

Spatial Representativeness of Climatic Data from Baffin Island, N.W.T., with Implications for Muskoxen and Caribou Distribution

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(Received 31 May 1988; accepted in revised form 4 October 1988)

ABSTRACT. Climatic records from often widely scattered arctic stations are commonly used to draw conclusions about such matters as wildlife habitat and distribution, yet little is known about the validity of extrapolating from such limited data. Statistical tests of meteorological network representativeness can be applied where station numbers and record length permit. Such an analysis was carried out on 29 years of temperature and precipitation data from five stations in central Baffin Island and Foxe Basin. It was found that seasonal temperatures and degree-days correlate highly across the region, indicating that interpolation and extrapolation can be carried out with confidence. Such was not the case for rainfall, snowfall, and depth of snow cover, all of which showed large extrapolation errors over modest (mesoscale) distances. This is attributed to the intrinsic variability of precipitation in the region and, in the case of snowfall and snow depth, the inadequacy of the measurement method. The results have been applied in an evaluation of suggestions concerning climatic constraints on the distribution and numbers of muskoxen and caribou, with the conclusion that the data do not support a causal relationship based on climate.

Key words: climate, spatial representativeness, Baffin Island, muskoxen, caribou

RÉSUMÉ. Des données climatiques de stations arctiques souvent très éloignées les unes des autres, sont couramment utilisées pour tirer des conclusions sur des questions telles que l'habitat et la distribution de la faune, mais on ne sait pas grand chose de la validité des extrapolations à partir de données aussi limitées. Là où le nombre de stations et la durée des observations le permettent, on peut appliquer des tests statistiques pour savoir si le réseau météorologique est représentatif. Une analyse de ce genre a été effectuée avec des données de température et de précipitation recueillies sur une durée de 29 ans, dans cinq stations du centre de la terre de Baffin et du bassin de Foxe. On a trouvé que les températures saisonnières et les degrés-jours avaient une forte corrélation dans toute la région, ce qui prouve qu'on peut faire des interpolations et des extrapolations en toute confiance. Tel n'était pas le cas pour les précipitations de pluie, de neige et pour l'épaisseur de la couverture de neige, qui montraient toutes de grosses erreurs d'extrapolation sur des distances moyennes (mésoséchelle). Cela est attribué à la variabilité intrinsèque des précipitations dans la région et, dans le cas des chutes de neige et de la profondeur de la neige, au fait que la méthode de mesure était inadéquate. Les résultats ont été appliqués dans une évaluation des suggestions concernant l'influence des contraintes climatiques sur la distribution et le nombre des boeufs musqués et des caribous, et ont abouti à la conclusion que les données n'appuyaient pas une relation causale fondée sur le climat.

Mots clés: climat, représentativité spatiale, terre de Baffin, boeuf musqué, caribou

Traduit pour le journal par Nésida Loyer.

INTRODUCTION

Meteorological coverage in the Canadian Arctic is sparse; nevertheless, users in many fields commonly attempt to apply the available data to particular problems where weather and climate may be a factor. Sometimes this is done uncritically, with little regard for the uncertainties inherent in the climatic record, but more often than not it is a matter of trying to make the best of a limited data set.

Consider the question of muskoxen (*Ovibos moschatus*) on Baffin Island, something that has long intrigued arctic scholars. There is no firm observational or fossil evidence that this species was ever anywhere on the island, although there is one unverified report of a sighting in central Baffin Island (Urquhart, 1982), as well as a muskox horn fragment found near Longstaff Bluff on the west coast that Harington (1975) dismissed as probably having been brought by Inuit from the mainland. Harington (1975) went on to consider factors mitigating against muskoxen in the region, concluding that snow depths in Baffin Island were probably too great to reliably allow winter feeding. In support of this he cited "average" depths of more than 76 cm from a report by Thomas (1953) based on meteorological data from before 1950, when there were few meteorological stations in the region and the depth of snow cover was not routinely reported.

A much improved climatology became available with the publication of Maxwell's (1980) *Climate of the Arctic Islands*, based on records through 1972. This shows the average snow

depth for the month of maximum snow depth (usually March, April, or May) over most of Baffin Island to be less than 50 cm. This is decidedly less than the 76 cm cited above; but, in any case, one has to question whether a single average value has any meaning for an island that spans 12 degrees of latitude and has an area of some 500 000 km². While the argument that snow depth is the limiting factor on muskox distribution in Baffin Island might be true (a point considered further in this paper), the underlying assumption that the snow depth data support this argument may not be. One object of this paper is to test the adequacy of those data.

There are reasons for examining the temperature data as well. In earlier work (Jacobs and Newell, 1979) it was found that there is good agreement in year-to-year variations in seasonal temperatures across the eastern Canadian Arctic but that this region is climatically distinct from West Greenland. However, a study of solar radiation in southern and eastern Baffin Island (Jacobs and Andrews, 1983) showed a high variability in daily radiation totals over distances of a few hundred kilometres. Air temperature is the product of energy budget processes in which solar radiation is dominant, but it does not vary as greatly as radiation because of heat storage and transfer effects. Still, those results indicate a need to re-examine the degree of variability in temperature over distances of a few hundred kilometres, what is usually referred to as the *mesoscale*.

In spite of the low density of meteorological stations in the eastern Canadian Arctic (Fig. 1), the length of record

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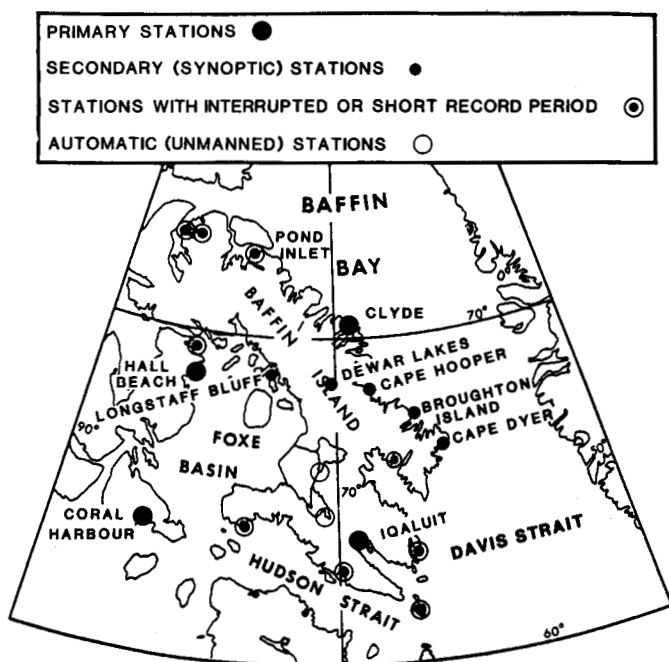


FIG. 1. The eastern Canadian arctic region showing the locations of meteorological stations.

is now sufficient in many areas to allow a systematic examination of the spatial characteristics of the data. I present here a brief review of the problem, followed by an analysis of temperature and precipitation elements from a line of stations across central Baffin Island and Foxe Basin. The results provide a quantitative basis for assessing the validity of inferences concerning the effects of climate on biota in the region.

THE PROBLEM OF REPRESENTATIVENESS

There are two parts to the problem of climatological observations: (1) the standards and errors of the observational method and (2) the spatial representativeness of the observing stations. In operational networks, such as that of the Atmospheric Environment Service in Canada, observing practices are set out in detail in observers' manuals (e.g., Government of Canada, 1977). The Arctic presents special observational problems; however, whatever the shortcomings of the measurements, the uniformity of observing standards insures that comparisons can be made between stations.

Representativeness can be defined as a quantitative measure of the accuracy with which a station network represents the actual climate of a particular area. Observing networks in the Arctic have evolved under locational constraints other than those of climatological representativeness. How well the existing network represents the climate of a region must be determined *a posteriori* from the accumulated records. Such an evaluation should give an indication of the usefulness of the climatic descriptions in various applications, as well as being a guide to planning the installation of additional stations, should these be justified.

Certain standards are recognized in meteorological practice for the requisite number of stations to cover a particular

area. These are usually based on experience and vary with topography and the particular element of interest. For example, the recommended minimum density of precipitation gauge stations in "arid and polar zones" is from 1 to 7 per 10 000 km² and of snow courses is 1 per 2000-3000 km² (World Meteorological Organization, 1974).

The criterion for an optimum observing network according to the World Meteorological Organization is "... that by interpolation between values at different stations, it should be possible to determine with sufficient accuracy for practical purposes the characteristics of the basic hydrological and meteorological elements anywhere in the country..." (World Meteorological Organization, 1974:3.2). Interpolation is the procedure whereby the data from individual points (the stations) are translated into the isopleths of the climatic maps. This may involve methods ranging from simple linear interpolation between points to more complex objective techniques incorporating the statistical characteristics of the data set, a method known as optimum interpolation (Gandin, 1963, 1970; Alaka, 1970). Some subjective adjustment of interpolated values is often called for, particularly in non-uniform terrain, as for example with precipitation inland across a mountainous coast. This informed subjective approach was used to a great extent in the atlas by Maxwell (1980) and in his subsequent analysis of climatic regions of the Arctic Islands (Maxwell, 1981).

An objective approach to the evaluation of network representativeness was derived from optimum interpolation by Gandin (1970). This has been applied in Canada by Johnstone (1983) to stations in the Mackenzie River Basin and by Radatz (1987) to precipitation gauges in the vicinity of Winnipeg, Manitoba. In the former study, 10 years of data from 50 stations over the 1 787 000 km² basin were considered. While monthly mean temperature was found to be adequately represented by the network, monthly precipitation totals and snow cover were not (Johnstone, 1983). In the study by Radatz (1987), a relatively dense mesoscale network (19 gauges in approximately 1000 km²) was used to evaluate the representativeness of the one official gauge operated by the Atmospheric Environment Service at Winnipeg. The conclusion was that the single station was fairly representative of the area average for monthly mean rainfall. However, for daily area averages, probable errors of single-station estimates were found to range from 21 to 85%.

Based on that experience, I have applied a simplified form of the Gandin (1970) method to records from stations in the eastern Canadian Arctic in order to evaluate the representativeness of the network there in terms of several climatic elements. The results of such an assessment then become a guide as to whether or not certain conclusions about climate impacts are necessarily valid.

METHOD

The descriptive statistics for a particular climatic element (x) at an individual station (i) with a record of N years length include the mean (\bar{x}_i) and standard deviation (SD_i). For purposes of interstation comparison, a relative measure of the temporal variation at each station is used. This is the temporal coefficient of variation (CV), defined as $CV_i = SD_i / \bar{x}_i$.

Comparison of the values of CV_i between stations gives a first indication of the spatial coherence of the meteorological field, as well as indicating possible anomalies in measurements at individual stations. The average of CV_i (or $\overline{CV_i}$) for all the stations in the region is an estimate of the intrinsic variability of the element over the region.

The product-moment correlation coefficient (r_{ij}) for matched records from pairs of stations is a further measure of spatial coherence in the meteorological field. Correlations between all pairs in the region provide the basis for asserting a functional dependence of r_{ij} on distance (d). It is usually found that r_{ij} decreases monotonically with d , with either a linear or exponential functional relationship. If the deviations about a linear regression of r_{ij} on d are evenly distributed, the linear form will suffice. Thus $R(d) = R(O) + Cd$, where the dependent variate $R(d)$ is the estimator of the correlation coefficient r_{ij} at some distance d from any station in the region. $R(O)$ is the limiting value of $R(d)$ as the interstation distance decreases to zero and represents the combined effects of local site factors and measurement error (Fig. 2). The uncertainty in the estimate of $R(d)$ is given by the standard error of the forecast (SE_R), which combines the standard error of the estimate, the standard error of the mean of sample values of R , and the standard error of the regression coefficient (Johnston, 1978). The coefficient of determination (r_{Rd}^2) resulting from the regression is a measure of the percentage of the variance in $R(d)$ that is due to distance.

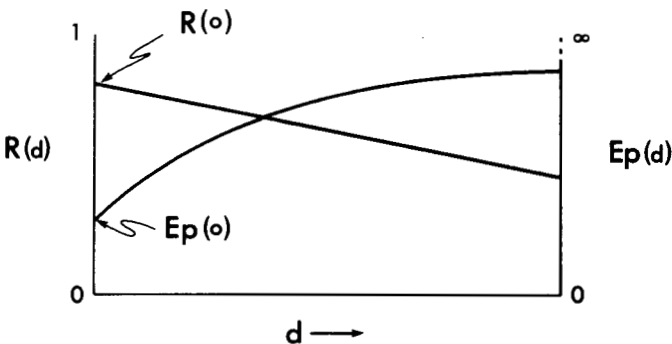


FIG. 2. An idealized representation of the correlation-distance function ($R(d)$) and the probable extrapolation error (E_p).

The probable extrapolation error (E_p) at a point some distance d from a reference station can be found in terms of the correlation-distance function from

$$E_p(d) = [2 \overline{CV}^2 (1 - R(O) - Cd)]^{1/2}$$

It is seen that E_p increases with distance at a decreasing rate (Fig. 2).

In summary, the representativeness of climatic data from one station when extrapolated to another point in its vicinity is a simple function of distance (i.e., the correlation-distance relationship), with the uncertainty of the extrapolation being due to the intrinsic variability of the element (indicated by CV) and combined local site factors and measurement error ($R(O)$), averaged over the region.

APPLICATION AND RESULTS

In few areas of the Canadian Arctic are meteorological station densities sufficient to provide an "optimum" network,

as previously defined. However, the stations constituting the Distant Early Warning Line (DEW-line), all of which are meteorological stations in the Atmospheric Environment Service network, are sufficiently closely spaced (ca. 200 km) to approach the recommended minimum spacing for some elements. As these stations were established around 1957-58, the period of record has now reached the 30 years of the "normal" averaging period.

For this analysis, I chose four DEW-line stations that lie approximately on the 68th parallel from Hall Beach on the west side of Foxe Basin to Cape Hooper on the east coast of Baffin Island, as well as a more northerly east coast station, Clyde (Fig. 1). The period of record for the analysis was 1958-86, or 29 years. The climatic elements chosen were: January maximum temperature, January minimum temperature, July maximum temperature, July minimum temperature (all of which refer to the mean maximum or minimum daily temperatures for the indicated month in each year); the cumulative degree-days above 0°C for the year (sometimes referred to as "thawing degree-days"); the maximum monthly snow depth (meaning the average daily snow depth in the month that had the greatest snow depth in a particular year); the total winter (October through May) snowfall; and the total summer (July + August) rainfall.

Figure 3 shows the 1958-86 average values for each of the elements and stations plotted as a cross-section according to the relative location of the stations, with the elevations of the stations indicated. For the four stations at the same latitude the points representing the average values have been connected to show the E-W spatial gradients of the elements. Temperatures have not been adjusted for elevation, as there is no simple lapse rate that applies near the surface in the Arctic, nor would a linear "correction" have any effect on the correlation analysis.

Some consistency is seen in the gradients for January temperatures and maximum snow depths (decreasing toward the west), but for the other elements there is little to suggest a regular spatial trend. This indicates that the construction of isopleths using data from these and other stations in the region must necessarily be subjective.

Correlations were carried out on the 10 station-pairs for each of the climatic elements. The results (Table 1) show a major difference in the correlation coefficients (r_{ij}) for temperature and degree-days compared with the precipitation elements. Fisher's significance test for the correlation coefficient (Snedecor and Cochran, 1967) was applied, the critical values for r varying somewhat because, due to missing data, the number of years and hence the degrees of freedom were not the same in all the correlations. To generalize from the worst case, the critical values for r are 0.433 and 0.549 at the 5% and 1% levels respectively. From Table 1 it is seen that for all 10 station-pairs (50 correlations) the correlation is significant for temperatures and degree-days. For the precipitation elements, however, only 5 out of 30 correlations meet or exceed the 95% criterion.

Following Gandin (1970), I plotted the correlation coefficients against interstation distance. Figure 4a is the resulting plot for element degree-days $> 0^\circ\text{C}$ and suggests a linear fit. The various temperature elements gave similar results. Figure 4b is a plot of maximum snow depth, which is typical of the precipitation elements. The values are low

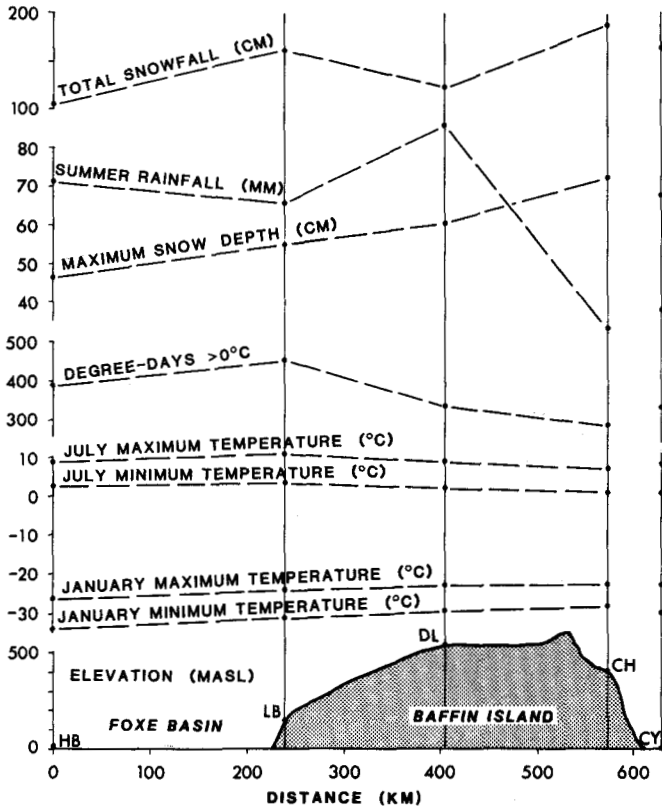


FIG. 3. Climatological cross-section of central Baffin Island and Foxe Basin. Units for the vertical scales are to be read as in the labels on the curves.

and the scatter great, but a linear fit is assumed for purposes of comparison. The resulting values of the parameters in the linear correlation-distance function are listed in Table 2. An examination of the standard errors and the scatter of the points around the regression line revealed no bias in the linear estimation.

As an independent check of the spatial variability in snow depth, I selected all years in which the central station showed a maximum May snow depth in the 75th percentile for that station record and compared the percentiles for the other stations in those same years (Table 3). In none of the six years so identified did all of the other stations show similarly great snow depths, although two others did in two years.

The probable extrapolation error was calculated for a distance of 100 km, as shown in the last column of Table 2. This mesoscale distance is of the order of the midpoint

distance for adjacent DEW-line stations and is far less than the typical spacing of climate stations in the Arctic. Again, a major distinction is found between the thermal elements, where $Ep(100)$ is less than \overline{CV} , and the precipitation elements, where it is greater.

These results show that while maximum and minimum temperatures and degree-days have a substantial intrinsic variability (CV), there is a high degree of spatial coherence in these elements compared with rain, snowfall, and snow depth. When extrapolated back to zero distance, the equivalent of having two stations side by side, the correlation ($R(0)$) is very high for the thermal elements and quite poor for precipitation. The resulting correlation-distance relationships for the thermal elements allows extrapolation with a high degree of confidence. However, the coefficient of determination (r_{Rd}^2) is low in all cases, and thus we can expect considerable uncertainty in all elements, indicated by the probable error (Ep), when making predictions about any single month or year.

DISCUSSION

The analysis shows that there is substantial temporal and spatial variability in the mesoscale climates in the study area. All of the climatic elements that were analyzed show this behavior. A fundamental difference exists, however, between thermal and precipitation elements; the first group is spatially coherent, while the second is not. This means that, with appropriate procedures for interpolation/extrapolation, one can predict with reasonable confidence the values of monthly mean temperature and cumulative degree-days throughout the region using data from the existing station network. However, this cannot be done for rainfall, snowfall, and snow depth. Given particular reported values for any or all of the stations, *there is no way of reliably estimating the values at points elsewhere in the region.*

A study by Barry (1974) of upper air data from Baffin Island and West Greenland showed a high spatial coherence in water vapor content in the free atmosphere over the region and a trend of decreasing moisture westward from Davis Strait. However, calculated values of vapor flux convergence compared poorly with estimates of precipitation minus evaporation based on surface data from Dewar Lakes and Broughton Island. That suggests a high degree of spatial variability in rain and snowfall data from the region, large measurement errors, or a combination of the two.

At the beginning of this study, questions of measurement error were disregarded and the station data taken at face value.

TABLE 1. Interstation correlations (r-values) for selected climatic variables

Station pair	Distance (km)	$T_x(\text{Jan})$	$T_n(\text{Jan})$	$T_x(\text{Jul})$	$T_n(\text{Jul})$	Deg-d > 0	Rain	Snowfall	Snow depth
Clyde - Cape Hooper	232	0.920	0.937	0.883	0.616	0.851	0.086	0.194	0.095
Clyde - Dewar Lakes	226	0.853	0.804	0.808	0.533	0.854	0.129	0.416	0.283
Clyde - Longstaff Bluff	322	0.758	0.864	0.739	0.579	0.831	0.002	0.164	0.097
Clyde - Hall Beach	536	0.771	0.811	0.720	0.645	0.874	0.153	0.049	0.101
Cape Hooper - Dewar Lakes	176	0.786	0.779	0.884	0.765	0.938	0.612	0.399	0.162
Cape Hooper - Longstaff Bluff	348	0.832	0.825	0.754	0.662	0.810	0.356	0.198	0.035
Cape Hooper - Hall Beach	586	0.719	0.754	0.629	0.501	0.748	0.435	0.066	0.002
Dewar Lakes - Longstaff Bluff	167	0.852	0.861	0.898	0.830	0.929	0.286	0.273	0.531
Dewar Lakes - Hall Beach	407	0.852	0.915	0.744	0.652	0.801	0.365	0.086	0.313
Longstaff Bluff - Hall Beach	241	0.802	0.914	0.790	0.793	0.917	0.435	0.000	0.566

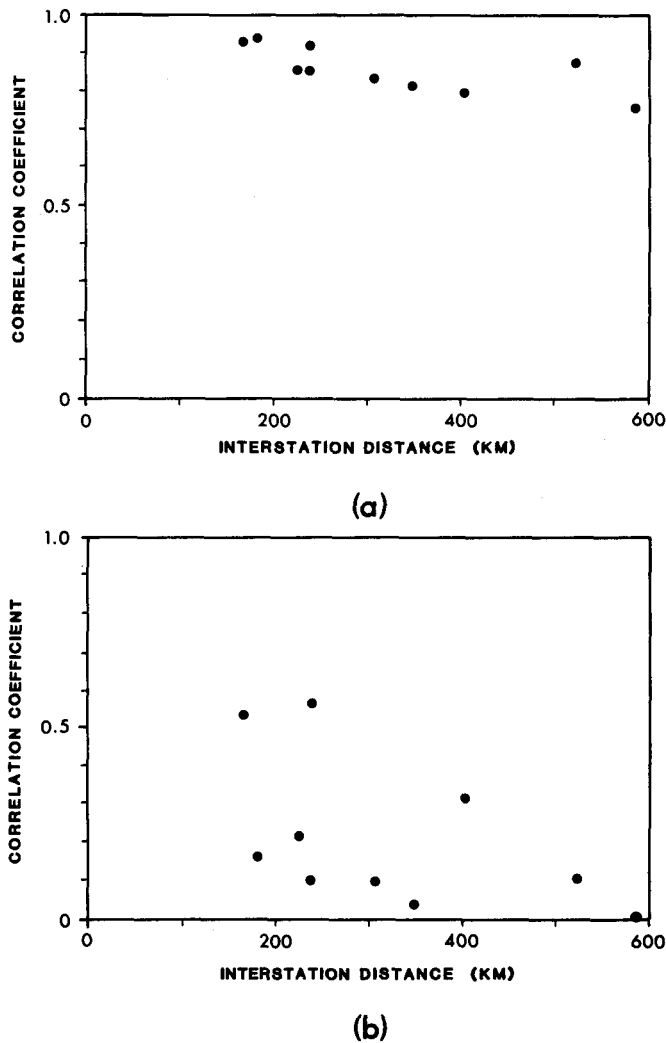


FIG. 4. Correlation-distance plots of (a) cumulative degree-days $>0^{\circ}\text{C}$ and (b) maximum snow depth for the five central stations.

Having found a lack of spatial coherence in the precipitation elements, it is now appropriate to examine possible causes. Either there is a high degree of spatial variability in those elements or the measurements contain large errors. A test of both possibilities can be done by carrying out a relatively large number of snow depth and density determinations over representative terrain in the vicinity of the reporting stations and comparing the results with the station data. This was done by Woo *et al.* (1983) for several years in small basins (30-60 km²) in the vicinity of Resolute, Eureka, and Mould

Bay in the Canadian High Arctic. Snow depths across the basins varied from a few centimetres to over a metre, and the average basin values (expressed as mm water equivalent) ranged from 1.3 times to more than 3 times the amounts reported by the stations. There was no significant correlation between their mean basin values and either the cumulative snowfall or snow depth values reported from the stations, nor was a significant correlation found between reported values of snowfall and snow depth at the stations. This latter result is interesting, since it seems reasonable to expect that snowfall and snow depth at a site are correlated, although compaction and metamorphosis in the snowpack will result in a depth that is less than the cumulative catch in the gauge. Indeed, when I carried out correlations between total winter snowfall and maximum snow depth for the five Baffin Island region stations over the 1959-86 period, the results were all significant at the 1% level.

It is not necessary to repeat the field experiment of Woo *et al.* (1983) for the Baffin Island stations to conclude: (1) that the snowfall measured by the gauge considerably underrepresents the actual snowfall, (2) that the snow surveys (usually 10 points) do not adequately represent the snow cover in the vicinity of the station, and (3) as a consequence of those factors and the larger scale variability in the precipitation elements, the station network does not adequately represent conditions in the region. However, such detailed surveys, particularly if conducted over long transects, would do much to quantify the uncertainty in the station data.

The resolution of mesoscale climate can be improved by operating automated stations at intermediate locations of special interest. Two such stations have been installed with the support of the Atmospheric Environment Service in the interior of south-central Baffin Island (Fig. 1), where short-term summer observations had revealed local temperature anomalies associated with the two large lakes in this region (Jacobs and Grondin, 1988).

Remote-sensing techniques have been used in an attempt to determine snow cover characteristics in the Arctic. Lauriol *et al.* (1986) used the area occupied by residual snow cover in July, as determined from aerial photographs, in conjunction with meteorological station snow depth data to provide "hypothetical" estimates of maximum winter snow depths in the eastern Arctic. They suggested that the technique could be improved using satellite imagery, but stressed the need for field verification. Passive microwave radiometry from the Nimbus-7 satellite was used by Hall *et al.* (1987) to map snow cover extent and snow depth in Alaska with a spatial resolution of 0.5° latitude by 5° longitude. Although a good correlation was found between microwave brightness temperature

TABLE 2. Parameters of correlation-distance function and interstation error

Element	Mean	\overline{CV} (%)	SE_R	R(O)	C ($\times 10^{-4}$)	r_{Rd}^2	Ep(100 km)
$T_x(\text{Jan})$	-23.9°C	17.2	0.05	0.89	-2.3	0.32	8.9% or 2.1°C
$T_n(\text{Jan})$	-30.9°C	11.6	0.06	0.89	-1.4	0.13	5.8% or 1.8°C
$T_x(\text{Jul})$	8.6°C	25.2	0.05	0.96	-5.3	0.82	10.9% or 0.9°C
$T_n(\text{Jul})$	2.0°C	56.6	0.10	0.79	-4.2	0.32	40.2% or 0.8°C
Deg-d >0	358.8°C-d	30.4	0.05	0.95	-3.0	0.53	12.2% or 43.6 deg-d
Rain	59.7 mm	65.2	0.20	0.29	0.0	0.00	77.8% or 46 mm
Snowfall	148.9 cm	40.1	0.12	0.39	-6.3	0.42	46.5% or 69.3 cm
Snow depth	60.8 cm	40.7	0.19	0.46	-7.3	0.25	45.1% or 27.4 cm

TABLE 3. Comparison of depth of May snow cover (cm) by percentile for years of exceptional cover at Dewar Lakes (1958-86)

Station	DL	CH	LB	HB	CY
Median depth	57.1	37.4	26.6	39.8	49.5
Depth of 75th percentile	73.1	70.9	54.0	47.2	95.1
Year/percentile					
1970	>75	>75	>75	<25	25-50
1971	>75	25-50	>75	25-50	25
1973	>75	25-50	50-75	>75	<25
1975	>75	50-75	<25	<25	<25
1976	>75	25-50	<25	50-75	25-50
1983	>75	>75	50-75	50-75	>75

the snow depth recorded at three meteorological stations, systematic errors appeared in the estimated depths due to changes in the radiometric properties of the snow with time and to spatial variations in these characteristics as well as in snow depth. Again, it was concluded that much more ground truthing is necessary.

IMPLICATIONS FOR MUSKOX AND CARIBOU DISTRIBUTION

The results reported here have implications for how climatology is applied to problems such as wildlife habitat and distribution. It is clear that there is considerable uncertainty about regional average snow depths in the long term. In addition, it is known that even in close proximity to a reporting station, actual snow depths vary greatly about the reported values. This suggests that even in years of heavy snowfall there will be areas of relatively thin snow cover, where forage is accessible, particularly in the western and northern parts of Baffin Island. A comparison of maps showing the distribution of muskoxen (e.g., Banfield, 1974) with maps of maximum snow depth (Maxwell, 1980) reveals an approximate coincidence of the muskox distributional limit with the 100 cm snow depth isopleth, except in Baffin Island. Yet a considerable area of northwestern Baffin Island has lesser maximum snow depths and, considering this factor alone, should not be excluded as possible muskox habitat. Furthermore, as has been shown by this analysis, *uniformly* deep snow cover is not to be expected over any extensive part of this large island.

Drastic declines in both muskox and caribou populations in the High Arctic and elsewhere have been attributed to one or more years of unfavorable snow cover and ground ice conditions (e.g., Ferguson, 1987). Observations of muskoxen on Bathurst Island by Gray (1987) indicate that a snow depth of over 30 cm, compounded by crusting, causes feeding difficulties. Burch (1977), on the other hand, has presented historical evidence for relatively abundant muskox populations in the 17th and 18th centuries more than 100 km south of the tree line on the mainland west of Hudson Bay and extending within the 100 cm maximum snow depth zone. The key to muskox persistence there, as in other areas, is a varied terrain that combines productive summer range in the lowlands with uplands that remain relatively snow free in winter (cf. Kelsall *et al.*, 1971; Thomas *et al.*, 1981). The complexity of topography in Baffin Island is well known and would appear at least in some areas to meet these conditions.

Climate is not static, and habitat conditions would be expected to vary as the climate changes. From palynology we know that the eastern Canadian Arctic was generally cooler and drier about 2500 years ago (Short *et al.*, 1985), so presumably the area of potential muskox habitat shifted southeastward. Since the muskox was present in the Arctic Islands by at least 7000 years ago (Harrington, 1980), it could have been present in Baffin Island during that later cooler period, if not more recently. Until fossil evidence is found, however, the argument must remain theoretical.

Much the same argument concerning snow cover and especially the impact of mild, wet winters has been used to explain the apparent cyclical nature of caribou populations. Meldgaard (1986) reviewed the long record of caribou census in west and southwest Greenland and concluded that "...climate change [is] the driving force in long-termed population fluctuations..." (Meldgaard, 1986:69). In the Thule district, however, Roby *et al.* (1984) found that unfavorable snow conditions alone could not explain the decline in caribou, but that other factors such as overhunting must be operating as well.

Caribou (*Rangifer tarandus groenlandicus*) are widely distributed in Baffin Island and, although census data are limited, they are known to have fluctuated greatly in numbers and area of concentration (M.A.D. Ferguson, pers. comm. 1987). Contrary to Banfield's map (Banfield, 1974:387), their range includes the southeastern part of the island, where average snow depths are greatest and winters mildest, although their numbers are largest in the west-central region. Again, it is the diversity of topography and the resulting spatial variability of snow cover and other habitat characteristics combined with the mobility of the animals over this large area of land that explain their persistence.

CONCLUSION

Climatic data accumulated in the Canadian Arctic over the past 30 years can be usefully applied to regional studies of wildlife distribution, provided that this is done with due regard for the limitations inherent in sparse observational networks. The correlation-distance function and probable extrapolation error are quantitative indicators of the spatial representativeness of the climatic data set. They provide a measure of the uncertainty in the interpolation and extrapolation of climatic variables over the region and thus an indication of the validity of arguments based on these extrapolations.

The evaluation of temperature and precipitation data from central Baffin Island has shown the usefulness of the test. Monthly maximum and minimum temperatures and cumulative degree-days show a high degree of spatial coherence. Thus, in any given year or period of years characterized by a particular deviation or trend in these elements, the effects will be similar throughout the region, and interpolation/extrapolation using appropriate models can be undertaken with confidence. On the other hand, there are no significant correlations in snowfall and snow depth data over the region. Extrapolations over any distance are meaningless. This places obvious limitations on inferences

about snow cover in relation to wildlife habitat. Caribou thrive in many areas of Baffin Island where bioclimatological generalizations would exclude them. That muskoxen apparently do not require an explanation that goes beyond what the available climatic data can tell us.

ACKNOWLEDGEMENTS

This research was supported by the Natural Sciences and Engineering Research Council. Meteorological records were provided in computer-ready form for this study by the Canadian Climate Centre. My thanks to A.N. Headley, J.B. Maxwell, W.R. Skinner, I.M. Weis, and R.M. Welch for their advice and assistance and to anonymous reviewers for their helpful suggestions.

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