. Average number of rainfall days. No comments in journals. Wind nothing significant.

Churchill - No record

1718 York - Average number of snow fall days. Comment on deep snow in October 11 days of recorded snowfall associated with higher than normal percentage of NE winds (20%) (easterly 46%) rainfall days average.

Churchill - Record begins in September. Comment on deep snow in Oct. and December. 12 days recorded snowfall in October. Above average snowfall days for the winter. High percentage of east winds in October (55%)

1719 York - Slightly above average rainfall days. Slightly below average snowfall days. Wind pattern normal except for high percentage east winds in February (20%). Comment that end of February mild.

Churchill - Above average rainfall days (same number of days as York 45) October high (14 days) above average snowfall days. Winds average for the year except February high percentage of southerly winds (30%). Comment that end of February mild.

1720 York - Average rainfall days and snowfall days. Winds normal for year. High percentage northeast winds in May (33%). No written comments.

Churchill - Average number of rainfall days and snowfall days. Winds normal for year. High percentage northeast winds in May (43%). No written comments.

1721 York - Average rainfall days slightly below average snowfall days. Winds for year normal. No written comments.

Churchill - Average rainfall days. Above average snowfall days. January and February above average. Winds normal for year although high percentage of south winds in March (29%). No written comments.

1722 York - Average rainfall days except August, slightly below average snowfall days. Winds normal for year. High percentage of SW winds in November (42%) comment on a moderate October (39% southerly winds)

Churchill - Well above average rainfall days especially June and August. Well above average snowfall days especially January and March. Winds for year show above average NW winds with January 61%, February 68% and March 45%, being well above average. Comment on moderate December.

1723 York - Average rainfall days, slightly above average snowfall days. April with 12 snowfall days. Thunder and lightning in April. Above average NE and E winds for the year. April very high percentage of NE (36%) and E (24%) winds. Written comments on thunder in April.

Churchill - slightly above average rainfall days. Slightly above average snowfall days. Winds about average although a high percentage of NE and E winds in April (NE 14% E 10%) May (ENE 13% E 32%) and June (NNE 24% E 28%) Written comment on mild winter.

1724 York - Well below average rainfall days. Well above average snowfall days especially January, March and May. Above average NE winds for year (27%) below average NW winds (15%) high percentage of NE winds in every month except October, November and December, with April the highest (35%). Written comment on snow melting in April and heavy snowfall in May. December extremely cold.

Churchill - Well below average rainfall days. Well above average snowfall days especially January and March. Slightly above average NE winds for the year. High percentage of east winds in April (37%) and very high percentage of NW winds in October, November and December. Written comments on strong winds in May.

1725 York - Slightly above average rainfall days for year but well above average for July (10) and August (14). Slightly above average snowfall days but well above for April (14). Winds about average for the year although especially high percentage of NE winds in April (46%) Written comments on heavy snow in April, heavy rain in July and wet fall.

Churchill - Slightly above average rainfall days but above average for July (10) and August (11). Average snow fall days. Winds average for the year although high percentage of NE winds in June (34%) and August (44%) no written comments.

1726 York - Well above average rainfall days particularly in the months of July (14), August (18) and September (12). Rain occurred twice in November and once in December. Snowfall days above average no month exceptional. Winds normal for the year although July, August and September show above average NE winds. A high percentage of SW winds in November (23%) and W winds in December (47%) Written comment "many rains" and remarks on the wet.

Churchill - Slightly above average rainfall days with August (11) and September (10) being rather high. Snowfall days slightly above average, no months exceptional. Winds normal for the year. South winds higher than normal for the months August (17%) and September (34%). No written comments.

1727 York - Above average rainfall days with an exceptionally high number for July (22) and high for September

(13). Snowfall days well below average. Only 2 recorded days in March. East winds above average for the year (16%) in July 46% from an easterly direction. NW winds lower than normal for the year (19%) Written comments on September being "pitious (sic) weather."

Churchill - Average rainfall days, although September high (12) snowfall days well above average. Winds normal for the year although July had 60% easterly winds. No written comments.

1728 York - Above average rainfall days particularly for July (15), August (14) and September (10). Snowfall days exceptionally high (89), every month being well above average. Above average percentage of NE winds for the year. January and February 59% of the winds from the NW. No written comments.

Churchill - Above average rainfall days with June particularly high (12) Above average snowfall days although no exceptional month. Wind pattern average for the year. January and February had 48% and 59% NW winds respectively. No written comment.

1729 York - Average rainfall days. Average snowfall days. June had 7 days of recorded snow. Higher than normal NE winds for year (24%) NE winds for May (56%) June (45%) and July (43%) account for the written comments. "cold unwholesome summer" November 48% southerly winds accounts comment on "fine fall" and "oldest Indian never was known such moderate weather."

Churchill - Above average rainfall days. Above average snowfall days. Winds normal for the year. High percentage of easterly winds in May (70%), June (45%) and July (50%) November 34% southerly winds. No written comments.

1730 York - Average rainfall days. Well above average snowfall days. February with (11) and April (10). Snow recorded in July. Normal winds for the year. Very few southerly winds in the spring. April only 12% southerly component. Written comments on cold extensive spring.

Churchill - Above average rainfall days. High values for August (10) and September (12). Well above average snowfall days. February records 10 days. Normal winds for the year. February with above average northerly winds (63%) Written comment on the extent of ice in the river.

1731 York - Above average rainfall days. July recorded 13 rainfall days. Snowfall days slightly above average. 3 days of snow recorded in July. Annual winds have higher than usual percentage of easterly winds (41%), June having 87% easterlies. No written comments.

Churchill - Well above average rainfall days. July recorded 14 rainfall days. Well above average snowfall days with 13 days recorded in May. Annual winds normal for the year. June records above average easterlies (63%) Written comment in October about the river being shallow suggesting drought in the interior.

1732 York - Below average rainfall days. Only one rainfall day in July. Slightly above average snowfall days. April recorded 14 days. Normal pattern of annual winds. High percentage of southwest winds in July (58%). No written comment.

Churchill - Average rainfall days. Average snowfall days. Above normal percentage of NW winds for year (32%). February had 71% NW winds. No written comments.

1733 York - Average rainfall days. July high with 13 days. Below average snowfall days. Normal percentages of annual winds. July high percentage easterlies (56%). No written comments.

Churchill - Average rainfall days. July high with 11 days. Below average snowfall days. Normal percentages of annual winds. July high percentage of southerly winds (52%) high percentage of northwest winds in February (77%) and March 72%. Written comments on starved Indians due to a bad winter.

1734 York - Average rainfall days. Above average snowfall days. May recorded 13 days. Low percentage of north winds for year (9%). Higher than normal percentage of northeast winds for year (20%). May recorded 50% northeast winds. Written comment concerning cold uncomfortable spring and summer.

Churchill - Average rainfall days. Slightly above average snowfall days. April recorded 11 days. High percentage of northwest winds for year (38%). January all winds for north (13%) and northwest (87%). Written comment that September more like November.

1735 York - Above average rainfall days. June (11), August (13) and September (11) being high. Slightly above average snowfall days. April high with (10) days. Normal annual percentages of winds. Written comments on warm spring, cold winter and vast quantities of snow. Latter accounted for by higher than average occurrence of heavy or continuous snowfall days (21).

Churchill - Well above average rainfall days August (12) and September (11) being high. Slightly above average snowfall days. April high with (11) days. Normal pattern of annual winds. Written comments on vast depths of snow. Higher than normal number of days with heavy or continuous snow (29).

1736 York - Average number of rainfall days. Above average number of snowfall days. April exceptionally high with 15 snowfall days. High number of heavy snowfall days (25) winds average for the year. No significant monthly winds. No written comments.

Churchill - Slightly above average rainfall days for the year August high with 12 rainfall days. Extremely high number of snowfall days (79), April (13), and May (16) being very high. Average number of heavy or continuous snowfall days. Lower than normal percentage of northwest winds, and above average percentage of easterly winds. Easterly winds above average in spring and summer months. eg. April 58% easterlies. Written comments on "vast quantity of snow" and "late spring".

1737 York - Above average rainfall days; July high with 14. Slightly below average snowfall days, although 11 days in April of which 6 were heavy or continuous snowfall days. Winds average for the year. A high percentage of westerly winds in January (91%), February (96%) and March (72%). No written comments.

Churchill - Slightly above average rainfall days and slightly above average snowfall days. One day of snow recorded in August. Normal percentage of winds for the year. Written comment "no snow in winter in north."

1738 York - Average rainfall days, August high with 13 days. Extremely high number of snowfall days with most occurring in early winter, January unusually high with 12 days recorded. The number of heavy or continuous snowfall days was also extremely high for the winter (39) and for January (9). An unusual wind pattern for the year with southwest winds being much more prevalent than usual. In January southwest winds occurred 39% of the time. Written comment on cold December.

Churchill - Average rainfall days. 5 days in May but no rain days recorded in June. Snowfall days extremely high. January unusually high with 10 days recorded. Extremely high number of heavy or continuous snowfall days for the year (38) and for January (7). A high percentage of north winds for the year (26%) due to a higher percentage in the summer months. No written comments.

1739 York - Rainfall record incomplete however it appears to have been a dry summer with only 15 days rainfall days up to the second week of September. Average number of snowfall days. Appears to be a higher than normal percentage of northeast winds for the year. No written comment.

Churchill - Below average rainfall days which supports speculation of drought at York. Average number of snowfall days. Below average percentage of north winds but above average northeast winds. No written comments.

1740 York - Records available for August to December. 7 days of snowfall in September. Winds evenly distributed for each direction in September. Written comments, October extremely cold.

Churchill - Slightly below average rainfall days. Above average snowfall days. 9 snowfall days in September. Normal wind percentages for the year. No northwest winds for June, July or August. No written comments.

1741 York - Below average rainfall days. Average snowfall days. Less than normal percentage of northwest winds for the year (19%). High percentage of east winds (14%) which occur in the summer months eg. June 54%. Written comment that the winter was cold.

Churchill - Average rainfall days. Below average snowfall days with no records for March. Slightly above normal percentage of east winds for the year (14%) which again show mostly in the summer. June (56%). No written comment.

1742 York - Average rainfall days and average snowfall days in this year. The most significant feature is the number of days with rain through the winter months, January (1), March (2), April (1) and May (7). Normal wind percentages for the year and no significant monthly patterns. Written comment on the rainfall in January.

Churchill - Average rainfall days and average snowfall days for the year. Very few cases of heavy or continuous rainfall days. A high percentage of northwest winds

(35%) but lower percentages of north and northeast winds. Written comment about the summer being dry.

1743 York - Slightly below average rainfall days, although July recorded 13 days. Slightly below average snowfall days. A high percentage of southwest winds (24%) and a low percentage of north winds (12%). Fewer than usual north winds in the first and last months of the year. Very few heavy rainfall days. No written comments.

Churchill - Average number of rainfall days and snowfall days. A much higher than normal percentage of southeast winds (16%) for the year most of which occurred in June with (58%). No written comments.

1744 York - Slightly below average rainfall days however rain in January (1), April (1) and May (2). Slightly below average snowfall days. Normal percentage distributions of winds for the year. Written comments regarding the rain in January and A mild spring.

Churchill - Slightly above average rainfall days and snowfall days. Normal pattern of winds for the year. Written comments regarding the moderate winter.

1745 York - Rainfall days slightly below average. An average number of snowfall days. No snowfall days recorded in May. Wind patterns for the year appear normal, although May has a higher percentage of southwest (12%) and west (15%) winds than usual. Written comments on the fine weather in May.

Churchill - Average number of rainfall days for the year. Slightly above average number of snowfall days for the year but only 3 events recorded in May. Above average percentage of northeast winds for the year (13%). A higher than normal percentage of east winds (33%) in May. Written comments on lack of game.

1746 York - Average number of rainfall days and an average number of snowfall days. A higher than normal percentage of north winds for the year (21%), but lower than normal southwest (17%) and west (13%) winds. Higher than normal percentages of southeast and southwest winds in the summer months. Written comment on there being open weather late in the summer.

Churchill - Well below average number of rainfall days, only 18 days for the summer. Average number of snowfall days, but high number in May (10). Wind pattern normal for the year. Written comments on scarcity of game.

1747 York - Average number of rainfall days, however rainfall recorded in April (1) and May (6). Above average number of snowfall days, but an unusually snowy February (12). Above average percentage of southwest winds for the year (16%). High percentage of northwest winds in March (48%). Written comments - mild March and polar bears at the Fort suggesting a shortage of food.

Churchill - Average number of rainfall days for the year but 2 days with rain recorded in November. Average number of snowfall days but a snowy February (11). Lower than normal percentage of northeast winds (9%) particularly in the summer months. A high percentage of northwest winds in March (60%). Written comments on the mild spring.

1748 York - Above average number of rainfall days with an exceptionally high number in August (19). Also 3 rainfall events in April, 1 in May and 2 in October. Above average number of snowfall days with most occurring in January (14) and March (13). Average percentage of winds for the year but above average southwest winds in January (26%) and east winds in March (28%). A high percentage of south winds in September (23%). Written comments concerning the extremely cold winter and very hot October.

Churchill - Above average number of rainfall days but an exceptionally high number in August (13). Also 1 rainfall event in April, 4 in May and 1 in October. Average snowfall days however 10 events in January. Wind patterns show slightly below normal percentages for north winds (18%) but slightly above for northwest winds (31%). Written comments concerning the cold winter and warm October.

1749 York - Average number of rainfall days but an exceptionally high number in July (18). An exceptionally high number of snowfall days (83) particularly in March (13), April (10) and May (10) with an added 6 events in June. Much below average northeast (13%) winds and above average south (10%) winds. South winds above average in August (27%) and September (21%). Written comments on heavy snow in winter. 32 snowfall days (above the normal total of all events) were recorded as heavy snowfalls.

Churchill - Average number of rainfall days. July high (10). Above average snowfall days with March (11), June (7), and July (1). Below normal percentage of east winds (8%). Above normal percentage of north winds (24%). Less east winds and more north winds in summer months. Written comments on lack of game, excessive snow, bad winter and spring.

1750 York - Below normal rainfall days, August high (12). Well above average snowfall days with a high of 13 days in March, and a record 11 days in June. Low percentage of northeast winds for the year (11%) and high percentage of south winds (11%). Latter unusually high in January (15%) and April (21%). No written comments.

Churchill - Average number of rainfall days, August high with an exceptional 15 days. Extremely high number of snowfall days with a high of 11 days in March equalled in June with 11 days. High percentage of northwest winds 34% and south winds (12%). February exceptional with 64% northwest winds. No written comments.

1751 York - Average number of rainfall days. Above average snowfall days. High percentage of northwest winds (33%). Low percentage of north winds (9%). No written comments.

Churchill - Average number of rainfall days. Above average snowfall days. One day of snow in August. High percentage of northwest winds (40%). April with (63%) and October with (62%) account for some to this shift. No written comments.

1752 York - Slightly below average rainfall days. Well above average snowfall days. Normal pattern of wind percentages. Written comment on severe snow storm in January.

Churchill - Above average rainfall days. 6 rainfall days in May. Above average snowfall days. Normal pattern of wind percentages. 58% easterly winds in July. Written comments on severe snow storm in January. Complaint of bad weather in July.

1753 York - Well below average rainfall days although 11 days in July. Above average snowfall days and high number of these (17) classified as heavy. Low percentage of northwest winds (20%). Northwest winds below average in early months of the year while northeast winds above average in summer months eg. July (65%). Written comment on thaw and rain in January and heavy snow.

Churchill - Average rainfall days. Slightly above average snowfall days. Above average percentage of north (20%) and east 18% winds. Below average percentage of northwest winds (21%). East winds higher in summer months eg. (45%) in July. Written comment on heavy snow and rain in January.

1754 York - Below average rainfall days with no events recorded in June. Average number of snowfall days but very few days in January (2) and February (4). Very high percentage of southwest winds (23%) for year, with February high (63%). Written comment on little snow by February.

Churchill - Slightly above average rainfall days. Average snowfall days although variable. January records (1) event, February (11), March (1) and April 12. High percentage of north winds (27%). Low percentage of northwest winds (23%). Written comments on the cold backward spring.

1755 York - Well above average rainfall days. Notably August (15), September (17) and November (1). Slightly above average snowfall days for the year. March had 11 events while May recorded an exceptional 15 snowfall days. February had 5 heavy snowfall days. Northwest (31%) and southwest (23%) winds were well above average, while east (2%) and west (6%) winds were below average. Significant months were February with (53%) northwest winds and May with (44%) northeast winds and November when (85%) of the winds were westerlies. Written comment on mild November.

Churchill - Well above average rainfall days with July (10), August (12) and September (12), while November had 3 rainfall events. Snowfall days average but (7) days in June. Winds percentage average for the year. In November a high percentage of south winds (13%) and westerlies (76%). Written comments on mild November and the lack of game.

1756 York - Exceptionally low number of rainfall days (18). Above average number of snowfall days, especially May (15). Normal percentage of winds but above normal northeast winds for June (43%), July (64%) and August (53%). Written comment on lack of snow in southern regions.

Churchill - Average number of rainfall days. Above average number of snowfall days, especially May (11). Slightly above average percentage of west winds (15%) and below average northeast winds (4%). Virtually no northeast winds in the summer months. No written comments.

1757 York - Average number of rainfall days. Slightly below average snowfall days. Exceptionally low percentage of northwest winds (14%), but above average northeast (28%) and south (8%) winds. Written comments that March and April were extremely cold but May was mild.

Churchill - Average number of rainfall days. Slightly below average snowfall days. Well below average percentage of Northwest winds (21%) but exceptionally high percentage of east winds (20%). Northwest winds are less and east winds more in the summer months. Exceptional east winds percentages were May (48%) and June (70%). Written comments May mild.

1758 York - Average rainfall days for the year with high months in July (10) and August (12), while June only recorded one day. July was also stormy as (7) of the events were classified as heavy. Snowfall days were well above average. There were (10) snowfall days in February, March, May and most exceptional, June. Wind patterns for the year are fairly normal, however south winds were below average (1%), and east winds were above average (9%). Written comment on snow in June.

Churchill - Well below average rainfall days (18). August was the highest with (8) days while June has (0) days recorded. Snowfall days were average for the year again June was exceptional (8). Wind percentages were near average for the year but south winds were below average (4%) and east winds were above average (18%). Written comment on the cold weather in May.

1759 York - Below average rainfall days with no exceptional months. Snowfall days were well below average with April only recording (1) event but June was again exceptional with (10) days. Most wind percentages are average for the year although east winds are above average (11%) and west winds below average (5%). Written comments on the cold and snow in June which is reflected in (56%) northeast winds for that month.

Churchill - Average rainfall days for the year with September high (11). Snowfall days below average with no exceptional months but June recorded (5) days. Wind percentages for the year were unusual. North winds were below average (19%) while northwest (30%) and east (16%) winds were above average. Written comments on the snow in June.

1760 York - Rainfall days well below average with July high (12) and one event in November being unusual. Snowfall days well below average with the highest months being January (6) and April (6). Wind patterns are unusual with below average northwest (20%) and north (11%) winds. Written comments about excessive snow in May that is only explained by the high number of days with drifting.

Churchill - Well below average rainfall days (16) and well below average snowfall days (35). There were no exceptional months except that each month was below average. Very unusual patterns of wind percentages. Months above average, northeast (8%), southeast (9%), south (10%), southwest (13%), west (12%); months below average north (11%), east (9%) and northwest (28%). No written comments.

1761 York - Average rainfall days for the year. More months with rainfall days than any year in the record. Rain was recorded in every month except January, March and December. Wind patterns for the year are not particularly unusual although west winds (15%) are slightly above normal and northeast winds are below normal (15%). Monthly patterns are dramatic as there are a much higher percentage of southwest and west winds in January, February and March but a lower percentage of northwest winds in the same months. Written comments on the lack of snow with the ground being bare in April.

Churchill - Average rainfall days for the year but rainfall days in each month except January, February, March, November and December. There were (7) events recorded in October. Snowfall days were well above average (60) with January (11) and April (15) being exceptional. The highest percentage of heavy or continuous snowfall events in this year (33) with a high in April (10). Again wind patterns for the year are not exceptional although southwest (11%) are slightly above normal and east (11%) slightly below. Monthly patterns - high percentages of north and northwest winds from January through May. Low percentages of all other directions. Written comments 'I never saw so much snow'.

1762 York - Above average rainfall days. July exceptionally high with (20) rainfall days. Well below average snowfall days. Above average percentage of south winds for the year (8%) but below average northeast (14%) and southwest (11%) winds. Above average south winds noticeably in October (14%) and November (23%). Written comment on the small amount of snow.

Churchill - Slightly above average rainfall days. July high with (13). Slightly below average snowfall days. Below average percentage of northwest winds (29%). Written comment on Bay being frozen still on 20th June.

1763 York - Well below average rainfall days (25). Slightly above average snowfall days. Dramatic shift in wind patterns. Winds above average; north (27%), northeast (20%). Winds below average northwest (20%), southwest (7%), and west (11%). No written comments.

Churchill - exceptionally low number of rainfall days (12). Below average snowfall days particularly in late spring. Wind patterns markedly different. Winds well above average; southeast (9%), northwest (33%), northeast (10%). Well below average north (10%) and east (13%). Written comments on lack of snow in spring.

1764 York - Well below average rainfall days. Unusual pattern as rainfall is recorded in each month except February, March and December. Average number of snowfall days. Unusual wind pattern continues. Above average; northwinds (21%), northeast (21%) and south (13%). Below average; northwest (17%), west (10%) and southwest (11%). Written comment on rain in January.

Churchill - Below average rainfall days. below average snowfall days. Unusual wind patterns. Above average; northwest (36%), northeast (14%). Below average; north (6%), west (8%), east (13%). Written comments. Lack of game "bad times".

1765 York - Well below average rainfall days although rain events were recorded in each month from April to October and 2 events Occurred in December. Snowfall days were slightly above normal. Winds continue unusual. Above average; north (28%), south (11%). Below average; northwest (19%), northeast (17%). No written comments.

Churchill - Exceptionally low rainfall days (11). Exceptionally low number of snowfall days (20). Winds continue unusual. Above average; northwest (34%), northeast (17%), southwest (11%). Below average; north (5%), east (12%), west (7%). Written comments on early spring and lack of snow in November.

1766 York - Below average rainfall days. June high (11) days. Slightly below average snowfall. January high (11) days. Return to more normal pattern of winds although north winds still high (20%) and northeast winds low (10%). Written comments on the " changeable weather".

Churchill - Lowest record of rainfall days in the study (6). Pattern for summer as follows; June (3) days, July (1) day, August (1) and September (1) day. Exceptionally low number of snowfall days (19). Winds still abnormal. Above average; northwest (33%), northeast (13%), southwest (11%). Below average; north (6%), south (4%). Written comments; no game; Low water in the creeks.

1767 York - Below average rainfall days. Above average snowfall days especially in early winter. North (31%) and west (14%) above average. Northwest (14%) and southwest (8%) below average. Written comments on late arrival snow in fall.

Churchill - Below average rainfall days. Well below average snowfall days. Monthly pattern of snowfall as follows; January (0), February (0), March (1), April (0) and May (0). Winds continue abnormal. West (16%) and southwest (11%) well above average. North (5%) and northeast (10%) well below average. Written comments about the natives starving due to lack of game.

1768 York - Slightly below average rainfall days. August high (10) events. Slightly below average snowfall days. No exceptional months. Wind patterns unusual. Above average north (30%) and northeast (23%) winds. Below average southeast (1%), southwest (5%) and northwest (12%) winds. Written comments on the poor weather in September.

Churchill - Well below average rainfall days (14). Well below average snowfall days (23). No events recorded in March. Above average west (17%), southeast (10%) and northeast (11%) winds. below average north (9%) and south (9%) winds. Written comments that July was very hot, probably accounted for by (41%) east winds, (24%) south winds but no north winds (0%).

1769 York - Average rainfall days for year but high in August (13) and September (11). Average snowfall days. North (36%) and west (21%) winds well above average. East (1%), southeast (1%) and northwest (13%) well below average. No written comments.

Churchill - Average rainfall days. June high (12). Slightly above average snowfall days, but no unusual months. Return to more normal pattern of winds although north (15%) winds below average but west winds above average (13%). No written comments.

1770 York - Slightly below average rainfall days. August high (13) days. Average snowfall days, no unusual months. Above average winds, north (36%) and south (10%). Below average winds, northwest (12%), southwest (14%). Written comments on heavy snow in April (4) events recorded as being heavy or continuous.

Churchill - Average rainfall days. August high (12) days. snowfall days well below average (18). No snowfall days recorded in March and April. Average percentage of winds for the year. Written comments on ice in the Bay in July and August.

1771 York - Average rainfall days. Average snowfall days. Above normal percentage of north (26%) and northeast (19%) winds. Below average; southwest (10%) and northwest (15%) winds. No written comments.

Churchill - Below average rainfall days. Below aveage snowfall days. No unusual months. Very unusual pattern of winds. Above average; northwest (37%), northeast (16%) winds. Below average north (5%), south (4%) winds. No written comments.

1772 York - Average rainfall days. June above average (14) days. Snowfall days slightly above average. Average wind percentages for the year. No written comments.

Churchill - Slightly below average rainfall days. July unusual with no days recorded. Snowfall days below normal. Only one event recorded in each of January, February and March. North (5%) and south (4%) winds well below average. Northeast (22%) and northwest (35%) winds well above average. Written comments. cold winter. Summer very dry - forest fires.

1773 York - Average rainfall days. August high (13). Slightly below average snowfall days. No events recorded in March. Dramatic wind pattern change. North winds (41%) well above average. Northwest (13%) well below average. No written comments.

Churchill - Below normal rainfall days. Below normal snowfall days. No events recorded in March. Wind patterns unusual. Northwest very high (40%). North very low (7%). Written comments on the increase of rapids in the Churchill river.

1774 York - Average rainfall days. Average snowfall days. Wind patterns remain unusual. (40%) north winds above average. (11%) northwest winds below average. No written comments.

Churchill - Well above average rainfall days. July (10), August (14) and September (10), all being high. Northwest winds remain well above average (40%). North winds below average (12%). No written comment.

1775 York - Well above average rainfall days. June high (11) events. Extremely high number of snowfall days (73). Return to previous, more normal, pattern of wind percentages. No written comments.

Churchill - Slightly below average rainfall days. August high (11) events. Average number of snowfall days. Normal pattern of winds. No written comments.

1776 York - Above average rainfall days with a long wet season. rainfall recorded in each month from April to November. July (11), August (11) and September (12) being the significant months. Snowfall days above average. March (11) and May (11) the notable months. Unusual winds. Above average northwest (31%), southwest (26%) and northeast (20%) winds. Below average north (3%) and west (4%) winds. No written comments.

Churchill - Average rainfall days. September above average (12). Slightly below average snowfall days. Unusual winds. Above average northwest (45%). Below average north (12%) and northeast (8%). Written comments. Deep snow all spring. Snow drifts 10 feet deep still in June.

1777 York - Exceptional level of rainfall days (61). Above average months as follows; June (10), July (17), August (17) and September (16). Winds above average; northwest (33%) and northeast (24%). Below average; north (6%) and west (4%). Written comments, wet July - lousy summer.

Churchill - Average number of rainfall days, but high number of heavy rain events. Below average number of snowfall days for the winter but most occurring in late spring. Northwest winds exceptionally high (46%). Written comments on the mild winter and late heavy snowfall followed by a wet summer.

1778 York - Above average rainfall days. Unusual due to (3) events in April and (8) in May. Snowfall days slightly below average. Normal pattern of wind percentages. No written comments.

Churchill - Above average number of rainfall days. April had (1) event, (2) in May. Snowfall days below average. Northwest winds were well above average (42%). North winds below average (6%). Written comment that snow was still on the ground on the 3rd June.

1779 York - Above average rainfall days particularly in July (14) August (15) and September (10). Snowfall days well above average especially in the early winter. Return to unusual wind patterns. North (6%) and west (8%) below normal percentages. Northeast (22%) and northwest (28%) above normal. No written comments.

Churchill - Average number of rainfall days. Below average number of snowfall days. Winds unusual. Above average; northeast 17% and northwest (39%) winds. Below average; north (7%) and southeast (6%) winds. Written comments on heavy ice.

1780 York - Well above average number of rainfall days (60) with high readings in July (15), August (20) and September (13). Important to note that none of these are listed as heavy or continuous events. Snowfall days slightly below average. Wind patterns unusual again. North (6%) below average. Northwest (33%) above average. No written comments.

Churchill - Below average number of rainfall days. Below average number of snowfall days. North (6%), west (1%) and east (5%) winds are well below average, while northwest (46%) winds are well above average. Written comments on the poor goose season.

1781 York - Average number of rainfall days. High months August (17), September (10). Slightly below average number of snowfall days. North (9%) and northeast (11%) winds slightly below average. South (11%) and west (13%) winds slightly above average. Written comment on hot weather in July.

Churchill - The Fort was captured in September therefore a complete year is not available. Up to that month the number of rainfall days appears to suggest a dry summer. Snowfall days were average. No written comments.

1782 York - Factory was surrendered to the French in August. Number of rainfall days for June (10), July (14) and August(10) suggest a wet summer. Number of snowfall days was well above average. No written comments.

Churchill - No record

1783 York - Record recommences in September. October records a remarkable (13) rainfall days. No written comments.

Churchill - Record recommences in September. October records (7) rainfall days. Written comment on deep snow in November.

1784 York - Average number of rainfall days. Well below average number of snowfall days (29). No snowfall days recorded in February. wind patterns return to more normal percentages. Although north (17%) and south (3%) are still below average while the northeast (30%) wind is well above average. Written comments on a wet July probably related to a very high percentage of northeast winds in that month (63%).

Churchill - Average number of rainfall days. Well below average number of snowfall days (29). Only one day in February. A high percentage of missing observations is disconcerting still the pattern is normal for the monthly distributions, however the yearly figure shows northwest winds occurring (63%) of the year. Written comments on cold in April and extreme variability of the weather in June.

1785 York - Average number of rainfall days. June high (12). Well below normal number of snowfall days. No days recorded for March. Average pattern of winds. No written comments.

Churchill - Average number of rainfall days. August high (15). Average number of snowfall days. Unusual pattern of winds. Above average; northeast (23%) and northwest (55%) winds. Below average; north (2%) and west (1%) winds. Written comments on north winds during goose season - Record shows May - Northerly winds comprise 100% of the winds.

1786 York - Above average number of rainfall days August (15) and September (13) high months. Well below average number of snowfall days. No snowfall days in February. Wind patterns unusual. Above average; north (20%) and northeast (21%) winds. Below average; southwest (13%) and northwest (19%) winds. Written comment that February was excessively cold.

Churchill - Average number of rainfall days, August (12) high month. Below average number of snowfall days. No snowfall days recorded in February or March. Wind patterns unusual. Above average; northwest (42%) and northeast (23%) winds. Below average; north (4%), east (6%) and southeast (4%) winds. Written comments on the earliest arrival of geese; the excessive cold in February and in July the Bay still covered with ice.

1787 York - Above average number of rainfall days. June (15), July (10) and August (15), the exceptional months. Number of snowfall days slightly below average. Wind pattern surprisingly uniform with no dominant direction. North (20%), northeast (21%), northwest (19%). Written comments on the extreme cold, scarcity of game, and bears and wolves close around the Fort.

Churchill - Well below average number of rainfall days (18). Only one rainfall day in September. Averagee number of snowfall days. Wind pattern unusual. Only dominant wind direction is northwest (39%). Remaining evenly distributed. Written comments on the extreme cold and late fall.

1788 York - Above average number of rainfall days. July (17) and September (15) are the exceptional months.

July also had (4) days of continuous or heavy rain. Well below average number of snowfall days. No snow in September. Percentage of north winds back to previous levels (24%). East (15%) and south (10%) winds above average. Southwest (9%) and northwest (18%) winds below average. No written comments.

Churchill - Below average number of rainfall days. (2) rainfall days in April. Average number of snowfall days. March high (14) days. Winds: above average; southwest (19%) and northwest (35%) winds. Below average; north (11%) and east (8%) winds. Written comment on the late fall.

1789 York - Average number of rainfall days. August (15) high. Slightly below average number of snowfall days but heavy early in the winter. October (12) days. Wind: above average; east (14%), south (13%) and north (25%) winds. Below average; northwest (14%) and southwest (7%) winds. Written comment about excessive snow.

Churchill - Average number of rainfall days. July (11) high. Below average number of snowfall days. Winds: below average; north (11%), east (8%) and northeast (3%) winds. Above average; northwest (35%) and southwest (19%) winds. Written comment that partridge are scarce.

1790 York - Above average number of rainfall days. July (10), August (15) and September (11) all above average. Slightly below average number of snowfall days. Well above average north (34%) and east (12%) winds. Well below average; northwest (12%) and souothwest (9%).

Written comment that the river was low in July suggesting drought in the interior.

Churchill - Above average number of rainfall days. August (10) and September (10) days. Below average number of snowfall days. No snow events recorded in January. Winds above average; west (16%) and south (14%). Below average; north (9%), east (6%). No written comments.

1791 York - Well above average number of rainfall days. June (13), July (13), August (14) and September (10) are all above average. Very few of these are heavy or continuous rainfall events. Number of snowfall days below average. Distribution is unusual. February has no events recorded while May had (11). May also had 5 rainfall days all of which were recorded as heavy or continuous. Winds were surprisingly uniform with the lowest annual percentage being southeast (5%) and the highest north (25%). May had a remarkable (36%) south winds. Written comments. Excessive snow. June the snow deep and the weather cold.

Churchill - Average number of rainfall days. September high (11). Snowfall days below average, however most events occurred in late spring. January (0) days while April (9), May (9) and June (2). (2) events in May were recorded as heavy or continuous. Winds above average; southwest (17%) and south (10%). Below average; north (4%) and east (9%). Written comments on the excessive amount of snow.

1792 York - Well above average number of rainfall days. June (11), July (14), August (12) and September (14) all above average. Snowfall days below average. Similar pattern to previous year with little snow in the winter, January (1) and February (2) while May recorded (11) events. Unusual wind patterns for the year. Above average; north (31%) and south (19%) winds are exceptionally high. Below average; northeast (4%) and east (4%) very low. Written comments note that an early winter trapped the migrating birds and that the winter was extremely cold.

Churchill - Average number of rainfall days. Average number of snowfall days. Winds unusual. Below average; north (6%) and east (5%). Above average; south (13%) and west (18%). Written comments on the scarcity of game.

1793 York - Above average number of rainfall days. July (14) and August an exceptional (21) days. Well below average number of snowfall days; only (2) days in February and (1) in March. Winds uniform in their percentages. Above average; south (18%) and northwest (24%). Below average; northeast (10%), southwest (13%) and west (4%). Written comments that February was cold and that there was 1/2 inch thick ice on the 18th of June.

Churchill - Average number of rainfall days. Well below average number of snowfall days. 4 months, June, July, August and September without snow. Very unusual pattern of annual winds. West winds (27%) well above average. South (13%) winds above average. Below average; north (12%), northwest (25%) and east (8%) winds. Written comment that it was cold in late January.

1794 York - Extremely high number of rainfall days (60). June (14), July (10), August (19) and September (13) all well above average. Also high number of heavy or continuous rainfall days (13). Extremely high number of snowfall days (86). January (14) and February (11) both well above average. Winds unusual. Below average; north (7%) and west (4%) winds. Above average; northeast (19%), east (10%) and southeast (10%) winds. Written comment on the 22nd of August that there had been 3 days of heavy rain.

Churchill - Extremely low number of rainfall days (17). However, there were (4) days of rain in April and (5) in May. Exceptionally low number of snowfall days (24). Only one day in the months of February, March and May. Winds above average; north (27%), west (26%) and northwest (21%). Below average; southeast (0%), northeast (3%) and east (5%). Written comments that the Indians were starving due to lack of game.

1795 York - Above average number of rainfall days. June (16) days. Extremely high number of snowfall days (76). March (12) and May (13) days. Winds above average; east (10%) and southeast (10%). Below average; west (4%) and north (7%). No written comments.

Churchill - Average number of rainfall days. Below average number of snowfall days. Pattern of snowfall days also unusual May had (17) of the total 35 days of snowfall events. Winds extremely unusual. North (37%) and northwest (33%) accounting for 70% of the yearly total. All other directions below average. No written comments.

1796 York - Average number of rainfall days. Slightly above average number of snowfall days. Wind patterns show no dominant directions and similar to those of the 1760's. No written comments.

Churchill - Extremely low number of rainfall days (7). No events recorded in August, September or October. Above average number of snowfall days. North winds (32%) exceptionally high. South (7%) and southwest (2%) below average. Written comment that January was excessively cold.

1797 York - Below average number of rainfall days. Above average number of snowfall days. May (16) days. Pattern still similar to that of 1760's. No written comment.

Churchill - Record inadequate to determine any patterns.

1798 York - Average number of rainfall days. August (13) high. Snowfall days well below average. Winds evenly distributed. No written comments.

Churchill - Insufficient rainfall record although it appears that it was a dry summer. Number of snowfall days also appears to be well below normal. Written comment that the summer was dry.

1799 York - Slightly below averge number of rainfall days. August only one day of record. Below average number of snowfall days. Winds above average; east (15%) and south (13%). Below average; north (12%) and southwest (12%). Written comment on the extremely cold winter but a mild fall.

Churchill - No record. No written comments.

1800 York - Average number of rainfall days. August (13) high. Average number of snowfall days. No exceptional months. Insufficient wind data to determine percentages. Written comment that the winter was mild.

Churchill - No record. Written comment that the summer was cold.

1801 York - Well below average number of rainfall days (19), June (2), July (1) exceptionally low. Below average number of snowfall days. No outstanding months. Written comment that it was a cold miserable year.

Churchill - No record. No written comment.

1802 York - Below average number of rainfall days. Slightly below average number of snowfall days. May (12) high. Written comment that it was a dry summer.

Churchill - No record. No written comments.

1803 York - Insufficient data. No written comments.

Churchill - No record. Written comment that the winter was cold.

1804 York - No record. No written comments.

Churchill - No record. Written comment that the winter was excessively cold.

1805 York - No record. No written comments.

Churchill - No record. Written comment: January no snow and cold. February no snow and mild.

1806 York - No record. Written comments. Heavy snow on the 23rd of June. The mildest fall in 50 years.

Churchill - No record. Written comments: February severe. November very mild, warm, close and overcast. Only 2 sunny days.

1807 York - No record. Written comments: mild winter. May cold the season backward and a summer of scarcity. November the first - weather fine as in July.

Churchill - No record. Written comments: "coldest month of May I ever saw." "extraordinary late fall."

1808 York - No record. Written comments: very mild winter. March - severe weather. Poor summer.

Churchill - No record. Written comments: March - Severe weather.

1809 York - No record. No written comments.

Churchill - No record. Written comment. April - plains bare of snow.

1810 York - No record. Written comment. January - Scarcity of game.

Churchill - No record. No written comments.

1811 York - No record. Written comments; extreme variability of weather, scarcity of game.

Churchill - Partial record. Appears like a wet summer. September (13) rainfall days. No written comments.

1812 York - No record. Writtten comments: scarcity of game. November extremely cold.

Churchill - Average number of rainfall days. Average number of snowfall days. Winds: below average; north (8%) and south (2%) winds. Above average; southeast (13%) and northeast (13%) winds. Written comments. Late spring, May cold. July bad weather.

1813 York - No record. No written comments.

Churchill - Below average number of rainfall days. June (10) high. Average number of snowfall days. One snowfall event in July. Winds. above average; southeast (16%) and northeast (17%) winds. Below average; north (11%) and south (6%) winds. Written comment: July warmest for 3 years.

1814 York - No record. No written comments.

Churchill - No record. No written comments.

1815 York - Average number of rainfall days. August (13) high. Slightly below average snowfall days. May (10) high. Insufficient wind data. Written comment: late snow.

Churchill - Insufficient record. No written comments.

1816 York - Insufficient record. Written comment: February extremely cold.

Churchill - Insufficient record. Written comment: late January was cold.

1817 York - No record. No written comments.

Churchill - Well below average number of rainfall days. Insufficient snowfall data. Wind data: above average; northeast (19%), southeast (12%) and west (17%). Below average; northwest (19%), north (13%) and southwest (7%). No written comments.

1818 York - Insufficient record. Written comment: November very mild, mildest for 30 years or more.

Churchill - Insufficient rainfall data. Slightly below average snowfall days. Winds unusual: above average; west (24%) and southeast (10%). Below average; northwest (15%) and northeast (9%) winds. No written comments.

1819 York - Insufficient record. No written comments.

Churchill - Insufficient record. Written comment: Three extremely mild days in mid-April.

1820 York - Insufficient record. Written comment. 10th November - clear after 5 weeks cloudy.

Churchill - Insufficient record. No written comments.

1821 York - Insufficient record. Written comments: Little snow through winter and early spring.

Churchill - Insufficient record. Written comments: Snow on the 6th of June. Dry summer - River very low.

1822 York - Insufficient record. No written comments.

Churchill - Insufficient record. Written comment: cold in the early winter.

1823 York - Below average number of rainfall days. August (12) high number of days. Well below average number of snowfall days. March (0) events. Insufficient wind data. No written comments.

Churchill - Insufficient record. Written comments: River broke late. Cold June. Spring late. Early heavy snowfall in the Fall.

1824 York - Well below average number of rainfall days. Slightly below average number of snowfall days. Insufficient wind data. No written comments.

Churchill - Insufficient record. Written comment: Much snow on the ground on the 2nd of June.

1825 York - Average number of rainfall days. September (11) high. Slightly below average number of snowfall days, most occurring in the early winter. Insufficient wind data. Written comment: rain and mild in February.

Churchill - Insufficient record. Written comments: March very mild. Late spring. November heavy snow.

1826 York - Average number of rainfall days. August (14) high. Slightly below average number of snowfall days. Insufficient wind data. Written comment: Rain on the 8th of December.

Churchill - Insufficient precipitation record. Normal wind percentages except northwest (46%) above average. Written comment: Coldest February ever witnessed.

1827 York - Extremely high number of rainfall days (66). June (15), July (19) and August (16) all being well above average. Average number of snowfall days. Insufficient wind data for reliable results. Written comment: Water temperature of Hudson Bay recorded as 32 degrees Fahrenheit on the 1st December.

Churchill - Insufficient precipitation record. Wind pattern: above average; northwest (42%) and north (16%) winds. Below average; northeast (1%), west (5%) and southwest (8%) winds. No written comments.

1828 York - Only 5 months of record. Above average number of snowfall days. Most snow in the early winter months. No written comments.

Churchill - Insufficient precipitation record. Winds: Above average; northwest (46%) and south (9%) winds. Below average; southwest (1%) and east (7%) winds. Written comments: May mild; June cold. Late spring.

1829 York - Above average number of rainfall days. Insufficient snowfall and wind data. No written comments.

Churchill - Insufficient precipitation data. Wind data: Above average; northwest (50%), Below average; northeast (4%) and west (6%) winds. No written comments.

1830 York - Number of rainfall days well above average. July (13), August (13), and September (13) all above average. Snowfall days well below average. Wind pattern unusual: Above average; east (13%), south (15%) and southeast (6%). Below average; north (20%), northeast (11%) and west (11%) winds. No written comments.

Churchill - Insufficient data. Written comment: No snow at York but much at Churchill.

1831 York - Average number of rainfall days. Slightly below average number of snowfall days. Winds: Above average; north (25%), east (15%) and south (16%). Below average; northwest (11%), southwest (6%) and west (10%) winds. Written comment: Mild February, accounted for by 30% south winds.

Churchill - Insufficient data. No written comments.

1832 York - Insufficient data. No written comments.

Churchill - Slightly above average number of rainfall days. Below average number of snowfall days. Winds unusual. Above average; northwest (41%) and east (16%). Below average; north (7%) and south (4%). Written comment: Heavy snow in April.

1833 York - No record. No written comments.

Churchill - Below average number of rainfall days, despite two above average months, July (11) and September (12). Below average number of snowfall days. Very unusual winds. Northwest (51%) represents one of the highest readings in the years of record. All other directions were well below average. No written comments.

1834 York - Insufficient record. Written comments: River low in October. A cold Fall with little snow.

Churchill - Average number of rainfall days. Well below average number of snowfall days. Wind pattern shows a continued dominance of northwest (40%) winds, also above average; west (17%). Below average; all other directions. No written comments.

1835 York - Average number of rainfall days. August (10) high. Well below average number of snowfall days. No events recorded in February. Insufficient wind data. Written comments: Cold in December (1834) and January.

Churchill - Below average number of rainfall days. Well below average number of snowfall days. No events recorded in February or April. Winds: Above average; northwest (46%). Below average; north (7%), south (2%). Written comment: the river was shallow.

1836 York - Insufficient record. Written comment: Heavy snow.

Churchill - The month of September data was not recorded, however the other months suggest a dry summer. Well below average number of snowfall days. Northwest winds make up an exceptional (53%) of the total annual percentage. All other directions were below average. No written comments.

1837 York - Insufficient record. No written comments.

Churchill - Again the record is not complete however it again appears like a dry summer. The number of snowfall days also appears to be below average. Wind percentages: Above average; west (21%). Below average; north (6%) and northeast (6%) winds. No written comments.

1838 York - Below average number of rainfall days. Well below average number of snowfall days. Winds: Above average; west (11%) and south (16%) winds. Below average; northeast (6%) winds. Written comments: Very mild Fall right through to December. This pattern is clearly accounted for by the high percentages of southerly winds as follows: August (53%), September (57%), October (50%), November (54%) and December (61%).

Churchill - Above average number of rainfall days. Average number of snowfall days. Normal pattern of wind. Written comments: Rain much required - A dry summer.

1839 York - Well below average number of rainfall days. Well below average number of snowfall days. Unusual pattern of winds. An exceptionally high percentage of north (35%) winds and south (25%) winds. A very low percentage of east(4%) and northeast (12%) winds. Written comments: Heavy ice and a prevalence of north winds. Ice in the Bay up to 3rd of August.

Churchill - Slightly below average number of rainfall days. Slightly above average number of snowfall days. Winds: Below average; north (6%) and south (6%) winds. Above average; west (14%) and east (14%) winds. No written comments.

1840 York - Insufficient rainfall data. Below average number of snowfall days. Only (1) event in April and (0) in May. Insufficient wind data. Written comment: Mild in April.

Churchill - Above average number of rainfall days. August (20) exceptionally high. Above average number of snowfall days. Winds: Above average; east (14%) and west (18%). Below average; north (5%) and south (6%) winds. No written comments.

1841 York - Insufficient data. Written comment: Latest spring since 1822.

Churchill - Above average number of rainfall days. Above average number of snowfall days. Wind: Above average; east (12%) and west (15%) winds. Below average; north (4%) wind. No written comments.

1842 York - Average number of rainfall days. July (14) high. Insufficient snowfall data for the whole winter, however it appears to be a well below average year. Unusual winds. Above average; north (23%) and south (28%). Below average; west (8%) and northwest (9%) winds. Written comments: No spring runoff. River very low in June. June very cold. Fires in the interior in August.

Churchill - Very high percentage of rainfall days. June (10), July (14), August (11) and September (11) all above average. Well above average number of snowfall days. Above average winds; east (14%) and west (16%). Below average winds; north (4%) and south (6%). No written comments.

1843 York - Well below average number of rainfall days. Average number of snowfall days. Winds; Above average:

north (33%) and south (16%). Below average: northwest (7%) and west (7%) winds. Written comment: Extreme drought in the interior.

Churchill - Slightly above average number of rainfall days. Above average number of sn^wfall days. Winds: Above average northeast (13%) and northwest (40%). Below average: north (5%) and south (5%) winds. No written comments.

1844 York - Below average number of rainfall days. Average number of snowfall days. Winds above average; north (28%) and south (14%). Below average; west (10%) and northwest (10%). Written comment: Late spring.

Churchill - Slightly above average number of rainfall days. slightly above average number of snowfall days. Winds above average; east (13%) and west (14%). Below average; north (6%) and south (6%) winds. No written comments.

1845 York - Average number of rainfall days. Slightly below average number of snowfall days. Normal pattern of wind percentages. No written comments.

Churchill - Above average number of rainfall days. Above average number of snowfall days. Above average winds; west (11%) and east (15%). Below average winds; north (6%) and south (6%). No written comments.

1846 York - Insufficient records. Written comment: Ice broke early.

Churchill - Average number of rainfall days. Below average number of snowfall days. March above average with (10) snowfall days. Above average wind; northwest (38%), below average; north (6%). All other average. No written comments.

1847 York - Insufficient records. No written comments.

Churchill - Incomplete rainfall record but appears like an average year. Below average number of snowfall days. Winds normal except northwest still above average at (41%). Written comment: No snow on the ground on the 15th of October.

1848 York - Well below average number of rainfall days. Average number of snowfall days. Wind percentages average except northwest which was below average (7%). Written comment: snow on ground on the 22nd of June.

Churchill - Average number of rainfall days. Below average number of snowfall days. Winds above average: northwest (34%) and northeast (16%). Below average: east (6%) and north (11%). Written comment: In April the Indians report that there is no snow on the plains.

1849 York - Average number of rainfall days. Average number of snowfall days. Extremely uniform distribution of winds. Seven of eight directions (except southeast (4%)) fall between (16%) and (12%). Written comments: Very late Fall. Interior rivers and lakes unfrozen until the 10th of December.

Churchill - Well above average numbr of rainfall days. August (12) high. Below average number of snowfall days. Slightly above average winds: northwest (40%). Below average wind; north (7%) and east (7%). No written comments.

1850 York - Below average number of rainfall days. Average number of snowfall days. Well above average south (23%) wind. Below average northwest (13%) and north (12%) winds. Written comment: April little snow.

Churchill - Insufficient record. No written comments.

1851 York - Well below average number of rainfall days. No rainfall days recorded in September. Slightly below average number of snowfall days. Above average winds; south (20%). Below average; west (9%) and north (14%. No written comments.

Churchill - Incomplete summer record however it appears to have been a slightly below average year. Average number of snowfall days. Wind: Above average; northwest (46%). Below average; north (6%), west (7%), southwest (5%). No written comments.

1852 York - Insufficient record. No written comments.

Churchill - Well above average number of rainfall days. July (10), August (11) and September (15) all above average. Slightly below average number of snowfall days. Normal distribution of winds. No written comment.

1853 York - No record. No written comments.

Churchill - Below average number of rainfall days. Below average number of snowfall days. Wind below average; east (5%), above average; west (20%). No written comments.

1854 York - No record No written comments.

Churchill - Above average number of rainfall days. Well below average number of snowfall days. No events recorded in January. Winds above average; northwest (37%)

and west (15%). Below average; north (11%) and east (4%). No written comments.

1855 York - No record. No written comments.

Churchill - Above average number of rainfall days. Average number of snowfall days. Wind above average; northwest (37%). Below average; south (5%) and north (12%). No written comments.

1856 York - No record. No written comments.

Churchill - Well above average number of rainfall days. August (15) above average. Well above average number of snowfall days. February (12) and April (11) both above average. Northwest 49% well above average, all other directions below average.

1857 York - No record. No written comments.

Churchill - Incomplete rainfall record, however it appears as if it was a dry summer. Well below average number of snowfall days. January no events recorded. Wind pattern continues with northwest winds being above average. No written comments.

1858 York - No record. No written comments.

Churchill - Incomplete rainfall data. Well above average number of snowfall days. (6) days of snow recorded in the first 20 days of June. Insufficient wind data. No written comments.

Appendix B

HUDSON'S BAY COMPANY FORTS IN NORTH AMERICA

Several references are made to the extent of coverage available from the Post Journals maintained at the Hudson's Bay Company Forts. The following is a list of the various Forts throughout North America and the length of time for which records are available. It should be noted that a few of the actual sites are at present unknown, however, research to determine the precise location is currently being carried out by W. Moodie and B. Kaye at the University of Manitoba.

Abitibi- 1794-1811, 1822-1829, 1952-53.

Aillik- 1855-58, 1865-1870.

A la Corne -1851-52, 1855, 1858-59, 1863-1873.

Albany- 1705-1707, 1711-1868.

Alexander Fort- 1795-1801, 1822-23, 1832-34, 1863.

Alexandria Fort- 1824-25, 1827-28, 1833-34, 1837-39, 1842-55, 1858-67.

Anderson, F.- 1861-62.

Ash Fall- 1798-99. (House ?)

Assiniboine F.- 1828-31.

Athabaska Lake- 1790-92.

Attawapiskat L.- 1814-15.

Babine- 1822-23, 1825, 1852.

Bad Lake- 1805-06.

Beaver Lake House- 1808-09.

Bedford House (Reindeer Lake)- 1796-97.

Belle Vue Sheep Farm- 1854-55, 1858-62.

Berens River- 1817-21, 1863-66.

Bersinies- 1865-79.

Big Fall- 1802-05.

Big Lake- 1818-1821.

Blood River- 1794-95.

Boloover House- 1799-1800.

Bow Fort- 1833-34.

Brandon House- 1793-1819, 1828-30.

Brunswick House- 1776-91.

Buckingham House- 1792-99.

Cappoon Icgomic- 1822-24.

Carlton House (Sask)- 1795-98, 1814-30, 1832-39, 1855.

Carlton House (Ass)-1795-1800.

Carlton House (3 pts.)- 1795-97.

Cat Lake- 1788-95.

Chatham House- 1791-92.

Chesterfield House (Bow River)- 1800-02, 1822-23.

Chilcotin-1837-40.

Chimo Fort-1830-43, 1866-73.

Chipewyan F.- 1802-06, 1815-29, 1831-61, 1865-71.

Chipewyan L.- 1800-01.

Chiswich House-1802-06.

Churchill F.- 1718-1781, 1783-98, 1800-67.

Colute House (Peace River)- 1818-21.

Colute Fort (Columbia R.)- 1830-31.

Cross Lake- 1795-96.

Cul de Sac- 1845-46.

Cumberland House-1774-1803, 1806-07, 1815-16, 1818-33,
1835-40, 1844-46.

Dalles-1832-34.

Dauphin Fort- 1795-96, 1819-21.

Davis Inlet- 1869-72.

Doubtful Post- 1797-98.

Duck Lake (Albany River)-1798-99.

Duck Portage-1795-96.

Dunvegan-1822-25, 1834-45, 1866. Peace.

Eagle Lake (Albany River)- 1805-06, 1809-1812.

Eagle Nest- 1865-66, 1868-69.

Eastmain- 1736-1837.

Edmonton- 1795-1800, 1806-1829, 1832-34, 1854-71.

Egg Lake (Churchill River)- 1809-11.

Egg Lake (Swan River)- 1853-54.

Ellice Fort- 1793-94, 1812-12, 1822-23, 1858-60, 1862-69.

Escabitchewan- 1792-93, 1796-99, 1807-09, 1818-21, 1823-24.

Fairford House (Churchill River)- 1795-96.

Finley River- 1824.

Flamborough House- 1750-54.

Flathead- 1824-25.

Flying Post- 1823-48.

Fly Lake- 1795-98.

Fond du Lac- 1856-63.

Frances Lake- 1842-46.

Fraser Lake- 1822-24.

Frederick House- 1785-1805.

Fort George (Columbia River)- 1824.

Fort George (Big River)- 1805-07, 1816-42, 1837-54,
1857-58, 1862-71.

Gloucester House- 1777-1795, 1812-18.

Good Hope- 1822-45, 1860-62 Mackenzie River

Gordon House- 1794-98, 1816-17.

Grand Lac- 1849-53, 1869-70.

Granville House- 1794-96.

Great Whale River- 1814-16, 1856-58, 1861-65.

Green Lake (English River)- 1799-1802, 1846.

Halkett F.- 1829-45, 1858-59.

Henley House- 1743-54, 1759, 1765-1816, 1870-71.

Hudson House (Upper)- 1778-79
(Lower)- 1779-1787

Hulse House- 1796-97.

Ile a la Crosse (Churchill R.)- 1805-06, 1810-11, 1815-16,
1819-45, 1847-65.

Indian Lake- 1805-11, 1819-23.

Island House- 1800-1801.

Island Lake- 1818-2, 1833-35, 1839-40, 1844-45.

Jasper House- 1827-31.

Kaipokok- 1850-57, 1861-66.

Kamloops- 1822-23, 1826-27, 1846.

Kaniapiskau- 1836-44.

Kenoganussi- 1794-1821.

Knee Lake- 1815-16.

Lac du Bonnet- 1807-08. Bas de la Riviere.

Lac La Biche- 1799-1800, 1819-20.

Lac la Pluie (Rainy River)- 1792-97, 1817-37, 1840-41.

Lac la Rouge- 1797-98, 1831.

Lac Seul- 1803-04, 1822-53.

Lac Travers- 1819-21.

La Cloche- 1827-36.

Lake St. John- 1846-54, 1865-67.

Fort Langley- 1827-30.

Lesser Slave Lake- 1817-27, 1830-31.

Fort Liard (Mackenzie River)- 1822-45, 1860-68.

Little Whale River- 1857-60, 1862-67, 1870-74.

Long Lake- 1815-21, 1828-32, 1834-36, 1859-62.

Loon River- 1798-99.

Lower Fort Garry- 1868-74.

McLeod Lake- 1823-24.

McLonghin Fort- 1833.

Manchester House- 1786-93.

Manitoba Lake- 1815-16, 1818-19.

Martin Fall- 1794-1812, 1818-71.

Matawaganiague- 1816-17, 1824-48.

Maltagami- 1803, 1816-|17.

Merry's House- 1817-18.

Mesackamy Lake- 1777-78.

Mesangamee Lake- 1815-16.

Michikaman House- 1845-49.

Michipicoten- 1797-1821, 1827-41. East end Lake Superior

Migiskan- 1829-67.

Miminiska Lake- 1785-86.

Mirgan (St. Lawrence River)- 1834-35, 1851-60.

Mistassini- 1814-15, 1820-64.

Moose Factory- 1730-31, 1871.

Nascopie Fort- 1842-63.

Nachvak- 1868-69.

Natshkwan- 1845-47.

Nelson House (Churchill River)- 1802-02, 1808-19.

Neniskan- 1794-99, 1805-09.

Neoskweskau- 1793-1820.

New Brunswick House- 1788-1842.

Nez Perce Fort- 1831-32.

Nichikun- 1834-70.

Nipawi- 1794-95.

Nipigon House (Lake Nipigon)- 1792-1803, 1827-39, 1842-44, 1870-76.

Fort Norman- 1822-45, 1861-67.

North West River- 1836-52, 1855-56, 1864-71.

Norway House- 1796-99, 1806-07, 1812-58, 1861-72.

Osnaburgh House- 1786-1863, 1868-71.

Oxford House- 1798-1801, 1810-12, 1817-22, 1827-51.

Peel River- 1840-44.

Pelican Lake- 1818-19.

Pelly Fort- 1793-1838, 1853-54, 1857.

Pembina- 1808-13.

Petaigan River- 1792-93.

Pic- 1827-41.

Pike Lake (Rupert River)- 1826-60.

Pine Lake- 1810-12.

Fort Pilt- 1830-32.

Pointe Bleue- 1866-68.

Portage de l'ile- 1793-95.

Portland House- 1796-97.

Rapid River- 1861, 1866, 1865-71.

Red Deer River (Swan River)- 1812-13.

Red Lake- 1790-1818.

Reed Lake- 1794-95.

Reindeer Lake- 1798-99, 1805-21, 1865-71.

Fort Reliance- 1855.

Fort Resolution- 1818-29, 1834-40, 1864-65.

Fort Richmond- 1750-59.

Rigolet- 1838-40, 1843-72.

Rocky Mtn. House- 1828-31, 1836-37, 1866-68.

Fort Rupert- 1849-50.

Rupert House- 1777-90, 1793-1810, 1822-71.

Rush Lake- 1821-22.

Fort St. James- 1820-33, 1840-51.

F. St. John- 1822-23.

F. St. Mary- 1818-21.

Shandy Lake (Albany River)- 1798-1801.

Sandy Narrows- 1807-10.

Sault Ste Marie- 1824-36.

Seaborn Fort- 1833-34.

Selting River- 1798-99.

Seven Islands- 1849-57.

Severn- 1759-1871 (Continuity)

Shell River (Swan River)- 1794-95.

Fort Simpson- (Mackenzie River)- 1822-1847, 1855, 1854-59, 1868-71.

Fort Simpson (Nass)- 1832-42, 1852-53, 1855-59, 1863-66.

Snake Country- 1824-32.p

Somerset House (Swan River)- 1794-96.

Somerset House (Turtle Creek)- 1799-1800.

South Branch House- 1786-94.

South River House (Kauiapiskau River)- 1832-33.

Split Lake House- 1815-16, 1824-25.

Sturgeon Creek- 1800-01.

Sturgeon Lake- (Albany River)- 1779-80, 1829-37.

Swan River- 1790-95, 1817-18.

Tadoussac (Sawuenay)- 1846-47.

Tenuiskamay- 1825-60.

Thunder Lake- 1806-07.

Timiskaming- 1840-41.

Fort Trial (George River)- 1841-42.

Fort Trial (Labrador Coast)- 1858-61.

Trout Lake (Severn)- 1807-10, 1814-15, 1826-28, 1843-65, 1868-72.

Turtle Lake- 1801-02.

Fort Vancouver- 1825-28, 1838.

Fort Vermilion (Peace River)- 1802-03, 1826-28, 1834-47, 1857-60, 1863-71.

Fort Victoria- 1846-50.

Waswanipi- 1820-70.

Wegg's House- 1795-96

Wepiskow Lake- 1793-94.

Weymmtachingue- 1827, 1846-47, 1857-58, 1864-68.

Fort William (Lake Superior)- 1817-51.

Windsor House- 1799-1800.

Winisk River- 1833-34.

Winnipeg- 1797-1800, 1814-15, 1820-30, 1839, 1851-54, 1858-60.

Winnipeg Lake- 1796-97.

Winskapan- 1863-69.

York Factory- 1714-1852 (1748)

Fort Yukon- 1847-56

Appendix C

NOTES AND COMMENTS OF THE JOURNALS

Although a great deal of the climate information contained in the Post and Meteorlogical Journals has been coded into this current study, many extraneous comments and reports did not lend themselves to classification. A mixture of phenological, proxy, and actual climatic information serves as supportive data to a more complete picture of the climate and its variablility. This appendix is a chronological listing by year, day and month of the comments as recorded. As the reader will note there is enormous potential for further research of individual elements throughout these notes. Most of the material presented here is verbatim from the original therefore the use of 'sic' occurs only in the first few entries as a reminder to the reader.

Remarks. York Factory

James Knight

B239/a/1

Old Calendar

1714

0709 Long passage due to the abundance of ice.

0709 Weather proving so bad we had like to have been lost and wee in very great danger in being in ye same condition there being so violent storm we struck several times by the sea running so high and the weather so thick.

1715

1401 A great flight of snow last night about 8" and a very great drift.

2901 Men out but not able to endure the weather Indians as well as English.

1302 Warm and thawed in ye sun a little.

1602 it has Rainie (sic) and thaw'd all day wind southerly till evening.

0903 Snowbirds come

2804 Geese

0505 sow'd some seeds in the garden

0805 8" thick ice.

0607 mosquitoes.

1007 Flies (Blackfly)

2508 Frost at night

1409 Turnips - we have had very cold weather and frosts for the time of year.

2109 frozen ever since the creation of the world (permafrost).

0710 Geese late

1110 Expect nothing but frost and snow till May

2710 Few large trees.

1716

0101 There has been 2 Mock Suns appeared all day long some distance from the sun. Very bright almost as the real sun, there went a large cross through them as bright as the brightest rainbow but it was strait (sic) not with a sweep as a rainbow is there was no part of the cross pointed to the sun for the arm that was single pointed to the SE and the other to ye westward of the sun. Pointed to ye NW but that part of the cross as pointed away both pointed to SW and North E.

2601 Petty dancers. - Northern lights.

0604 for there is not so much snow upon the ground nothing here as was when the river broke up last year nor the ice in the river not so thick by 2 foot as it was.

2404 Thunder and lightning at night.

2504 much thunder and lightning.

2604 Geese - 4" ground thaw'd.

0205 Garden sow'd.

0305 squalls of snow froze hard all day long but the snow is gone off from the ground allmost last year 8'6" and it is now 6' thick and yet has been much colder weather but the occasion of its being so thick last year was by the vast quantity of snow that fell and the hard winds that raised the tides to freeze to ice and this year we have had but very little snow but very cold northerly winds most part of this winter.

0705 because our summers are so short and the winters so excessive long and cold the sea being so encumbered with ice that it will be the latter end July before a man can gett with a boat (?) a long shoar and then he must be back again by the 10th and 14th of September or he will perish in the northern Latitudes for where we are at York Fort our May is no better than April in the Bottom of the Bay and our September is full as bad as there October.

1006 an extraordinary tide

1106 poor seeds and weather nothing showing in garden

1606 very cold and windy for the time of year snow'd in the night

2206 Cold and Raw all this spring no seeds.

2906 Frost

3007 we have had a pretty large frost tonight as likewise the night before killed vegetables in the garden.

1010 ground freezing hard now Thaw'd 8.5'

1510 more snow fell these 3 days than had fallen all last winter

3010 we have such abundance of snow on the ground I never know'd the like at this time of year.

2911 Petty dancers

0512 this day coldest I think I ever see.

2612 Petty dancers exceeding bright flew about which is a certain sign of bad weather.

1717

1803 ...now thawing time is coming on

1904 Geese

0905 only Spring day we have had this year. ground thaw'd 2"

1107 James Knight Journey to Churchill River

1107 Henry Kelsey keeping journal

1607 Knight returns

2309 Solar Deliguium caused such darkness

1718

1502 Ice 5.5' thick

1003 thaw'd a little being the first we have had this season.

2903 hath snow'd as much in these three days past as was upon the ground before all this winter.

1204 Geese seen

0505 Sow'd seed

0807 Ice in the river

1608 Froze thickness of a half crown last night.

2508 Ship arrived.

0510 more snow than all last winter.

1719

2001 Very thick Rhimey weather the forepart of the day which proceds from the sea and the mouth of Port Nelson river being open that when the is between the NW & E northerly the tuemy that rises from the open water drives on the land.

0802 the sun shin'd very clear and thaw'd on the eaves of the house that the ice ickels hang'd down a foot long.

3103 Moderate weather but has been the Severest Cold March that we have had since we came here.

2504 Geese seen

3005 very sultry weather and some of the plagues of Egypt appear.

1706 abundance of ice in river.

1720

1202 the fines day we have had for three months past.

1602 It thaw'd the forepart of the day with the wind in the SW Quad.

1904 Geese seen

2005 Sowed seed

3009 Snow knee deep

1721

0802 SW thawed a little

2102 Snow grains

0205 Geese seen

1705 Very close hot sultry weather.Very Dark in the sky looking of a very coprey couler I have not seen the like except the sun had been in a Eclip's

1722

0403 thawed a little being the first we have had this season.

1804 Geese seen

2407 excessive scorching weather

New record

1008 ------------

2309 Most of ice consumed by mod weather the like I never saw at Albany Fort at this time of year.

2809 Polar Bear

1110 Oldest Indian never knew such mod weather at this time of year.

1723

1404 This evening it rain'd hard with Thunder and lightning being rare at this time of year.

1504 Geese seen

2204 Most of snow consum'd

3006 extreme cold ice closes on shore

1507 18" ground frozen

0809 few geese

2309 Seal

1724

1004 abundance of snow consumed creek running

2704 all snow consumed

0505 Geese seen.17" snow since first of month.

0808 Ship arrived

0512 Extream cold weather

1725

0804 a vast quantity of snow on ground

1404 not one thaw as yet

0905 most of snow melted

2507 we have had abundance of hard rain this month.

1908 Ship arrived.

2609 we have hitherto had an extraordinary wet fall.

1311 so much moderate weather

1912 being first cold day we have had ye winter yet.

1726

0403 warm weather so as ye snow melts as it falls

1103 10' high drift of snow

1404 lack of deer

2304 Geese seen

1905 a continued snow 9 inches since yesterday.

2705 digging garden

3105 seeding

0306 few geese seen this year

1206 Hard winter for the Indians.

Anthony Beale

2908 new record with Beale.

1409 Eclipse of sun

1727

1504 Geese

2005 Dig'd and sow'd part of garden.

Thomas Macklish

1008 New record with Macklish

0609 Pitious weather

1728

3103 Snowbirds seen

2204 Geese seen

2705 Sow'd most of garden

1729

2503 Snowbirds seen

0604 most of snow gone

2604 Geese usually 8 or 10 of May

1305 Geese seen.Sowed garden

1805 Poor geese for four years

2306 very cold unwholesome summer

1007 ice in river ground froze hard below 6".

2407 Ship arrived

0211 we have hitherto had such a fine fall as the like has not been known in the memory of the oldest Indian at this place.

2311 never was known such a long continuous of moderate weather at this time of year.

1730

2404 Geese seen

1105 Water not rising suggesting cold is extensive.

0206 digging garden

1306 sowed - but wet and frost in ground

1008 Ship arrived

1012 so cold that 2 men froze in sawing a little wood before gate.

1731

1002 Here has fallen more snow since Monday last than has fallen since first of winter.

2604 Geese seen

0506 digging garden

0808 new journal

1732

2403 Snowbirds seen

Thomas Macklish Jr.

0304 Here has fallen as much snow since last Thursday night as has fallen the whole winter.

2004 Geese seen

1205 As much snow since Sunday as has fallen all winter

0206 digging part of garden rest still frozen

0108 Ship arrived

1733

1503 Snowbirds seen

1904 Geese seen

1008 Ship arrived

1011 Almost total eclipse of moon.

1734

1502 Men froze going a little way for water

0703 as much snow since Saturday last as all winter

1903 Snowbirds seen

0405 Geese seen

0506 sowed seed rest of ground so wet and ice so in ground that we cannot sow any more seed as yet we have had hitherto a very cold and uncomfortable spring and Summer.

0408 Ship arrived

Thomas White

0808 New journal Thomas White

1909 Continued snow all night not less than 6" snow on ground which is extraordinary early for snow to lye on ye ground in such quantity.

1735

2503 Snowbirds seen

1604 most snow consumed

1804 not as warm up country as we have had this spring

2404 Geese

1005 very few geese

2605 sowed garden

0407 complain cold winter vast quantity of snow cold winter dress skins.

3107 Ship arrived

2110 2' of snow

1736

1005 Geese seen

1106 Buffaloes (sic) mentioned.

2208 Ship arrived. -Hudson Bay lost.

1737

2804 Snowbirds seen

0205 Geese seen

2907 Ship arrived

James Isham

0708 new journal James Isham.

1738

0503 hardes gale and greatest drift of ye year.

0205Geese seen

0408Ship arrived

2609 Eclipse of the sun.

2012 extreme cold sharp weather so that we can scarcely keep ourselves warm by a good fire in Factory.

1739

1703 Snowbird seen

2304 Geese seen

0805 River rising

1305 Froze very hard 10 nights past.

1405 digging garden

0706 Lightning fires

2408 Ship arrived

1739

Missing from Aug. 29 to July 28, 1740 - Ship sank at Severn

1740

2807 Journal commences

2710 Never was such cold weather know at time of year

1741

0103 Winter excessive cold

1005 Geese seen

1706 Plenty of musketoes.

0408 Ship arrived.

Thomas White

1008 New Journal Thomas White.

1742

0601 Rain (?)

2204 most of snow gone

3004 Geese seen

0108 Ship arrived.

1743

2904 Geese

1008 Ship arrived.

1744

0501 Rain in afternoon

2204 Geese seen Great deal of snow melted.

2404 most of snow melted

0405 Sow'd seeds

1208 Ship arrived

1410 Snow mostly melted.

0510 Surveyor measuring river.

1745

1804 most of snow melted

2804 Geese seen

0505 fine weather for some time.

2807 Ship arrived

1746

1503 Snowbirds seen

2704 Geese seen

0208 Ship arrived

James Isham

1408 new journal James Isham

2709 This 15 years past never knew such a continuance of open weather so late.

1747

2903 Froze very little since 19th

2304 Geese seen

0808 Ship arrived.

2809 Something bitter

1111 Many bears about Fort.

2212 River open 80 miles up.

1748

2001 Dismal winter

2101 Insufferable cold. Almost froze my arm in bed.

0102 Insufferable sharp

0402 No one out

0502 Sad weather

1202 prodigious sharp.

1003 Winter violent cold.

2503 Snowbirds seen

1504 High water - river broke.

1904 Geese seen

2507 Hay and cattle.

1808 Ship arrived

John Newton

2808 New journal John Newton

0809 Sultry hot weather I hardly remember the like at the time of year in any Latt above 40 degrees.

2711 Yet far from very cold weather (at least such as I expected long ere this time).

2812 Fine clear sharp weather and indeed in my opinion for the time I have been here taken together have had the weather preferable much to what I ever saw or expect to see in England in the same month.

1749

0202 Coldest of winter

0302 Drifts 10-12' deep.

3003 The snow wastes considerably Daily tho' very little or no water made by it as I take it the great heat of the Sun occasions it exhale chiefly.

2204 Snowbirds seen

0105 Snow depths 4-12-15' hard packed ...the old Standers several times this winter agreed (and I must note, that it is I think the only thing I have hitherto found any two of them agree on) that they had not seen near so much snow in any winter before.

0405 Geese seen

0907 Very warm (I never felt it more so in England)

2607 Ship arrived.

0410 Considerable quantity of snow

1110 Snow keeping ice from forming.

1610 Corono with parhelia for first time this winter

1811 Very troublesome to write ink freezing in pen.

2611 Calm moderate clear weather (a rarity this winter).

0412 Hard walking for snow.

1750

0601 People kept in 3-4 days due to cold.

1701 Coldest day this winter

2703 7' snow

2803 Showers of rain 3 to 4 hrs

0704 thawing in shade as well as sun.

1904 Geese seen

2406 Regular land and sea breeze.

2706 Newton drowned

2806 Journal kept by Skrimsher.

1808 Ship arrived.

James Isham

3008 new journal James Isham

1751

1503 Snowbird seen

2804 Geese seen

0605 Sowed garden

2507 Ship arrived

0808 Carpenter fell overboard

2511 Thick River action of north river being open.

1752

1201 it has drifted to that degree ever since Wed. night last we have not seen a 1/4 of a mile from the Fort since till 4 this afternoon.

0902 Size of Moose described.

2403 Snowbirds seen

1904 Geese seen

0205 Sowed seeds

0606 At 4 afternoon froze hard and very cold Snow lyes as it falls much such weather as we commonly have in October (not June).

2307 Ship arrived

0209 Last entry under old calendar.

1409 First entry under new calendar.

1753

0401 small snow or what is called a Rhyme which comes of Nelson River it being open yet.

1301 at 8 this morning fill a hogshead of water out of the river left it upon the ice for an experiment to see how long before froze solid.

1501 Hogshead solid at 10 this morning.

2901 Thaw very much all last night and this day. it has not froze any since 22 Instant. A great deal of snow consumed Very remarkable such a prodigious thaw at this time of year.

3001 Snow and Drift and Sharp ie notwithstanding it thaw so much till 10 last night. Ink freezes today in house.

0802 Ice 4'1" thick.

0504 Snowbirds seen

0205 Geese seen

2708 Ship arrived.

1710 Snow Sleet and Rain Surprising weather for the time of year.

2510 First night it has froze anything worth noticing.

1754

1002 very little snow as yet upon the ground in comparison of some years by this time.

1202 thaw has been for these many days.

0304 Snowbirds seen

0205 Geese seen

2805 Sowed garden

3108 Ship arrived

1755

1501 Ice 3'4" thick.

0604 Snowbirds seen

0405 Geese seen

1505 Sowed seeds

2305 Scrimshire dead

2308 Ship arrived

Thomas Hendy

3008 New journal Thomas Hendy

0311 So warm see magpie first I ever see alive at this fort, at Churchill killed 2.

1756

3103 Snowbird seen

0705 Geese seen

1105 notwithstanding the sun has such power it has thawed none since Sunday morning.

0206 Sowed seeds

0208 Ship arrived.

2109 Indians surprised to see Snow none 50 mile S.

0211 The river entirely fast as low as the Cross Barr, never knew it to fasten so soon by 15 days, and sometimes a month later.

1757

2001 Ice 3'10"

2801 Brandy freezing

0203 Ice 5' thick.

1303 Mittens on in bed because of cold.

3103 Snowbirds seen

1904 Caribou crossing river.

2504 Geese seen

2804 Severity of weather froze beer in cellar.

0605 sowed beans and peas.

2807 Polar Bear killed.

0908 Ship arrived

2710 for want of frost cannot preserve provisions

1111 Surprising weather for the time a sudden thaw rained hard best part of day.

1758

2403 Snowbird seen

0605 Geese seen

2405 Sowed seeds

2505 Ice broke out to sea.

1406 Snow Surprising weather for the time.

2606 Weather more like March than June.

0609 Ship arrived.

Humphrey Marten

1609 New journal Humphrey Marten

0110 last 48 hours has fallen the greatest flight of snow I ever saw at this time of year.

0311 Ink freezing in pen

2011 10" ice.

1512 I think it is as cold as ever I felt it.

1759

2301 Indian says snow as deep as ever he saw it.

1503 I think we have had as much snow this year as in the last 2 years.

2503 I think it worth notice of the wind remaining so long in the E quarter without any snow falling.

3004 11' drift.

0905 Geese seen

1506 Freezes harder than I ever knew it at this time of year.

1908 Ship arrived.

James Isham

B239/a/47

2908 New journal James Isham

1760

2001 Thick Rime (which is caused by open water).

2702 Extraordinary weather ever since the 17th (warm)

2903 Snowbirds seen

0105 Geese seen

0605 2 times snow about Fort more than I ever knew

2705 Sowed garden

1007 Washing in river it extreme hot.

2508 Ship arrived.

1761

1801 Last snowbird Rarity this time of year.

1002 Very little snow as yet.

0503 Ice 4' thick

2903 Snowbird seen

2404 Ground bare of snow

0405 Impossible to dig ground before July

0505 Geese seen

3006 Stockade blow down

1608 Ship arrived.

1412 Sharp as I ever knew it this time of year.

1762

0904 Snowbirds seen

2604 little snow on ground Indians report.

1005 Geese seen

1705 Sow'd seeds

Ferdinand Jacobs

0409 New journal Ferdinand Jacobs

1763

0905 Geese seen

2908 Ship arrived

1764

1501 Rain all last night and till noon this day which has thawed the greatest part of the little snow that was on the ground a very uncommon thing at this time of the year.

1005 Sowed seeds

1208 Ship arrived

0712 Last night channel froze over which is a month later than last year.

1765

2102 Porcupine mentioned.

0405 Geese seen

0509 Ship arrived.

1110 dug up garden

1766

0905 Geese seen

1406 Changeable weather

0708 Ship arrived

1767

0805 Geese seen

B239/a/57

2808 Ship arrived

1011 It is very Remarkable we have no snow on the ground, nor have we had but one Days snow this year, on Saterday the 17th of last month, which thaw'd away very soon.

1768

0905 Geese seen

1806 few whales.

0806 York Boats mentioned.

B239/a/58

1008 Ship arrived.

0110 We have had so much wind Rain and Snow in the last month has been a great hinderance to our gathering sufficient quantity of hay, and the bad weather has spoiled a considerable quantity of that we have got.

1769

0505 Geese seen

1408 Ship arrived.

1770

2604 much snow very great Drift and cold (never see so much snow).

0105 Geese

2408 Ship arrived.

1771

1405 Geese seen

2508 Ship arrived

Andrew Graham

0408 New journal Andrew Graham Meteorological Journal -

1772

B239/a/68

2108 Journal kept by Ferdinand Jacobs.

0811 Snow which melts on the ground

1773

0905 Geese seen

2208 Ship arrived.

1774

1708 Ship arrived.

1775

0305 Geese seen

1105 No sign of river breaking.

Humphrey Marten

2708 New journal Humphrey Marten

B239/a/73

0606 White Whales (Beluga)

1408 Ship arrived.

1776

1301 Brandy thick as jelly.

1305 Geese seen

1607 Ice in river from Bay.

2208 Ship arrived.

1777

1005 Geese seen

2907 wet uncomfortable weather

1778

0402 the sky very full of angular ice particles.

0904 Snowbirds seen.

0305 Geese seen

1507 the offing full of ice 10 miles distance.

2408 Ship arrived.

2909 Meteorological record

1780

2808 New journal

2710 Eclipse of sun.

1811 Steem from North river.

1781

0304 Thermometer 44 above the cypher at 6 PM it blew almost a hurricane with a great drift of snow thermometer at 9 PM sunk to 10.

1105 Geese seen

0307 Thermometer at 6 this morning at 92 highest I ever knew it.

1307 Thermometer dropped 72 to 50.

1908 Ship arrived.

Mathew Cocking

3008 new journal Mathew Cocking

1309 N. B.The characters + and - which are annexed to the Altitudes evidence that they stood so many degrees above or below the cypher. The altitudes will always be taken at 12 o'clock.

1782

1204 Sun eclipsed

1005 Geese seen

2808 Fort captured by the French no journal from Aug 1782 to Sept. 1783

1783

1509 New Journal

1784

0304 Snowbird seen

1505 Geese seen

1907 Foggy wet raw cold uncomfortable weather more like the latter end of October than the middle of July.

0109 Ship arrived

2510 This channel set fast but did not stand, at the house but a mile above it is fast from side to side. which is 24 days sooner than last year.

0511 Thickish occasioned by the Steam that arises from the open water

1785

0205 Geese seen

2508 Ship arrived.

1786

2602 exceeding sharp this continuance of cold weather occasions a prodigious consumption of firewood, the officers declaring they cannot do without an almost constant fire. The firewood already consumed is I think as much as ever I remember during a whole winter in any year since I have been in your Honours service.

1907 much ice in sight

0208 as cold as in the latter end of November in England

Joseph Colen

3008 New journal Joseph Colen

1787

0603 excessive cold more so than I have felt it this season.

1803 more snow in 2 days than all winter.

1404 few drops of rain fell the first for nearly 6 mos. last rain at York was 19th Aug which is 177 days.

0105 Geese seen.

2205 2 feet snow

2106 The severity of the weather last winter hath proved fatal to many who have large debts: parents compelled thro' piercing necessity of devouring their own offspring.

1508 much ice appeared in sight

2708 Ship arrived

0610 French creek is set fast which is earlier by one month than known for years past.

1310 Snow above tops of door.

2210 Game of all kinds scarce but that White Bears are so numerous and troublesome as to attack them and their stages where their provisions is deposited.

2312 Late in the evening large herd of wolves surrounded the Factory.

1788

0305 Geese seen

1708 Ship arrived

1789

0301 No partridge

0902 Gusts of wind became so strong that feared for building.

2803 The snow fallen yesterday and last night is four feet deep

0104 Comments on Scurvey and lack of game.

3004 they (Indians) say the Snow is deeper than they ever saw it at this season of the year indeed it is from 6' to 10 feet deep around us.

2508 Ship arrived

3010 The most sudden change of weather I ever before noticed in one day. This morning the Thermometer being up at 40 and at eight o'clock in the evening below 0.

0312 Timber in short supply

1790

0803 Comments on food supply

0604 Snowbirds seen

3005 Very few geeses.

0107 Comment on river being very low.

2408 Ship arrived

0110 Mice a problem

1611 Weather colder this day by 23 degrees than any this season being 2 degrees below the cypher.

1791

3103 An old native now on the plantation tells me he has not seen the snow so deep as it is at this time since the winter after Governor Isham died.

0406 Never was such a continuance of cold weather known at this Season of the year. Snow is many feet deep in our garden.

3108 Ship arrived.

0910 The river ice upwards set fast, 5 weeks earlier than ever I knew it to be froze over.

2412 Comment on lack of food.

2512 mild as to thaw the snow from the Leads of the dwelling house, which is a singular phenomena at this season of the year at this Factory.

1792

0801 During last night - Brandy-Rum and Quicksilver froze solid in Phyals placed in the open air, the latter became malleable.

0502 They (Indians) also inform me that the winter set in so early upwards that many Swans and other waterfowl were froze in the Lakes and they found many of the former not fledged, they likewise say that the snow is remarkably deep.

1903 as cold as ever I felt the severity of the weather.

2604 Geese seen.

2008 Ship arrived

1511 No Rain has fallen so late in the season for seven years past.

1793

0202 The weather has been severe within these few days past as to freeze our English Brandy so solid as it could not be drawn off.

1802 Comments on unwashed men.

0504 Light Snow. Much the same as that which falls in England.

1806 Ice 1/2 inch thick.

1008 Ship arrived.

0210 More successful this fall killing geese than any preceeding one for years past.

1794

2501 Very deep snow, the height of a man.

2704 Geese seen

2708 I do not remember such a continuance of heavy rain as that which has fallen for three nights and days.

1795

0105 Geese seen.

2708 Ship arrived.

1796

No weather recorded by Joseph Colen for this year which seems to suggest that there was a concurrent meteorological journal

1797

3110 Coal mentioned.

0112 Remarkably mild thermometer nearly at freezing point.

1798

0102 Remarkably mild WSW till 3 PM when thermometer stood at +42 wind changed to NW blowing strong then rapidly fell to 8 below in the evening.

0405 Geese seen.

1405 Garden begun

1407 53 degrees colder today than it was yesterday.

0409 Ship arrived

Thomas Ballenden

2309 New Journal Thomas Ballenden.

1799

2701 Severe weather. During my residence in Hudson Bay I have never seen the like. (Temp. -53).

3004 Geese seen

2908 Ship arrived.

1411 In general the fall has hither to proved more favourable than has been known for many years past. Very little snow as yet on the ground.

1800

1702 Indeed this winter is very remarkable for its fineness of weather, scarce a day but a person might have walked anywhere without equiping him much in his winter dress.

2703 Snowbirds seen.

2804 Geese seen.

0905 Swallow seen as early as I ever heard of.

0906 Digging garden

2709 Much snow on ground.

0912 No country provisions.

1801

2801 Brandy freezes to consistance of oil

2202 Remarkable sharp weather - thick throughout the whole of the winter, so far has been as cold as ever I have known.

0404 Snowbirds seen.

2004 Cold disagreeable weather as I ever knew at this season.

2704 Geese seen.

1605 NE and little variance from that quarter the last fortnight.

0506 Digging garden

0408 Disagreeable weather as ever was seen at this season.

2708 Ship arrived.

John McNab

1509 New Journal. John McNab.

2004 Geese seen

0706 Digging garden

2306 Sowing garden.

0208 Heavy Rain till noon the first of continuance since the latter end of May.

1408 Ship arrived.

1803

-Very few entries -

1804

0508 Ship arrived.

1310 A daily sameness for months to come may now be expected.

1805

0104 Now the occurrences vary daily.

0905 Geese seen.

2705 Digging garden many deer seen through this year.

1806

0203 Many foxes and Martens.

1304 Plentiful Partridges.

2004 Successful winter.

1105 Geese seen

2306 Heavy fall of snow all this day.

1808 Ship arrived.

2310 So mild weather at so late a period was never before witnessed by the oldest native about the Factory, and there are two now on the plantation who well remember two vessels sent on discovery wintering in Ten Shilling Creek.

0712 Snowbirds still around

1807

1801 Winter continues uncommonly mild - on the 16th a a Gull was seen a rara avis in terra.

1705 Many hundreds of deer seen above the mile sand crossing the river.

2305 Indians from Oxford House says the season is backward, many of the lakes still fast.

1706 Seeded garden.

1707 a summer of scarcity

3107 That oldest men say they never saw a summer of greater scarcity at York.

1909 Ship arrived

0111 Weather fine as in July.

1808

1001 Weather remarkably mild and has been hitherto since winter commenced.

0802-0814 Very severe weather during this week.

2904 Geese seen

2108 Ship arrived.

2809 First fine day for weeks past.

1809

2104 Geese seen

0609 Ship arrived.

William Cook

1509 New Journal William Cook

1810

0101 Indians complain of scarcity of food.

1201 Scarcity of partridge and rabbits.

0905 Geese seen

1908 Ship arrived.

2008 No deer in any direction.

1811

2001 Thus are we receiving supplies from one party and witnessing the most abject poverty in another but it is perfectly consistent with the nature of the country that it being not at all uncommon for one set of Indians to be absolutely starving while another party at the distance of 40 miles are living in the utmost profusion - so local are the haunts of animals in this part of the Globe and so uncertain the daily supply.

0505 Geese seen

2109 Ship arrived.

1812

0904 Scarcity of furrs around Factory is without a parallel.

2811 frozen feet and no wonder as the Thermometer for the last 3 nights was -36, -42, -38.

1815

2702 Snow on ground 2'5" in level places.

0805 The snow when measured proved to be more than has fallen at any time during the winter being in depth 2 feet in level places.

1505 Geese seen

2708 Ship arrived.

J. Swain

1709 New Journal J. Swain.

1816

2902 Weather more intensely cold than ever I knew it before in Hudsons Bay during a period of 25 years having tried the freezing of Mercury, find the thermometer not erroneously graduated as some are.

0705 Geese seen.

1817

Ship lost at Sea with Journals.

1818

1811 Very mild for the season much more so than has been known these last thirty years.

1819

0904 Snowbird seen

0605 Geese seen

1820

3001 Very cold quicksilver remained frozen or in a malable state the five last days.

2603 Snowbird seen.

1105 Geese seen.

1011 Clear for the first time these five weeks being continuous cloudy.

1912 Very cold being the first time this season.

1821

2301 extremely cold quicksilver frozen like a piece of lead.

0402 Very little snow since the commencement of winter.

1703 extremely cold even more so than it has been during the winter.

0304 snow melting fast being uncommon at so early a period in this part of Hudson Bay.

1604 Goose seen uncommonly early for this part of the country.

2208 Ship arrived

0412 River frozen for first time this fall.

1822

2801 Some quicksilver that had been put out some time ago for trying the cold was observed to be frozen while the thermometer was only 36 below zero which proves the weather to have been six degrees colder than per the thermometer.

2102 Eclipse of the sun (total)

Dr. Todd

0609 New Journal. Dr. Todd.

1823

1105 Geese seen

1806 Some snow on the ground.

0909 Ship arrived.

1824

1202 -43 the quicksilver remained solid the whole of the day.

1009 New journal

1825

2802 From the rain and mild weather lately there is now a hard crust on the snow.

2006 6" snow on ground

1508 Ship arrived.

0110 +64 degrees This allowed to be an extraordinary occurrence.

1826

1105 Geese seen.

0709 Ship arrived

1909 New journal Hargrave.

0812 During last night we had a heavy shower of rain.

1827

B239/a/139

0112 Temperature of the water 32 degrees above the Cypher.

1828

2303 Being the greatest fall of snow we have had this season.

B239/a/140

0106 Brief journal entry

1829

B239/a/142

0106 Meteorological observations by Robert Miles.

1830

B239/a/144

0106 Meteorological Journal.

1831

0102 Very mild February

1832

Meteorological Journals end May 31 1832 . Recommence Oct. 8, 1837.

B239/a/153.

1834

1310 Low state of the water and early commencement of cold season.

B239/a/148

0111 River clear of ice sufficient to allow a boat crossing.

2511 Season's snow so slight walking without snow shoes.

1835

0901 Ice on Hayes River measured opposite Factory - 3' 2 " thick. This was considered less than expected considering severity of weather throughout last month.

2503 The ice on the middle of the river abreast the Factory, where the blocks of ice were cut for the ice House was this day measured and found to be 5 1/12 feet thick.

0905 Geese seen.

B239/a/149

1809 new journal

1010 Halley's Comet observed at 8 P. M.

1836

1501 The quantity of the snow which has fallen this season is unusually great, measuring among the heavy woods where it has not drifted full 40 inches deep.

1901 Discussion on Thermometers ie their accuracy and the freezing point of Quicksilver. The expression of doubt as to the correctness of the records as kept for the past 5 years using one of these "Gilbert, London" thermometers.

2002 Firewood duty...this duty in this season scarcely practicable owing to the immense quantity of snow fallen.

1838

B239/a/150

B239/a/151

1509 New Journal

2210 This season so far is unusually moderate. The ground is yet uncovered with snow the swamps as open as in the middle of July, and no ice on either of the shores of the river, or drifting with the Tide. Indeed the mild weather this year has endured a full month longer than any instance within the last 10 years.

2911 The weather has assumed a degree of mildness quite unusual at this season of the year.

0812 Small pox Vacccine. Distribution figures.

2112 The weather still continues cloudy but scarcely any fall of snow, and is unusually mild for the season.

2912 - 35 degree by the incorrect one presently in use here, which when rectified may be registered at - 44 degree full.

1839

1602 new journal keeper Mr Gladman.

2505 The quantity of snow fallen these few days past is much greater than we have had for months.

2207 the ice still forms an impenetrable barrier from Port Nelson eastward and Cape Tatnum; between which and the shore even a small boat cannot as yet find a passage. The prevalence of Northerly winds is considered to be the cause of this.

1708 the proximity of the ice to the coast... up to the unprecedented date of the 3rd Instant.

B239/a/152

0809 new journal

1840

1301 Nelson River now frozen over.

1704 The thermometer ranges from 0 to -7 at sunrise generally this month.

0705 Geese seen.

Nicol Finlayson

1507 New journal Nicol Finlayson.

B239/a/154

0609 new journal

2612 overcast with clouds of evaporation from the open water around us.

1841

0505 The snow is at this date as deep as it was in the month of February....the season is more backward than it has been known to be since 1822.

1805 In consequence of the lateness of this season and the late thaw some apprehension of an inundation, such as had occurred in 1836 has been entertained.

B239/a/155

1209 new journal

1842

2005 No perceptible rise of the water has taken place.

1006 ...owing to the very uncommon low state of the water in the river.

3006 still unusually cold for the season. The nights are cold with hoar frost, and the willows and trees around the Factory stil look as bare of leaves as they did in January. No Moschettoes have yet made their appearance, a circumstance in the month of June almost unprecedented at this Factory.

0108 Southerly winds bringing clouds of smoke from the interior where the woods are evidently on fire.

B239/a/157

1309 new journal

1843

2005 Geese seen.

B239/a/159

2009 new journal

1844

0202 He adds that the reason why the proceeds of the fishery this season are not so large as those of last, was the dried up state of the shallow lakes where the fish are procured owing to the great drought of last summer.

0405 Geese seen

1005 Late coldness of the weather

2411 Moon eclipsed

1845

No daily journal for 1846, however John Rae's meteorological journal provides coverage.

B239/a/164

1845 - 46

1845-46 John Rae Memorandum

In noting the force of the wind and description of the weather the figures and letters recommended by Capt'n Beaufort have been used. It is unnecessary to enter their explanations here, as they are to be found at page 94 at Raper.

The Thermometers were suspended within a couple of inches of each other, under a funnel like covering of stout canvas, facing north and protected as much as possible from the sun's rays at the same time quite detached from any building. Height of thermometers from the ground, four feet six inches- thermometers A & B did not at first agree closely, on account of a small quantity of the spirit having got fixed in the upper end of the tube of one of them. This was removed by applying a piece of heated iron close to the detached spirit until it converted into vapour, which was speedily condensed by the spirit in the lower part of the tube. Some of the camphine in Ther #263 having got lodged in the small expansion at the upper end of the tube, was displaced by the above method, most of the usual plans having been first tried.

	Thermometers				Therm
	A	B	#236	WB	A and B by J. Jones Charing Cross
Freezing point of Water	31.8	31.8	32.2	32.4	#236 and WB by J. Newman Regent Street
	31.9	31.8	32.3	32.4	
	31.8	31.8	32.2	32.3	
Means	+31.8	+31.8	+32.2	+32.4	The WB Ther is probably more correct at very low temperatures than any of the others.
Freezing point of Mercury	-36	-36	-37.2		
	-35.8	-36	-37.0		
			-37.0		
Means	-35.9	-36	-37.1		

The quicksilver with which the Thermometers were tested was exposed for a week to the free action of the air and retained its' metallic lustre on the surface, thus shewing (sic) that it was unadulterated (sic) with any other metals. The Thermometers were immersed to the depth of two inches in the mercury whilst it was in a semifluid state. The wet bulb thermometer, varied so much from the others at different temperatures that its use was discontinued and Thermometer A fitted up so as to supply its place.

The Barometer is one of Newman's with iron cistern. It was hung in a room, the lower end being three feet from the floor and about 30 feet above the level of the sea at half tide. The data for corrections - for Capacities 1/54

Neutral Point 30.302
Capillary Action +. 042
Temperature 60 degrees

The winds are entered from the true points of the compass. The bearings of the centres of Aurora are registered from the true North, and their attitudes taken with a small quadrant having a narrow tube and plummet attached. On trying the correctness of this instrument it was found to measure the altitude of an object (if care was taken) within half a degree.

Not having a Declination magnetometer I could take no note of the effect of the aurora on the horizontal suspended magnet or needle.

1846

3004 Geese seen

0505 Ice breaking up in the river being the earliest known for many years.

B239/a/168

2309 New journal

1848

2404 41 degree change in 12 hours.

2206 Snow lay full five inches deep.

1849

2502 48 degrees change within last 24 hours.

2404 wind rolled up lead on roof

0505 Geese seen.

1012 Very long period of mild weather this autumn. Letter from Oxford House. All lakes and rivers still open.

1850

1904 Snow is too shallow and crusted to admit of their approaching the deer.

B239/a/176

0709 New journal

1851

2703 Snowbirds seen

CHURCHILL FACTORY RECORD

B42/a/1

H. Stanton

1718

1309 Geese left. Weather bad (snow, hail, & rain.)

1809 food shortage for Indians

2309 snow 4' deep

2409 ice thick on river in morning, clearing later

1110 river clear of ice

1210 river closed

2010 hunters report no partridge

2710 snow 7' deep

3010 weather to cold to hunt

2211 no deer

1012 weather extremely cold Indian could not return back to north this day without freezing

1812 cold sharp weather ordered all men to come home next Sat. with their things

1912 Indian told me the partridge had taken their flight not having anything to feed on for the deepness of the snow

2112 Indian family came starved

2912 Weather so bad men not able to face the wind

1719

2102 snow drifted as high as our heads

2802 men freeze in sawing wood for the stove

3002 mild weather. Hunters killed 4 Buffalo.Being almost starved before they met with this good fortune. Likewise they caught a beaver but their hunger being so extreme that they singed the hairs off the skin and ate the pelt.

2802 the wind at the S. E. hard gales and much snow. we have not had three good days this month to work in.

0604 beginning to thaw

2004 snow thaws as it falls

2904 the young hunter came down the river with a goose and 3 white gulls and 1 eagle having seen many geese up the river

0705 the wind at S. W. the latter part it came away to the N. W. blowing fresh gales and much snow.The young hunter after 6 nights absence brought to the Factory 30 Geese he killed them yesterday. This morning our men killed 5 geese and the 3 Indians brought to the Factory 15 geese. The cold and bad weather intercepted their game but if the wird had continued in its first station S. W. we might have better hopes of plenty of geese. I pray God divert the storm

1106 river open

3006 ship arrived

1208 abundance of geese sighted

1908 ship left for England

2408 cutting firewood weather beginning to be cold

1309 river frozen

1720

0402 "so cold that those who stand at the saw to cut firewood freeze. "

0403 rained. Snow like glass.Some men & Indians snow blind

0804 starting to thaw

1104 "Evening very cold for this time of year and it seems to

1304 4 geese killed

0205 "plenty of geese sighted. "

1505 first mention of any abundance of geese killed "46"

0806 "river opened"

1706 Whales in river but able to reach them for ice

3006 fishing impeded by ice

1721

0305 geese return 3 killed wind S. E.

B42/a/12

2008 "an Indian say they saw something at sea 5 nights ago that looked very big but it was a great way out and if it be a ship pray God she Maybe well for we have had very bad weather

2208 ship at Factory left (York)

2408 five geese killed

1309 geese gone

1709 ship left for England not stopping at Fort because of weather

2309 "Endeavoured to get the vessel in but could not the tide being very low at present for the season of the year. "

1010 River full of ice

1910 River clear of ice

2010 River frozen

1722

2302 men cannot see 100 yards to windward neither can one hardly get out of our gates for snow.

2503 Indians cannot return to family because of snow they saying they have not seen so much snow upon the ground for many years. Up to there necks in the woods. Drifts. 5'

2803 Inclining to thaw

1304 Rained very hard last night. Every one indoors because it was too slippery to stand outdoors.

1604 Indians starving

2704 First gull sighted

2804 2 geese seen

1505 (across river) land covered by water

3105 Geese gone

0106 River open

B42/a/3

0408 ship from England arrived

Mr. N. Bishop

1409 fishing bad during summer

2211 river frozen

2912 Very fine warm weather for the season of the year.

1723

0903 Until now very mild winter plenty of food

1704 Indians trading for brandy & tobacco

2604 Geese sighted

3004 6 geese sighted

0605 Cold stormy weather. Geese diverted inland. Indians starving.

0805 Weather extemely bad since 29 April

1305 450 geese killed (first large kill)

1405 Afraid we shall have but an indifferent season for we have had such a warm winter. (geese)

0706 river broken up

2506 ice thick in river

3006 Mr. Bishop dies.New Author Richard Norton.

Richard Norton

B42/a/4

0608 ship leaves for York Fort, 3 geese killed

1708 ship arrived

2308 ship sailed to Fort York

2509 geese gone

0811 River frozen

1724

2304 first geese sighted

0105 hurricane winds

0305 Indians starving

1505 200 geese killed

1506 River open; geese gone

B42/a/5

1708 ships in harbour

Richard Norton

2108 ships left

2308 lots of geese killed

1109 every one collecting wood

1909 snow

1725

0205 a few geese sighted

1405 goose season hindered by weather

2607 goose killed

B42/a/6

0608 2 geese killed

Richard Norton

1209 geese gone

1310 tides 7' higher than usual

1810 river frozen

1726

3004 1st goose sighted. Wind S.Great deal of water and bare ground

0905 20 geese killed

3005 Men worried season (goose) is over.

0606 river open

2606 ship sailed to York for supplies

B42/a/7

1308 ship sailed

R. Norton

2008 geese killed

1210 drifting snow

1510 ice in river

2311 river frozen

1727

1904 Indians sight 2 gulls

2104 2 geese sighted at Factory. Sooner than usual for any geese to be seen here.

2504 no more geese sighted

1005 35 geese killed

0106 river clear of ice

0308 ship at anchor in mouth of river

B42/a/8

Thomas Bird

0608 Thomas Bird now Author; ship sailed

1908 2 geese killed

2208 ship at Fort

3108 ship sailed

1409 geese gone

1609 snow

1611 river frozen over

1728

2804 first goose sighted

1205 28 geese killed

0206 river open

2907 ship arrives

B42/a/9

0508 ship sails

Thomas Bird

0908 8 geese killed

2311 river frozen

1729

1104 Indian hunter and families return to Fort hungry

2104 goose sighted at Factory

2904 2 geese killed

0805 30 geese killed

1505 geese gone

0106 river open

1807 ship arrived

B42/a/10

2707 ship sailed

Thomas Bird

1211 river frozen

1730

2604 geese sighted at Factory

1306 river open

0407 ice driving up into river

0308 ship arrived

B42/a/11

1208 ship sailed for England

Thomas Bird

1809 snow

2411 River frozen

1731

0205 6 geese sighted

0406 gardens planted

0906 river open

2807 two ships arrive from England

B42/a/12

1408 ships sailed for England

Richard Norton

0810 ice is thick in the river. 3 men in a boat attempted to cross and were stuck. They tried to cross the ice on foot and fell in. 1 died.

2911 (Fishermen) They are complaining the water (lake) is very shallow. Insomuch they cannot keep their nets from freezing to the ice.

1732

2802 All people employed hauling home firewood.

0104 Indian women came to the Factory being starved almost to death.

2104 1st Gray Goose brought home by an Indian.

0606 river open

1108 ship arrives

B42/a/13

2508 ship sails for England

Richard Norton

2710 People employed at digging of earth and covering the top our our square houses as the boards being too thin to keep out the weather.

1733

0701 starved Indians arrive at Fort. News of a bad winter told to them by other natives.

2104 first goose killed

2106 river plaqued by ice

0408 2 ships arrive

B42/a/14

1608 ships sail

Richard Norton

0810 have to haul water for cattle as water supply dry. River frozen over.

1734

0101 men play football

1302 calf died. Attributed to piercing cold weather.

2004 geese sighted

1206 river open (broke up)

2807 ship arrives

B42/a/15

0808 ship sails

Richard Norton

2509 much ice in river

1734 Date B42/a/15

2809 Wx not at all inferior to usually the month of Nov.

0710 Flood in River

1912 Not able to go outdoors.

1735

2702 Bad storm

2903 Such great quantities of snow on the ground we have not had ye least sign of spring or summer approaching as yet wx little inferior to ye dead of winter.

1204 Vast depth of snow on ground

2204 Much snow

B42/a/16

0610 Snow melts as it falls

Ian Napper

2912 Yard full of snow from drifts

1736

1103 Support of 'close' meaning cloudy

1304 Never saw so much snow on ground at this time of year

2204 I declare I never saw so much snow on ye ground

0605 Most backward spring

1405 Geese seen

2305 Backward spring

0806 River broke

B42/a/17

1208 Ship Arrived

Richard Norton

1737

0906 No snow this winter in N.

B42/a/18

0108 Ship arrived

1738

0405 Geese Seen

B42/a/19

0108 Ship Arrived

R. Norton

1739

1308 Ship Arrived

B42/a/20

1740

See Richard Whites Journal for a comparison

B42/a/21

1741.

Ferdinand Jacobs

B42/a/23

James Isham

1742

B42/a/24

James Isham

2009 Dry Summer

1743

2603 Snowbird

B42/a/25

James Isham

1744

0201 Cold and moderate?

0801 Moderate winter this month more like April than January

0304 Snow bad wx

0904 Snow depth

1204 Gull early

2505 Permafrost encountered in well digging. 12'

0406 Ice breaking

0908 Ship Arrived

B42/a/27

1209 Few Geese

James Isham

3010 Magpie

0712 Wx comments, Ice broke by wind past 10 days. 12" thick

1745

1601 Few animals

2701 No deer.

2804 No deer.

0904 Snowbird

2004 No Game

2504 Goose

2005 Sow'd Garden

2905 1' Snow

B42/a/28

Robert Pilgrim

1746

2804 Scarcity of game

1105 Geese seen

2405 Could not work with mortar

2807 Ice on River

B42/a/29

1108 Hail stones 4 3/4 inches in circumference

2910 Great deal of snow

1812 As thick a drift as I have seen since I have known the country

1747

0101 Not as cold

2501 No one outside

1502 Extremely pleasant day

0203 Men inside

2904 So cold men not out

0405 Cannot work with mortar

1405 Men unable to work outside

2205 Could work with mortar at 11

2805 Men in

1606 River broke

0608 Ship Arrived

B42/a/31

Robert Pilgrim

0611 Men in

1611 River fast

2211 Men in

2912 So sharp this day that no man could stir from the Fort

1748

2302 Something warmer than we have had it for 6 weeks past

0406 River broke

0607 Loose ice in river

B42/a/32

Joseph Isbister

1309 Ice on shore

2810 Warm wx not usual at this place

0311 Bay to N. covered with ice

1711 Distance of wood. 9 mos. to gather firewood

0412 Men in

1912 Indians starving. No game

1749

2503 Many Indians starving and suffering from the flux.

3103 6 mos. preparing 1 winter wood

1604 Snow to top of doors.

2404 Indian family froze to death.

2804 Geese seen. Snowbirds.

0305 Men In.

0405 Hardest frost seen for time.

1905 Snow 10' deep in places never saw such a continuance of cold wx. Rain froze on hitting ground.

2405 Froze as it fell.

2805 If we have one hour fine wx. we have ten bad for it.

0406 Best day this year.

0906 No grass as yet.

1806 Indians mention great death rate through winter.

2606 Brings in Ice.

0107 More complaints of lack of game and starved Indians.

2507 Ship Arrived.

B42/a/34

Joseph Isbister

0609 Men In.

2409 Wx bad since first of month.

0211 River still clear of ice.

2912 Worse wx. for 2 years.

1750

0101 River Ice broken. Open water Ducks?

0303 Men in.

2504 Scurvy.

0105 Geese Seen.

1406 River broke.

0907 Newtons death (at York)

2607 Ship Arriv.

B42/a/36

Joseph Isbister

1508 Men In.

0409 We have not had a harder gale of wind at this place since I have been here.

2409 Men In.

2509 Ships Ice forms on bow 1" thick from spray.

1011 River froze seems fast.

2811 Vapor that arised from sea.

1751

2601 Worse wx in ye country since I have known it.

0405 Geese seen.

2005 Sowed garden.

1706 Indians complain of extensive sickness...Flux.

2507 Ship Arrived.

3007 Indians with measles never known before. B42/a/38 . 2208

Joseph Isbister

0510 Snow grains.

0112 River froze.

1752

1001 Snow "man high".

2904 Geese seen.

2305 River broke

1007 Complaints of bad wx.

2207 Ship arrived.

0209 Calendar change Old style - New style

2009 21 years in this country and never see or hear so dismal a night.

B42/a/39

1753

2301 Small rain which is what I have not seen this 21 years in these parts

0602 Little work done indoors - lack of light created by snow blocking windows

2603 Men in

2803 Men in

0904 Men in

1004 Men in

1304 Excessive drift and volume of snow

1404 16' drifts 8' overall

0805 Geese seen

0106 Ice as fast as middle of winter

0206 Garden sowed

0406 River broke

2208 Ship arrived

1754

0505 Geese seen

2205 Different sorts of bad weather cold backward spring

2605 Scurvy

0206 Digging garden

0706 Sowed garden

1606 Ice broke

2608 Ship arrived

B42/a/42

Ferdinand Jacobs

1509 Comment on lack of wood

0911 River froze

3012 Men in due to cold

1755

0703 Men in

1105 Geese seen

2905 Frost gone at 10

1706 Sowed garden

0109 Ship arrived

B42/a/46

Ferdinand Jacobs

2910 Indians starving no food to be got

0111 Partridge very scarce

0611 River and Bay clear of ice

1756

1903 Deep snow

2003 Men in

2404 Men in

0505 Geese seen

1405 Pieces of ship left by Cptn Munck 137 years ago (1619)

2105 Cold as in winter

2506 River broke

0208 Ship arrived

B42/a/48

F. Jacobs

1757

0803 Elk killed

0505 Goose killed

1205 Snow'd thaw'd off ground which is soon for this place
so early in spring

1805 Very few geese

1905 Seeds sown

1108 Ship arrived

B42/a/50

Ferdinand Jacobs

0811 River froze

0212 Large quantities of deer meat

1758

1301 Men in

1401 Snow 7' deep

2603 4000 partridge

1505 Comment on cold wx

0106 Comment on frost & snow

1406 River still frozen

2506 River broke

3008 North River low

1009 Ship arrived

B42/a/52

2411 River froze

F. Jacobs

1759

0403 Heavy drifts

2804 12000 partridge since last winter

1305 Geese seen

0706 Sowed seed

2108 Ship arrived

B42/a/53

Moses Norton

0510 Storm of wind Such a hard storm not known in these parts for many years.

2310 Men in

2011 River froze

1212 Prediction of scarce country provisions

1760

3003 Snowbird

1105 Goose

2006 River broke

2408 Ship arrived

1611 River froze

1761

2701 8' snow Roof collapsing due to weight

0202 I never saw so much snow

0605 Goose seen

1006 River broke

1506 Digging garden

1408 Ship arrived

B42/a/56

F. Jacobs

3009 Dug up turnips green from garden

2211 River froze

1762

1804 4000 partridge

1205 Goose seen

2305 Bad as winter

0506 Men in

1106 Ice not broken in river

1306 River broke

2006 Bay still frozen

0807 Men in

2208 Ship arrived

B42/a/59

Moses Norton

2709 Men in

3010 River froze

1412 Drifts over doors

2512 Comment on great quantity of snow

2812 Men in

1763

0302 Indians starving

2502 No partridges at North River or east there being so much bare ground.

1604 Comment on bare ground

0705 Duck seen

0905 Geese seen

1306 Sowed garden

2806 River broke

1207 Loose ice still in river

1608 Fresh provisions scarce

2808 Ship arrived

B42/a/60

Moses Norton

1109 Blew Haystacks down

1610 Loose ice in river

2910 Partridge scarce

1511 Hard times

0611 Such scarcity of Country provisions has not been known at this place for many years.

1111 "God send us better times. "

2911 No partridge

1712 Ice thick

2412 Water shallow

2612 Porcupine

1764

0701 1/2 a goose per man per day

3101 Kings Evil Scurvy

2502 Bad times indeed.

1003 6 men sick

1603 Scurvy

0604 River mouth broke which is remarkable to break up so soon.

0904 Scurvy

0205 Saw Gulls which is a sine of a forward Spring in regard to geese

0505 Geese seen

0606 Digging Garden

1506 River broke

1607 Natives a sickly year

1308 Ship arrived

B42/a/62

Moses Norton

0711 Rain remarkable this time of year

0911 Reference to lack of timber.

1811 River froze

2811 Very little snow on ground yet.

1765

2402 No game

0503 No game

2703 Snowbirds

1204 Poor luck in regard to Furs

1804 York Fort letter Many natives starved to death

2604 Geese seen

2804 Dogs killed for food No deer no partridge

0305 Starving Indians

0309 Ship arrived

B42/a/64

Moses Norton

0311 Partridge scarce

0312 Timber & Partridge scarce

1766

2804 Partridge scarce

2804 Starving Indians

0505 Goose seen

0708 Ship Arrived.

B42/a/67

Moses Norton

1010 Comment on low water in creeks.

2510 Said well will be of great service to ye fort in supply's it with snow water for ye first part of the summer the snow laying there till about ye beginning of Aug it being greatly screened from ye heat of ye sun by ye Fort.

2412 Partridge from distance

3112 Cold wx drove partridge inland

1767

1401 Natives starving

1901 Men in

2103 Many partridge

2804 Indians hard winter

0605 Comment on snow in yard

1505 Geese Received

1606 River broke

2307 Indians starved to death

0908 Map of Arctic coastline

2208 Mention of wreck on Marble Island

2808 Ship arrived

B42/a/70

1768

1502 Men in

0804 Much bare ground

0905 Geese seen

2005 Hale

2306 Bay broken

1707 Hot and Sultry of which I never see the like in the country.

0508 Men in

0808 Ship arrived

B42/a/74

John Fowler

1009 Wales & Dymond

0711 River frozen

1769

1506 Ice broke

2808 Ship arrived

B42/a/77.

Moses Norton

0412 Short of wood

2612 Men in

1770

2702 Great amt of snow in yard above eaves.

2104 Men in the drift so heavy

0605 Geese seen

1605 Drifts filled yard quite full of snow which is something extraordinary for this time of the year.

1806 6600 Geese killed

2306 River broke

0807 Ice in river and Bay

2707 Comment on garden and vegetables for health.

0908 Ice in Bay blocked ships trying to sail North.

2408 Ship Arrived.

B42/a/80

Moses Norton

2009 High seas

0111 River frozen

1212 Few partridge

1771

1401 Ever since I knew the country I never experienced so great a scarcity of partridges.

2001 Wx has been so very bad and cold lately that some of our hunting Indians is very much froze.

2901 10 men sick

1102 Men in

1105 Geese

1705 Indians with eye trouble

2406 River broke

0407 Ice in the Bay

2308 Ship arrived

B42/a/83

Moses Norton

0910 Reference to sea breeze land breeze.

2210 Ice driving in River later than usual

2510 Ice freezing to moorings of vessel.

0211 River & Bay clear to Musketo Point remarkable for this time of year.

1611 River set fast

1772

2401 No game

0702 No partridge

1102 Yard full of snow

0903 Snow drifts to top of parapet walls

1603 Comment on cold winter

0904 Vis. 10 yds.

1004 River broke with wind

1905 Geese seen

3006 Comment on S. Hearnes expedition. Woods 30 miles from mouth of river.

1808 Mosses catching fire. Summer a remarkable dry one ship arrived.

B42/a/86

Moses Norton

1310 Men in

3110 River & Bay clear of ice remarkable for this time of year.

1811 River Froze

2811 Winds out of the sea

1612 River mouth clear of ice.

ce;1773

2804 Indians general complaint that a great part of the country inland has been on fire the last summer it being so very a dry one to which the natives compute the scarcity of animals

1706 River broke

2808 Comment of increase of rapids of Churchill River.

0408 Ice in Bay.

2008 Ship arrived

2208 Northward voyage encountered much ice.

B42/a/88

Moses Norton

3010 Men in

2912 Norton died. Journal kept by Mssrs. Wills Johnston & Jefferson

1774

1502 Masters Room wash'd three prople hath died in it this winter

0303 Andrew Graham took command

2204 Th & L.

1105 Geese seen

1808 Ship arrived

B42/a/90

Andrew Graham

1310 Veg removed from garden

1311 Killed cattle no pasturage

1775

0101 River open at mouth

0401 overflowing

1705 Geese seen

2005 Wx cold

2505 First rain of season

1206 River still fast

2406 River broke

2606 Bay ice broke

0407 Meter journal somewhere? *

1907 temp at 4 P. M.

1208 Ship arrived

B42/a/92

Samuel Hearne

0410 Digging Garden

2210 No snow on ground

3110 Ice in River

2211 River clear of ice

1776

0203 Wind in evening

1404 Snow to roof level

1205 Geese seen

2305 Many Indians frozen to death on Bay

2805 River broke

0706 Snow drifts still 10' high

1706 River Ice broke

2308 Ship arrived

B42/a/94

Samuel Hearne

2210 Loose ice in river

2710 River froze above Musqueto pt.

2411 River froze

1777

0503 Snow over roof of house Upper and lower windows blocked.

Letter from Samuel Hearne to Humphrey Marten

(York Fort)

(2nd paragraph) The winter in general has been the mildest I every knew at Churchill and till the first of March the least snow that has been remembered at which time a Violent snow came on the NNW and lasted four days without intermission the snow that drifted into the yard during those days by far exceeded anything of the kind that has been known ever at this place. The snow were higher than the house consequently all the windows of the upper as well as lower storey were entirely blocked up. I were obliged to burn candles in my appartments for several days and tho' all my home people and one of the horses has been employed ever since in clearing the yard yet most of the mens cabbins are still buried. Our stone walls are at present of little use, for both men and horses can come over them with as much ease as through the gate. The depth of drift in the yard is about 22 feet. Mr. Johnston who is the Chronicle of this place says he never saw the like.

Letter from Humphrey Martens to Samuel Hearne

B42/a/94

5th April 1777

(3rd paragraph) "The gale you speak of began with us March 1 in the evening and continued till the 4th at midnight. A great flight of snow and a great drift were consequent upon it but not in any proportion to that at Prince of Wales Fort. A green old age is very desirable, but not twice childhood.

Letter from H. Martens to S. Hearne

2 August 1777

I have not been able to fit out a whaling- boat this summer, summer did I say no Sir I recall that word, for we have had nothing but NW & NNE winds with cold thick foggs and rain all June and July.

Letter to H. Martens From S. Hearne

8 August 1777

The summer has been equally unfavourable as
with you the two preceeding months having been one
continued round of rain and thick weather and winds
much the same as with you.

1608 Ship arrived

2508 Evidence of noon entry

B42/a/96

Samuel Hearne

0410 Comment on weather "...has been so precarious with rains....".

1210 Ice driving in river

2610 River froze to Whale Pt.

1778

0501 Ice very thick

0103 Wind more moderate

2604 Note - Rain first we have had since latter end of september last.

0505 Wet Snow

1805 Goose killed latest ever known at this place.

0106 Mungo Carear froze to death

0306 Still much snow on ground

1606 Digging garden for turnips

2106 Crossed river on the ice

2606 River broke

2208 Ship Arrived

B42/a/98

Samuel Hearne

2409 Men in

0510 Digging up Turnips and Coleworts

2611 River froze

0912 Game scarce

1779

1403 First that since Nov.

1704 Thick flaky snow

1504 Snow on roof 8 - 9' thick

0805 Goose killed

1305 First Rain

0706 Digging and sowing garden

2806 Much ice still in river

0807 Ice in River and Bay

2007 Ice loose in River and Bay

2707 Ice in river

0408 Transplanting coleworts

1608 Much ice in Bay

1708 Ice thick on all coasts

1009 Ship arrived

1109 York Factory ship force in by ice.

1509 Indian report on ice

B/42/a/100

Samuel Hearne

0211 Game scarce

0311 River froze

2711 Fog and Snow

1780

2601 Men in

1503 First thaw of spring

0505 River broke

1205 Geese seen

1805 Worst goose season

2205 Warm. Men fell through ice

1407 Transplanted coleworts.

0108 Great swell from sea.

3108 Ship arrived.

B/42/a/102

Samuel Hearne

1309 Sea swell

1010 Ponds frozen over

2710 Full eclipse of the sun

1111 River froze

1781

0904 No thaw

1005 Geese killed

2405 Digging Turnip garden that is clear of snow

2008 Ship arrived

Note that 1782 & 1783 to Sept are missing as the Fort was captured by the French.

1783

1411 Never remember the snow so deep at this season of the year.

1784

0703 Partridge near house.

1603 Men in

2304 Coldest we ever remember at this season.

2404 Snow at least 10' deep

0405 First Rain since 21st Oct.

1805 Geese

0706 Var extreme cold to excessive hot.

1107 Shipwright blind from the stings of the muskettoes which are exceeding numerous.

0209 Ship arrived

B42/a/104

Samuel Hearne

1311 First time sun visible since 31st last month.

1785

0401 Men in

1201 Many partridge

0702 Almost thaw

2403 Drifts 20' deep in yard

0505 Goose seen

0406 Remark on constant northerly wind thru goose season

0906 River open Bay frozen

1807 River and Bay full of ice.

2108 Ship arrived

B42/a/106

Samuel Hearne

2910 Snow melting as it falls.

1786

1402 the coldest weather we ever remember to have experience.

0903 the Ice is at least 5 and 1/2 or 6 feet thick.

1704 Uncommon great thaw

2504 In the course of this day our people saw three geese and some of the Indians saw two Ducks which is the earliest ever know at this place.

0407 Bay covered with ice.

1507 Ice in Bay

1308 Ship arrived

B42/1/108

S. Hearne

1787

2501 Indians 16 days York to Churchill. Dogs froze to death.

2803 Cold as ever experienced.

2804 Goose seen

2206 Ice broke

1408 Ship arrived

B42/a/110

William Jefferson

2009 Turnips Peas Coleworts from garden.

1788

1202 Ice 5' thick

1602 Comments on Parchetion Notes has no Thermometer or Barometer.

1304 Snowbird. Notes that this is late

0705 Geese

3005 Sowing garden

1206 River broke

0708 Ship arrived

B42/a/112

William Jefferson

2610 River froze

2011 First day this fall cooks has been able to procure clean snow to boil victuals.

3011 Snow bunting killed latest I ever know them to stay.

1012 Partridge scarce

1789

1703 Report of scurvy at York Fort

0204 No subsistence

0805 Geese

0206 Sowing garden

1608 Ship arrived

B42/a/114

William Jefferson

3009 Garden 36 bushels turnips 2 gals peas. Colewarts Lettuce Radish Under God I attribute the healthfulness of your Honours servants here to the produce of our garden.

1790

2101 1/2 oz Quicksilver exposed last night to the air was frozen as to bear to be pressed flat with my finger

1104 We dined this day on two very fine geese killed last October kept sweet by the frost without the assistance of salt.

2604 Indians short of food

0905 Geese

1509 Ship arrived

B42/a/116

William Jefferson

1791

2101 Th. -36 degrees three oz of Quicksilver exposed to the weather last night in a marble mortar this morning was so much frozen as to bear to be pressed that with my finger and cut with a knife. NB - degrees below 0, freezing point 32, above 0, + above 0.

2201 Low - 10Hi - 2

0104 Snow drift 16' deep

0205 Geese

1606 River broke

0508 Gives temps of +80 and +108

1108 Temp +70 to +80

1208 +56 +59

1308 +52 +60

2708 +40 +50

3108 Ship arrived

B42/a/117

William Jefferson

pp. 889-8 91Temps. twice a day. No indication of

time. Seem suspect Appears that
thermometer is in an exposed location.

2310 Temps given for 8 AM, 11 AM, 4 PM, 5, 6, 8, 9 PM.

2510 River frozen

1792

1701 Indeed this winter has been so far the most remarkable for scarcity of provisions for neither Englishman or Indians can find anything to kill

0702 Note on scurvey Mention of Sour Kraut

3103 Snowbird seen

0505 Geese

1608 Ship arrived

B42/a/118

Thomas Stayner

1793

3001 Quicksilver froze all day

0905 Geese

0806 River broke

0608 Ship arrived

B42/a/119

Thomas Stayner

2210 Temp -3

1794

0602 Temp +25

0703 "+37

1603 Indians ate own cloathes to stay alive

1204 +61

1105 Geese

1608 Ship arrived

B42/a/121a

T. Stayner

1795

3001 Them Min -12

2703 +43

0105 Geese

2006 River broke

2708 Ship arrived

1812 +30

2410 -44 -35

2512 min-23

1796

2001 Continued excessive cold wx

1506 Ice broke

1408 Ship arrived

B42/a/123

Thomas Stayner

-------(It appears that there is a Meteorological journal somewhere)

1797

Temp -41

1908 Ship Arrived

B42/a/124

William Auld

1110 +13

1798

0102 +38

0102 +12

0102 -10

0203 Disease amongst Indians

1005 Geese

0508 In the afternoon I went into the marsh to see whether the grass was ready for cutting. Found it but short yet, owing to the very small quantity of Rain that has fallen.

3108 Ship arrived

1799

1800

1909 The summer has been so remarkably cold.

2609 Poor vegetable yield from garden

0310 All ponds frozen over

0510 Ice 6"

2010 Ice melted

1801

2403 Snowbird

0305 Geese

1506 River broke

1608 Ship arrived

B42/a/126

John McNab

1802

2106 River broke

2508 Ship arrived

B42/a/128

William Auld

November. During this month the weather has been unusually severe the frost set in early which was fortunate for the preservation of our fresh venison. December. Remarkably cold weather.

1803

May in general a very cold and disagreeable season. July 6 Eskimau arrived with a very few furs they bring the dreadful intelligence of a great no. of their tribe having perished by famine during the winter which was remarkably cold.

B42/a/129

0508 Ship arrived

W. Auld

1804

3101 The weather since the 1st of the month has been colder than ever I remember before the first 8 days the thermometer stood between -40 and -50 but generally clear weather throughout the latter part of the month has been colder.

0305 Geese

3006 Unnormally early thaw

1208 Ship arrived

B42/a/130

3009 Wx this month in general very indifferent and cold

3110 Much ice in the river but not yet fast with much snow on the ground.

3112 A few very sharp days before Christmas when quicksilver froze solid.

1805

3101 Jan. A cold month Quicksilver freezing frequently but not much snow fell.

2802 Feb. A remarkable fine month with no snow and the warmest February I have seen in the country.

3103 March. A very fine month with little snow received.

3004 April. The weather this month moderately fine with hardly any fall of snow or rain

0805 Geese

1508 Ship arrived.

B42/a/131

0709 Bad wx Hay litle progress.

William Auld

0809 Frequent storms which agitate the sea at this time of the year.

1806

0102 Feb. Month severe

0111 Nov. There is only a very slight coat of snow on the ground barely sufficient to discover the tracks of partridges.

0911 all the little snow was thawed off again, due to the extraordinary warmth of the season

2911 Untill this day it has thawed regularly more or less each day since the 19th...that is consequence of the unusual depth and overflowing of the river over its banks joined with the very warm weather....

3011 a warmer, closer or more overcast gloomy and disagreeable November was never before seen- we only saw the sun twice during the whole month.

0912 River ice breaking -26 river flooding.

1807

1005 Geese

3105 The coldest month of May I ever saw.

2006 River broke.

0509 Ship arrived.

B42/a/133

William Auld

1610 First frost

1610 Most extraordinary late fall ever known here.

2511 As much snow on the ground as in some years at the latter end of January.

1808

B42/a/133

William Auld

The only bitch we have at the Factory the last sever wx. badly shockingly frozen utterly incapable of rearing young.

2904 Many geese

1205 Rivers already broken up.

1606 One River broke up clear out to sea.

B42/a/134

1809

3103 The beginning of the month Quicksilver frequently solid, the latter part milder on the 29th a fly crawling in the window.

1904 Indians are coming to the Factory and complain much of the plains being bare of snow which makes it bad travelling.

2404 temp. 0

2704 Geese

1806 River broke

0907 +30

2708 Ship arrived

B42/a/135

Thomas Topping

1810

2005 Geese

1906 River open to sea.

1811 - 1813 Thomas Topping

B42/a/139a

Memoranda for a Meteorological Journal. The Thermometer should be kept where the direct and reflected rays of the sun cannot affect it of course the C'F is placed (?)

No. 0 or Calm may denote a perfect calm.

1	Light air just observable	
2	Gentle breeze in which a boat may go	2
3	Fresh - - - - - - -	3
4	Strong breeze in which a boat may go	4
5	Gentle Gale	5
6	Fresh Gale	6 or 7
7	Strong Gale. Almost too bad for boats	
8	Heavy Gale	
9	A storm	

Diagram showing "Scale of Thermometer" from 50-0 to 120+0

Fever heat

Blood heat

80 Very hot

Summer heat

50 Temperate

40 Cold

+32 Freezing

-40 Quicksilver freezes solid

-60

ce;1811

0609 Comet close to the bear.

1709 Eclipse of sun

0710 4" snow.

2412 Mercury Frozen

2709 Sharp frost last night

2809 Sharp frost

2909 Sharp frost with snow and sleet

0610 Thermometer +2

0710 Winter properly set in

0810 River impassable

2110 Very small space of water open in river.

1812

1201 Quicksilver frozen

2101 Them. this AM at 8'o'clock 50 degrees below zero.

2403 Bad weather

2503 Bad weather

1309 Very fine wx.

0410 Fine wx

1010 bad wx sharp frost

1813

0204 It rained a little and thawed in the middle of the road.

2204 The river broke clear to the sea

1812

2603 Better wx

2604 Very cold wx for the time of year.

2804 Very cold wx

0105 Them at 8 AM -5

0305 Very cold wx

1305 Geese

2005 The wx extremely cold and the whole country around appears the same as in winter.

2205 wx still the same, no water upon the river.

2505 No water to be seen anywhere and still continues very cold.

3005 Better wx.

0407 a little water for first time on river.

0606 a fine day

0706 a very cold day

0906 Fine warme day

1106 much water upon the river.

1206 extreme cold wx.

0307 River opening a little but capable of being crossed.

0507 River broke to sea

2707 Bad wx.

B42/a/136b

1810

2408 A heavy rain

1811

1906 River breaking up fast

1207 Heavy gale of wd.

1307 Better wx

2007 Much Ice in Bay

2307 Boat journey cancelled blew too hard.

0208 Bad foggy wx.

1108 Fine wx.

1812

0304 Snowbirds

1205 Geese

2905 2" Snow

0507 River broke

2208 Ship Arrived.

1310 Snow 2 "

1610 - 12"

0411 River broke

2712 2" Snow fell.

1813

1202 6" Snow fell

0304 Snowbird

0405 Geese

0406 River broke

3107 Warmest for three years.

B42/a/140

J. Charles

1814

0705 Geese

0805 River covered with water

1509 Sleet.

1815

3006 River open to sea

2010 Snow 5 "

2310 1/2" snow

2810 2" snow

3010 7" snow

0111 2" snow

0411 4" snow

1711 3" snow

1012 3" snow

2312 3" snow

1816

1901 Snow 3"

2401 Quicksilver frozen

2004 Fly in room.

2104 Butterflies

2304 Swan. Gull.Ducks.

2604 Geese

0306 Hail & Rain

0406 Snow 2"

B42/a/148

1813 - 1822

B42/a/143

1815 - 1818

1817

2502 2" snow

0104 3" snow

0504 Snowbirds

2404 4" snow

2604 Geese

1210 3" snow

1111 6" snow

1311 9" snow

1818

2502 2" snow

0604 Snowbirds

1804 Geese

1105 Season 14 days earlier than last year.

1205 6" snow

1810 6" snow

1819

1901 Quicksilver frozen.

B42/a/144

1704 This and the two last days the weather has been warm beyond anything ever remembered by the Servants of the Company at this place so early in the spring a considerable part of the snow are melted and the ground bare save in low places where large quantities were accumilated

2904 Geese.

1820

B42/a/146

Wm. Ross

1821

0505 Geese

0606 3" deep snow

2506 River broke 15 days later than last year.

1007 there not being water in Seal River to get up their canoe through, tho' several years ago a Boat went up through it, this proves the River this summer to be lower than on former year.

2108 Ship Arrived.

B42/a/147

Hugh Leslie

1109 River very low.

0711 River frozen

1822

2101 Thermometer -40 to -45

1505 Geese

1506 River broke

2406 6" snow on ground

B42/a/150

0312 Partridge scarce

1512 Weather in general very cold more so than I have seen so early of the winter but the quantity of snow now on the ground is not nearly so much as last year.

1823

1305 Geese

1706 Weather still cold for the season of the year wind always in the North Quarter and the sky overcast.

0207 River broke The spring in every respect is uncommonly late even the grass and other vegetation wears but little of summer appearance.

0711 the quantity of snow on the ground is unaccountable so early of the season it is already over the stockheads in many places.

0811 River frozen

1824

2004 Much snow on ground

1705 Geese

0206 Still much snow on ground

2106 Ice broke

B42/a/154

Hugh Leslie

1609 Still expects fine wx.

0211 River froze

1825

3101 Cold week

0103 Thermometer +7 to +24

0303 Uncommonly mild

1703 Weather still fine and has been for the last month so much so that the oldest servants here have not witnessed such a continuation and so early of the season.

0504 Indians report earthquake.

1005 Geese

0106 No melt of snow

1206 River broke

2210 River frozen

0811 8' drifts

1826

0402 Coldest witnessed -51

0505 Geese

2406 River clear

B42/a/155

Robt. Harding

1828

2902 Comment on bad weather

2603 Bay clear of ice

1004 Snowbirds

0105 Geese

0205 Most of snow melted

B42/a/156

Robert Harding

1306 Ice broke

1706 Hitherto this has been a long lingering spring and the warm weather commencing the beginning of May I fully expected we should have had an early summer but the season is now more backward than at this time last year.

1829

0404 Snowbird

0305 Geese

1830

1205 They report having seen a great many geese on their
route here and say there is no snow at or near York al-
tho there is a great deal in the vicinity of this
place.

1305 Geese

1605 First Rain

1831

1906 Ice broke

B42/a/159

1711 Ice open

Robt. Harding

1832

1004 Snowbirds

1604 There is now an amazing quantity of snow on the ground
I never seen so much before.

2005 Geese

B42/a/160

Robt. Harding

2607 Raining heavily this evening which is seasonable for
our Gardens that are backward for the want of rain.

1833

1903 Thaw at night

0504 Snowbirds

0305 Geese

1006 River open

B42/a/164

1833 - 1835

1834

0704 Snowbirds

1405 Geese

1508 Ship Arrived

3011 Eclipse of the sun

1835

2903 Snowbirds

1205 Geese

B42/a/165

Robert Harding

2406 River shallow (low)

1836

2803 Snowbird

2405 Geese

3005 Bay clear of ice.

B41/a/166

R. Harding

1837

0904 Snowbirds

0905 Geese

B42/a/167

Robert Harding

1506 Thought there was an eclipse.

1838

0806 Temp dropped 43 degrees

B42/a/172

Robert Harding

rain that was much required for our gardens everything therein being parched.

2010 River frozen

2511 River frozen again

1840

2903 Snowbirds

1105 Geese

R. Harding

1841 - 1844

No written comments in the meteorological journal kept during these years.

1845

B42/a/183

1844-4 7

1845

Robert Harding

1906 River broke

1610 I say cold because I have been used to a different climate to this and this makes the difference.

1846

0805Geese

0506 River open

1847

B42/a/183

1606 River open

B42/a/185

1510 No snow on ground

2910 Reference to Mr. Audubon

1848

1604 Indians complain of no snow on the plains

1105 Geese

1910 Much snow on ground.

1849

Great deal of snow on ground

2604 No sign of spring

2704 Snowbirds

1905 Geese

0709 Ponds frozen over

2711 River froze

1850

2409 The following journal is only partially available, it had been catalogued under Grant Lake. The first part is missing and the journal commences in Sept. 1850

1511 River froze

1851

0605 Geese

0206 Bare ground showing

B42/a/186

0112 River froze

1852

0302 Too warm for sleds to run

0205 Geese

0505 Above freezing last night

1306 River clear

2610 River frozen

1611 Freezing rain.

1853

2703 Snowbirds

0905 Geese

B42/a/187

Christie

1806 River open

0310 River very low

1854

2204 Snowbirds

3004 Geese

0806 River open

0906 the weather has been exceedingly warm for the fhree preceding days Thermometer varying from 60 to 95 degrees above zero.

0107 Hail the size of a Musket Ball

1710 Ice 1' thick already

1855

1502 Above zero

0805 Geese

B42/a/188

0810 6" snow

1856

0105 Geese

0806 River clear

2510 No snow on ground.

1857

2003 Snowbirds

1205 Geese

B42/a/189a

0908 Journal kept for 2 months by Nancy Dunning following her husband's death.

1858

James Hackland

1203 that is a rise of 40 degrees in 9 hours not unusual here;

0405 Geese

1506 The snow is yet level with the top of the Pickets the like was never seen at Churchill before we cannot get on with our outdoor work.

BIBLIOGRAPHY

Allsopp, T.R., 1977, Agricultural weather in the Red River Basin of Southern Manitoba over the period 1800 to 1975. Canada, Atmospheric Environment Service, CLI - 3 - 77, pp. 28.

Alt, B.T., 1978, Synoptic climate controls of mass - balance variations on Devon Island Ice Cap. Arctic and Alpine Research, Vol. 10, pp. 61-80.

Arakawa, H., 1954, Five Centuries of freezing dates of Lake Suwa in Central Japan. Arch. Met., Wien, B, Vol. 6. Pp. 152-166.

Arakawa, H., 1956(a), Climatic change as revealed by the blooming dates of the cherry blossoms at Kyoto, J. Met., Vol. 13, pp. 599-600.

Arakawa, H., 1956(b), Dates of irst or earliest snow covering for Tokyo since 1632. Quarterly Journal of the Royal Met. Society. Vol. 82. Pp. 72-84.

Arakawa, H., 1957, Climatic change as revealed by data from the Far East, Weather, Vol. 12. Pp. 46-51.

Andrews, J.T., Barry, R.G., Bradley, R.S., Miller, G.H., and Williams, L.D., 1972, Past and present glaciological responses to climate in Eastern Baffin Island, Quaternary Research, Vol. 2. Pp. 303-314.

Baker, D.G., 1960, Temperature trends in Minnesota, Bull. Amer. Met. Soc., Vol. 41, pp. 18-27.

Barry, R.G., 1967, Seasonal location of the Arctic Front over North America, in Geographical Bulletin Vol. 9, pp. 79-95.

Barry, R.G., Bradley, R.S., and Jacobs, J.D., 1975, Synoptic climatological studies of the Baffin Island area. in Climate of the Arctic ed. by G. Weller and S.A. Bowlings. (New York: Harper and Rowe).

Bell, B., 1953, Solar variation as an explanation of climatic change, in Climatic Change ed. by H. Shapley (Cambridge, Harvard Univ. Press).

Blasing, T.J., 1973, Methods for analyzing climatic variations in the North Pacific sector and Western North America for the last 500 years. Unpublished Ph.D. dissertation, University of Wisconsin. Pp. 177.

Blasing, T.J., and Fritts, H.C., 1976, Past climate of Alaska and Northwestern Canada as reconstructed from tree rings, in _Climate of the Arctic_ ed. by G. Weller and S.A. Bowlings, (New York: Harper and Rowe).

Blokpoel, H., 1973, _Migration of Lesser Snow and Blue Geese in spring across southern Manitoba: Part 1: Distribution, chronology, directions, numbers, height and speeds._ Canadian Wildlife Series Report # 28. Ottawa. Pp. 27.

Blokpoel, H., and Gauthier, M.C., 1975, _Migration of Lesser Snow and Blue Geese across southern Manitoba: Part 2: Influence of the weather and prediction of major flights._ Canadian Wildlife Series Report # 32. Ottawa. Pp. 28.

Bonacina, L.C.W., 1976, Phenology. _Weather_ Vol. 28. Pp. 58-60.

Bradley, R.S., 1976, Seasonal precipitation fluctuations in the Western United States during the late Nineteenth century. _Monthly Weather Review_, Vol. 104. Pp. 501-512.

Bray, J.R., and Strike, G.J., 1963, Forest growth and glacial chronology in Eastern British Columbia and their relation to recent climatic trends. _Canadian Journal of Botany_. Vol. 41. Pp. 1245-1271.

Brier, G.W., 1968, Long-range prediction of the zonal westerlies and some problems in data analysis, _Rev. Geophys_, Vol. 6. Pp. 525-551.

Brinkmann, W.A.R., and Barry, R.G., 1972, Paleoclimatological aspects of the synoptic climatology of Keewatin, Northwest Territories, Canada. _Paleogeography, Paleoclimatology, Paleoecology_. Vol. 11. pp. 77-91.

Britton, C.E., 1936, A meteorological chronology to A.D. 1450, _Geophysical Memoirs_. Vol. 8. Pp. 2-177.

Brooks, C.E.P., 1949, _Climate through the Ages_. McGraw-Hill New York. pp. 372.

Brown, G.M., and John, J.I., 1974, Solar cycle influences in tropospheric circulation, _EOS_, Vol. 58. Pp. 695-701.

Bryson, R., 1966, Air Masses, streamlines and the Boreal Forest. _Geog. Bulletin_. Vol. 9. Pp. 228-269.

Bryson, R., Irving, W., and Larsen, J., 1965, Radiocarbon and soil evidence of former forest in the Southern Canadian Tundra. _Science_. Vol. 147. Pp. 46-48.

Cassedy, J.H., 1969, Meteorology and medicine in Colonial America. _Journal of the History of Medicine_. Vol. 2. Pp. 12-17.

Catchpole, A.J.W., 1969, The solar control of diurnal temperature variation at Winnipeg. Canadian Geographer. Vol. 13. Pp. 255-268.

Catchpole, A.J.W., 1978, in Syllogeus, ed. by. C.R. Harrington (Ottawa: National Museum of Canada) pp. 5-17.

Catchpole, A.J.W., Moodie, D.W., and Kaye, B., 1970, Content analysis: A method for the identification of dates of first freezing and first breaking from descriptive accounts. The Prof. Geog. Vol. 22. pp. 252-257.

Catchpole, A.J.W., and Moodie, D.W., 1978, Archives and the Environmental Scientist. Archivaria Vol. 6. Pp. 113-137.

Chapman, L.J., and Thomas, M.K., 1968, The Climate of Northern Ontario, Dept. of Transport, Met. Branch Climatological Studies 6. Toronto, pp. 58.

Claiborne, R., 1970. Climate, Man and History. W.W. Norton and Company, New York. Pp. 444.

Conrad, V., and Pollack, L.W., 1950, Methods in Climatology. Harvard Univ. Press. Cambridge. Pp. 459.

Cowell, D.W., 1982, Earth Sciences of the Hudson Bay lowland: Literature Review and Annotated Bibliography. Working paper No. 18. Lands Directorate, Environment Canada, Burlington, Ont. Pp. 309.

Craddock, J.M., 1970, Work in synoptic climatology with a digitized data bank. Met. Mag. Vol. 99. Pp. 221-232.

Craddock, J.M., 1973, A plan for the determination of the large-scale weather pattern during the period 1493-1860. Met. Mag. Vol. 102. pp. 217-224.

Dansgaard, W., Johson, S.J., Clausen, H.B., and Langway, C.C., 1971, Climatic record revealed by the Camp Century ice core, in The Late Cenozoric Glacial Ages ed. by. K. Turekian, (Yale Univ. Press, New Haven) pp. 267-306.

Darter, L.J., 1942, List of climatological records in the National Archives, Special List No. 1, National Archives, Washinton, D.C. pp. 160.

Davis, N.E., 1972(a), Classified Central-England temperatures and England and Wales rainfall, Met. Mag., Vol. 101. Pp. 205-217.

Davis, N.E., 1972(b), The variability of the onset of spring in Britain, Q.J.R. Met. Soc. Vol. 98. Pp. 763-777.

Dey, B., 1973, Synoptic climatological aspects of summer dry spells in the Canadian Prairies. Unpublished Ph.D. University of Saskatchewan. pp. 180.

Douglas, R., and Wallace, J.N., 1926, Twenty years of York Factory Kings Printer, Ottawa. Pp 45.

Douglass, A.E., 1928, Climatic cycles and tree growth Vol. 11. Publication No. 289. Carnegie Institute, Washington, D.C. Pp. 147.

Dymond, J., and Wales, W., 1771, Observation on the state of the Air, Winds, Weather etc., made at Prince of Wales Fort on the North-West Coast of Hudson's Bay in the Years 1768 and 1769. Phil. Trans., LX. pp. 137-178.

Easton, C., 1928, Les hivers dans L'Europe occidentale. Brill, Leyden pp. 208.

Eichenlaub, V.L., 1976, Climatic change in the Southern Great Lakeseastern corn belt areas. East Lakes Geographer. Vol. 10. pp. 124-134.

Elliot, R.D., 1949, The weather types of North America. Weatherwise Vol. 2. Pp. 15-18, 40-43, 64-67, 86-88, 110-113, and 136-138.

Faurer, M., 1981, Evidence of sea ice condition in Hudson Strait, 1750 - 1870, using ships logs. Unpublished Masters Thesis. University of Manitoba. Pp. 138.
Fletcher, R.J., and Young, G.S., 1976, Climate of Arctic Canada in Maps, Occasional Publication Number 13. Boreal Institute for Northern Studies. Edmonton. Pp. 85.

Fritts, H.C., 1965. Tree ring evidence for climatic changes in western North America, Monthly Weather Review. Vol. 93. Pp. 421-443.

Fritts, H.C., Blasing, T., Hayden, B.P., and Kutzbach, J.E., 1971, Multivariate techniques for specifying tree-growth and climate relationships +and for reconstructing anomalies in Paleoclimate. Journal of Applied Meteorology. Vol. 10. Pp. 845-864.

Fuller, O., 1963, The Marines at Sloop Cove. The Beaver. Summer. pp. 44-53.

Gargett, A., 1965, Long-term fluctuations in the Toronto temperature and precipitation record. Dept. of Trans. Met. Branch. CIR-4199, TEC559. Pp 10.

Giddings, J.L., 1947, Mackenzie River delta chronology. Tree Ring Bulletin. April. Pp. 28-32.

Gleissberg, W., 1944, A Table of secular variations of the solar cycle. Terr. Magnet. Atmos. Elec. 49. Pp. 243.

Graham, A., Gray, B.M., Japanese and European winter temperatures, Weather. pp. 359-368.

Griffiths, J.F., 1977, Achronology of items of meteorological interest. Bull. Amer. Met. Soc. Vol. 58. Pp. 1058-1067.

Hanson, H.C., 1965, The Giant Canada Goose. Southern Illinois University Press. Carbondale and Edwardsville. Pp. 225.

Hare, F.K., 1951, Some notes on Post Glacial climate change in Eastern Canada, Royal Meteo. Soc., Canadian Branch. Vol. 2. Pp. 8-18.

Hare, F.K., 1960, The Westerlies, Geog. Review. Vol. 50. Pp. 345-367.

Hare, F.K., 1970, The Tundra Climate, Transactions of the Royal Society of Canada, 4th series. Vol. 7. Pp. 393-399.

Hare, F.K., and Montgomery, M.R., 1949, Ice, Open water and winter climate in the Eastern Arctic of North America. Arctic. Vol. 2. pp. 79-89.

Hare, F.K., and Ritchie, J.C., 1972, The Boreal Bioclimates. Geographical Review. Vol. 62. Pp. 333-365.

Hare, F.K., and Thomas, M., 1980, Climate Canada. 2nd ed. Wiley Publishers of Canada Ltd. Toronto. Pp. 230.

Harington, C.R., (ed). 1980, Climatic Change in Canada. Syllogeus No. 26. National Museums of Canada. Ottawa. pp. 246.

Hattie, S.A., and Hornstein, R.A., 1963, Recent precipitation fluctuations and trends in the Atlantic Provinces. Dept. of Transport. Met. Branch. CIR - 3864. TEC - 475, Toronto. Pp. 9.

Haven, J.M., 1958, An annotated bibliography of meteorological observations in the United States, 1715-1818. Key to Meteo. Records. Documentation No. 5-11, U.S. Dept. Commerce. Weather Bureau, Washington, D.C. Pp. 14.

Haworth, S.E., Cowell, D.W., and Sims, R.A., 1978, Bibliography of Published and Unpublished literature on the Hudson Bay Lowland. Report 0-X-273 Canadian Forestry Service, Dept. of the Environment Sault Ste. Marie, Ont. Pp. 270.

Helland-Hansen, B., and Nansen, F., 1920, Temperature variations in the North Atlantic Ocean and in the atmosphere. Smithsonian Misc. Collection. Vol. 70. Pp.38. Herman, J.R., and Goldberg, R.A., 1978, Sun, Weather and Climate, Scientific and Technical Information Branch, National Aeronautics and Space Administration. Washington, D.C., Pp. 360.

Hills, L.V., and Sangster, E.V., 1980, A review of paleobotanical studies dealing with the last 20,000 years; Alaska, Canada and Greenland. in Climatic Change in Canada Ed. by C.R. Harington. (National Museums of Canada: Ottawa) Pp. 61-224.

Hoyanagi, M., 1966, Research on climatic change in Japan. Japanese Geography its recent trends. Special Publication No. 1. Pp. 57-60.

Ives, R.L., 1954, Climatic studies in western North America. Proc. Toronto Meteor. Conf. London, Royal Meteorological Society. pp. 218-222.

Jurin, J., 1722, Invitatio ad observationas Meteorologican communi consilio instituendos, Phil. Trans. of the Royal Society. Vol. 32. pp. 422-427.

Khrgian, A.K., 1970, Meteorology. A Historical Survey Vol. 1. 2nd ed. Ginz, Leningrad. Trans. from Russian. Israel program for Scientific Trans. Jerusalem. Pp. 376.

King, E.C., Bryson, R.A., and Lenschow, D.H., 1964, Study of a continental surface albedo on the basis of flight measurements and structure of the earth's surface cover over North America. Monthly Weather Review. Vol. 92. Pp. 550-551.

Kington, J.A., 1974, A late eighteenth century source of meteorological data. Weather. Vol. 25. Pp. 169-175.

Kington, J.A., 1974, An application of phenological data to historical climatology. Weather. Vol. 29. Pp. 320-328.

Kington, J.A., 1975(a), A comparison of British Isles weather type frequencies in the climatic record from 1781 to 1971. Weather. Vol. 30. Pp. 21-24.

Kington, J.A., 1975(b), An analysis of the seasonal characteristics of 1781-1784 and 1968-1971 using the PSCM indices. Weather. Vol. 30. pp. 109-114.

Kington, J.A., 1975(c), Daily synoptic weather maps from the 1780's: A research project of synoptic climatology. Meteorological Magazine. Vol. 104. Pp. 33-52.

Kington, J.A., 1976, An introduction to an examination of monthly and seasonal extremes in the climatic record of England and Wales using historical daily synoptic weather maps from 1781 onward. Weather. Vol. 31. Pp. 72-78.

Koerner, R.M., 1977, Devon Island Ice Cap: Core stratigraphy and paleoclimate. Science. Vol. 196. Pp. 15-18.

Kullmer, C.J., 1933 , The latitude shift of the storm track in the 11 - yr solar period. Smithsonian Misc. Collection. Vol. 89. Pp. 27.

Ladurie, E. LeRoy, 1971, Times of feast and times of famine. Doubleday, Garden City, N.Y., pp. 426.

La Marche, V.C., 1973, Holocene climatic variations inferred from treeline fluctuations in the White Mountains, California. Quaternary Research. Vol. 3. Pp. 632-660.

Lamb, H.H., 1950, Types and spells of weather around the year in the British Isles: Annual trends, seasonal structure of the year, singularities. Quarterly Journal of the Royal Meteorological Society. Vol. 76. Pp. 393-430.

Lamb, H.H., 1966, The Changing Climate. Methuen and Co. Ltd. London. Pp. 236.

Lamb, H.H., 1972a, British Isles weather types and a register of the daily sequence of circulation patterns 1861-1971. Geophysical Memoirs Number 116. H.M.S.O. for Meteorological office. Pp. 85.

Lamb, H.H., 1972b, Climate, Present, Past and Future. Fundamentals and Climate. Vol. 1. Methuen and Co., Ltd. London. Pp. 613.

Lamb, H.H., 1973, The seasonal progression of the general atmospheric circulation affecting the North Atlantic and Europe. Climatic Research Unit. Research Publication No. 1. Pp. 32.

Lamb, H.H., 1977, Climate, Present, Past and Future. Climatic history and the future, Vol. 2. Methuen and Co. Ltd. London. Pp. 835.

Lamb, H.H., 1979, Climatic variation and changes in the wind and ocean circulation: The Little Ice Age in the Northeast Atlantic. Quaternary Research Vol. 11. pp. 1-20.

Lamb, H.H., and Johnson, A.I., 1959, Climatic variation and observed changes in the general circulation. Geografiska Annaler. Vol. 41. pp. 94-133.

Lamb, H.H., and Johnson, A.I., 1966, Secular variation of the atmospheric circulation since 1750. Geophysical Memoirs. No. 110. H.M.S.O. Lpondon. Pp. 125.

Lamb, H.H., and Morth, H.T., 1978, Arctic Ice, atmospheric circlation and world climate. Geog. Journal. Vol. 144. Pp. 37-42.

Landsberg, H.E., Ya, C.S., and Huang, L., 1968, Preliminary reconstruction of a long time series of climatic data for the Eastern United States. Tech. Note BN-571. Univ. of Maryland. Pp. 37.

Libby, L.M., 1974, Final Technical Report on historical climatology R and D Associates, Santa Monica, California. U.S. Govt. Report AD-780 121. Pp. 95.

Locke, C.W., and Locke, W.W., 1977, Little Ice Age snowcover extent and paleoglaciation thresholds: North-Central Baffin Island, N.W.T. Canada. Arctic and Alpine Research. Vol. 9. Pp. 291-300.

Long, C., 1974, The oldest European weather diary? Weather. Vol. 29 pp. 233-237.

Longley, R.W., 1972, The Climate of the Prairie Provinces. Environment Services, Climatological Studies 13. Toronto. Pp. 79.

Lowe, A.B., 1961, Canada's first weathermen. Beaver. Summer. Pp. 4-7.

Ludlum, D.L., 1966, Early American Winters, 1604-1820. Am. Meteorological Society., Boston, Mass. Pp. 283.

Ludlum, D.L., 1968, Early American Winters 1821-1870. Am. Meteorological Society., Boston, Mass. Pp. 257.

MacKay, D.K., and MacKay, J.R., 1965, Historical records of freeze-up and break-up on the Churchill and Hayes rivers. Geographical Bulletin. Vol. 7. Pp. 7-16.

Manley, G., 1953, The mean temperature of Central England 1698-1952. Quarterly Journal Royal Met. Soc. Vol. 76. Pp. 242-262.

Manley, G., 1974, Central England temperatures: monthly means 1695 to 1973. Quarterly Journal Royal Met. Soc. Vol. 100. Pp. 389-405.

Manusco, R.L., 1970, An objective method for estimating wind-speed fields from wind-direction fields. Quarterly Journal Royal Met. Soc. Vol. 96. Pp. 601-609.

Meteorological Branch., 1967, The Climate of the Canadian Arctic. Air Services. Department of Transport. Toronto, pp. 32.

Middleton, W.E., 1969, Invention of the Meteorological Instruments. Johns Hopkins Press. Baltimore. Pp. 362.

Middleton, W.E., 1964, The History of the Barometer. Johns Hopkins Press. Baltimore. Pp. 4859.

Minns, R., 1970, An Air Mass climatology of Canada during the early Nineteenth century: an analysis of the weather records fo certain Hudson's Bay Company Forts. Unpublished Masters thesis. Univ. of British Columbia. Pp. 73.

Mitchell, J.M., Jr., 1961a, Changes of mean temperature since 1870, Annals New York Academy of Science. Vol. 95. Pp. 232-250.

Mitchell, J.M., Jr., 1961b, The measurement of secular temperature change in the eastern United States. Research Paper No. 43, U.S. Weather Bureau, Washington, D.C. Pp. 70.

Mitchell, J.M., Jr., 1963, On the wold-wide pattern of secular temperature change in Changes in Climate. Proceedings of the Rome Symposium, 1961, organized by UNESCO and the World Meteorological Organization, Arid Zone Research XX, UNESCO, Paris, pp. 161-181.

Mitchell, J.M., Jr., 1965, The solar inconstant. Proceedingvs of the Seminar on possible responses of weather phenomena to variable Extraterrestrial influences. National Centre for Atmospheric Research Technical Note, TN-8, Boulder, Colorado. Pp. 155-174.

Mitchell, J.M., Jr., 1968, Causes of Climatic Change. American Met. Society. Boston. Pp. 159.

Mock, S.J., and Hybler, W.D., 1976, The 20-year oscillation in Eastern North American Temperature records. Nature. Vol. 261. pp. 484-486.

Moodie, D.W., 1977, The Hudson's Bay Company Archives: a resource for historical geography. The Canadian Geographer. Vol. 21 ?. pp. 268-274.

Moodie, D.W., and Catchpole, A.J.W., 1975, Environmental data from historical documents by content analysis. Manitoba Geographical Studies 5. Department of Geography, University of Manitoba. Pp. 119.

Murray, R., and Benwell, P.R., 1970, PSCM indices in synoptic climatology and longrange forecastry. Met. Mag. Vol. 99. Pp. 232-245.

Murray, R., and Lewis, R.P.W., 1966, Some aspects of the synoptic climatology of the British Isles as measured by simple indices. Met. Mag. Vol. 95. Pp. 193-203.

Namias, J., 1957, Characteristics of cold winters and warm summers over Scandinavia related to the general circulation. J. Meteorol. Vol. 14. Pp. 235-250.

Neumann, J., 1977, The winds in the world of the ancient Mesopotamian civilization. Bulletin American Met. Society. Vol. 58. Pp. 1050-1055.

Nichols, H., 1967a, Central Canadian Palynology and its relevance to northwestern Europe in the Late Quaternary period. Review of Palaeobotany and Palynology. Vol. 3. Pp. 231-243.

Nichols, H., 1967b, The postglacial history of vegetation and climate at Ennadai Lake, Keewatin and Lynn Lake, Manitoba (Canada). Eiszeitalter and Segenwant. Vol. 18. Pp. 176-197.

Nichols, H., 1970, Late Quaternary pollen diagrams from the Canadian Arctic barren grounds at Pelly Lake, Keewatin, N.W.T. Arctic and Alpine Res. Vol. 2. Pp. 43-61.

Nicholas, F.J., and Glasspoole, H., 1931, General monthly rainfall over England and Wales, 1727 to 1931. British Rainfall. Vol. 8. pp. 299-306.

Norcliffe, G.B., 1977, Inferential Statistics for Geographers. Hutchinson and Co. Ltd. London. Pp. 272.

Oliver, J.E., 1973, Climate and Man's Environment: An Introduction to Applied Climatology. John Wiley and Sons Ipnc. New York. Pp. 517.

Oliver, J.E., 1975, Recollection of past weather by the elderly in Terre Haute, Indiana. Weatherwise. Vol. 74. Pp. 161-171.

Oliver, J.E., and Kington, J.A., 1970, The usefulness of ship's log-books in the synoptic analysis of past climates. Weather. Vol. 25. Pp. 222-233.

Oort, A.H., 1974, Year-to-Year variations in the energy balance of the Arctic atmosphere, Journal of Geophysical Res. Vol. 79. Pp. 1253-1260.

Perry, A.H., and Barry, R.G., 1973, Recent temperature changes due to changes in the frequency and average temperature of weather types over the British Isles. Met. Mag. Vol. 102. Pp. 73-82.

Pfaller, L., 1967, North Dakota weather: An analytic summary of conditions over the last century, North Dakota History. Vol. 34. pp. 82-96.

Ponte, L., 1976, The Cooling. Prentice-Hall, New Jersey. Pp. 306.

Post, J.D., 1973, Meteorological Historiography. Journal of Interdisciplinary History. Vol. 3. Pp. 721-732.

Powell, J.M., 1965, Annual and seasonal temperature and precipitation in British Columbia since 1890. Dept. of Transport Met. Branch CIR-4296, CLI-34 Toronto. Pp. 42.

Powell, J.M., 1965, Changes in amounts of sunshine in British Columbia, 1901-1960. Quant. Journal of the Royal Met. Soc. Vol. 91. pp. 95-98.

Rigby, M., 1976, Sources of historical meteorological data available in reprints. Weatherwise. Vol. 72. Pp. 242-243.

Ritchie, J.C. and Hare, F.K., 1971, Late-Quaternary vegetation and climate near the Arctic treeline of northwestern North America. Quaternary Research. Vol. 1. Pp. 331-42.

Roden, G.I., 1966, A modern statistical analysis and documentation of historical temperature records in California, Oregon and Washington, 1821-1964. Journal of Applied Meteorology. Vol. 5. Pp. 3-24.

Rosenberg, N.J., 1978, North American Droughts. Westerview, New Jersey. pp. 192.

Rosendal, H.E., 1970, The unusual circulation pattern of early 1843. Monthly Weather Review. Vol. 98. Pp. 266-270.

Ross, E., 1970, Beyond the River and the Bay. University of Toronto Press. Toronto. Pp. 190.

Rotberg, R.I., and Rabb, T.K., 1981, Climate and History, Princeton University Press, Princeton, N.J. Pp. 280.

Sekiguti, T., 1976, Historical dates of Japanese Cherry festivals since the 8th Century. Japanese Progress in Climatology. Vol. 3. Laboratory of climatology. Tokyo University. Pp. 38-45.

Sellers, W.D., 1968, Climatology of monthly precipitation patterns in Western United States, 1931-1966. Mon. Wea. Rev. Vol. 96. pp. 585-595.

Selte, R.W., 1970, Periodicities in London winters. Weather. Vol. 25. pp. 374-378.

Schell, I.I., Corkum, D.A., and Sabbagh, E.N., 1975, Recent climatic changes in the Eastern North American Sub-Arctic. in Climate of the Arctic. Ed. by G. Weller and S.A. Bowlings. (New York: Harper and Rowe) pp. 76-81.

Schove, D.J., 1954, Summer temperatures and tree rings in North Scandinavia, A.D. 1461-1950, Geografisker Annaler. Vol. 36. pp. 40-80.

Skaggs, R., 1978, Climatic change and persistnance in Western Kansas. Annals of the Assoc. of Am. Geog. Vol. 68. pp. 73-80.

Smith, C.G.,1974, Monthly seasonal and annual fluctuations of rainfall at Oxford since 1815. Weather. Vol. 29. Pp. 1-16.

Stearns, R.P., 1945, The Royal Society and the Company. Beaver. June. pp. 8-14.

Sugden,D.E., 1977, Reconstruction of the morphology, dynamics and thermal characteristics of the Laurentide ice sheet at its maximum. Arctic and Alpine Research. Vol. 19. Pp. 21-47.

Ten Brink, N.W., and Weidick, A., 1974, Greenland Ice sheet history since the last glaciation. Quaternary Research. Vol. 4. Pp. 429-440.

Thomas, M.K., 1966, Climatic trends on the Canadian Prairies. Water Studies Institute, Saskatoon, Report #2. Water and Climate a Symposium. Pp. 21-42.

Thomas, M.K., 1968, Some notes on the climatic history of the Great Lakes region. Proceedings of the Entomological Society of Ontario #99. pp. 21-31.

Thomas, M.K., 1974, Canada's climates are changing more rapidly. Can. Geog. Journal. Vol. 88. Pp. 32-39.

Thomas, M.K., 1975, Recent Climatic fluctuations in Canada. Environment Canada. Climatological Studies Number 28. Toronto. pp. 92.

Thompson, H.A., 1968, The climate of Hudson Bay. In Science, History and Hudson Bay. Vol. 1. Queen's Printer. Ottawa. Pp. 263-286.

Travis, P.D., 1978, Changing climate in Kansas: A late 19th Century myth. Kansas History. Vol. 1. pp. 48-58.

Tsuchiya, I., 1974, Little Ice Ages in earth's climate. Polar News. Vol. 10. Pp. 8-12.

Tullett, M.T., 1970, The nature of climatic change. Weather. Vol. 25 pp. 465-471.

U.S. Committee for the Global Atmospheric Research Program., 1975, Understanding Climatic Change. A Program for Action. National Academy of Sciences, Washington, D.C. pp. 239.

Veryand, R.S., 1963, A review of studies on climatic fluctuations during the period of the meteorological record. Arid Zone Research. Vol. 20. pp. 3-17.

W.M.O., 1966, Climatic Change. World Meteorological Organization, Technical Note. No. 79. Geneva. pp. 79.

W.M.O., 1967, A note on climatological normals. Technical Note. No. 84. Geneva. pp. 84.

Wagner, A.J., 1973, The influence of average snow depth on monthly mean temperature anomaly. Monthly Weather Rev. Vol. 100. pp. 624-626.

Wahl, E.W., 1968, A comparison of the Eastern U.S. during the 1830's with the current normals. Monthly Weather Review. Vol. 96. pp. 73-82.

Wahl, E.W., and Lawson, T.L., 1970, The climate of the mid-nineteenth century United States compared to the current normals. Monthly Weather Review Vol. 98. pp. 259-265.

Wales, W., 1770, Journal of a voyage made by order of the Royal Society, to Churchill River, on the Northwest coast of Hudson's Bay; of thirteen months residence in that country; and of the voyage back to England; in the years 1768 and 1769. Transactions of the Royal Society. Vol. 13. pp. 100-136.

Wales-Smith, B.G., 1971, Monthly and annual totals of rainfall representative of Kew Surrey, from 1697 to 1970. Met. Magazine. Vol. 100. pp. 345-360.

Weller, G., and Holngren, B., 1974, The microclimates of the Arctic tundra. Journal of Applied Meteorology. Vol. 13. pp. 854-862.

Will, G.F., 1946, Tree Ring Studies in North Dakota. Bulletin 338, Agricultural Experiment Station, North Dakota Agricultural College. pp. 24.

Willett, H.C., 1962, The relationship of total atmospheric ozone to the sunspot cycle. Journal of Geophysical Research. Vol. 67., pp. 661-670.

Williams, Glyndior, (Ed.), 1969, Andrew Graham's Observations on Hudson's Bay 1767-91. The Hudson's Bay Record Society. London. PP. 423.

Yamanoto, T., 1974, The changing climate through the period of meteorological records and the historical past in Japan and some considerations about the cold climate in the alluvial epoch. The Quaternary Res. Vol. 12. pp. 145-160.