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RELATIONSHIPS BETWEEN CLIMATE AND REGIONAL VARIATIONS IN SNOW-COVER DENSITY IN NORTH AMERICA

Michael A. Bilello

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CORPS OF ENGINEERS, U.S. ARMY
COLD REGIONS RESEARCH AND ENGINEERING LABORATORY
HANOVER, NEW HAMPSHIRE

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PREFACE

This report was prepared by Michael A. Bilello, Research Meteorologist, of the Research Division, U. S. Army Cold Regions Research and Engineering Laboratory. It is published under DA Task 1T061102B52A02, *Research in Military Aspects of Terrestrial Sciences – Military Aspects of Cold Regions Research.*

The data used in this report were made available through the combined efforts of personnel associated with the Air Weather Service, U.S. Air Force; the Weather Bureau, U.S. Department of Commerce; and the Meteorological Branch, Canadian Department of Transport. The author wishes to thank Dr. Robert Gerdel, formerly of USA CRREL, now retired, and Mr. Frederick Sanger, USA CRREL, for their technical review of the paper. Mr. Roy Bates, USA CRREL, assisted with the computation and tabulation of the data.

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RELATIONSHIPS BETWEEN CLIMATE AND REGIONAL VARIATIONS IN SNOW-COVER DENSITY IN NORTH AMERICA

by

Michael A. Bilello

INTRODUCTION

Knowledge of the regional distribution of snow-cover density would help solve numerous winter problems. For example, the density-dependent thermal conductivity of the snow cover greatly influences the rate of penetration of ground frost and the growth of ice on lakes and rivers. Trafficability of men and vehicles depends strongly upon the density of the snow cover. Dense snow may support a wheeled vehicle. Sinkage in snow of low density seriously impedes or prevents movement. Studies in hydrology and in snow removal also require knowledge of the density of the snowpack during the winter.

This study investigates the regional variations of snow-cover density in the North American Arctic, Subarctic and Temperate Zones for the nonmelting period only. This permits direct association of regional variations in density with air temperatures and wind speeds, and the development of a method by which average snow-cover densities can be estimated where the influence of melting on density may be disregarded. The purpose of this correlation is to make use of climatological data to determine snow density in areas where such measurements have not been made.

An investigation of this type requires concurrent measurements of snow-cover density and the meteorological elements. To obtain such measurements, a systematic snow observation program began during the winter season of 1952-53 at various locations in Canada, Greenland and the United States including Alaska. The observations were made at weather stations supported by the United States Air Force, United States Weather Bureau and the Meteorological Branch of the Canadian Department of Transport.

Two to eleven years of snow-cover data have been compiled for nine locations in Canada, ten in Alaska, seven on the United States mainland and one in Greenland. The Greenland station, Sondrestrom, although not on the North American continent, was included because of its proximity to the network.

The snow observations, made weekly and sometimes biweekly in accordance with standard procedures described in USA CRREL Instruction Manual No. 1 (USA SIPRE, 1954), provide density, temperature, and hardness data on the layers of snow in vertical profile. The different layers of snow are delineated by structural or textural variations identifying periods of major snow accumulation or metamorphism.

Previous studies (Wengler, 1914; Rikhter, 1945; Formozov, 1946; and Klein, 1950) show that there are important regional differences in the density of the snow cover throughout the Northern Hemisphere. In an earlier study (Bilello, 1957), it was found that the snow cover during the winter months is denser in the Canadian Archipelago than in the interior of Alaska. Additional data have since become available which permit extension of the analysis to other parts of North America.

REGIONAL VARIATIONS IN DENSITY

In the analysis of the new data a weighted mean of snow-cover density for each observation was used (as was done in the earlier study), thus:

	Thickness of each layer (cm)	*% of total depth*	*Observed snow density (g/cm^3)*	*Weighted snow density (g/cm^3)*
Layer 1 (bottom)	6	20	0.205	0.041
Layer 2	15	50	0.290	0.145
Layer 3 (top)	9	30	0.230	0.069
Total	30	100		0.255

This method of computation was used to allow for the variations in thickness and density of the different layers of snow.

The average seasonal (November - March) snow-cover density for each station (Table I) is the arithmetic mean of all the weekly mean weighted values based on a total of over 2500 observations. The number of years of record for each station is also shown. (Data are presented in Appendix A.) For some low latitude stations November and/or March was excluded because the observed average monthly air temperatures were above freezing and some melting may have occurred. Periods of above-freezing temperatures that may have occurred during the other winter months were assumed to be brief, and effective only in raising the temperature of the snow without causing melt; they were therefore disregarded. The effect of one day of freezing rain or thaw during midwinter would have little influence on the snow cover and would not be reflected in the monthly average density.

The concurrent average seasonal air temperature and wind speed for each station are also given in Table I.

Analysis indicated that the stations could be put in four categories based upon the observed densities, climatic factors and to some extent on geographical location (CRREL network, Fig. 1). These categories were grouped so as to emphasize regional, rather than point, variations in snow-cover density. Category 1 included the four stations with lowest observed densities (between 0.199 and 0.233 g/cm^3). These stations are located in the interior of Alaska and western United States and have, in general, light winds. The second group comprises nine stations with average densities between 0.241 and 0.268 g/cm^3, most of which are near the coast. The seven stations in Category 3 have densities between 0.279 and 0.297 g/cm^3. This group does not have a geographic entity; the stations are located both inland and near coasts. Category 4 consists of seven Arctic stations where the highest densities (between 0.320 and 0.363 g/cm^3) and the lowest seasonal temperatures were observed. The frequency curves in Figure 2 show the increasing densities of the four categories. Naturally, the local topography and vegetation create differences in the density from point to point within a categorically defined region. Deviations from the average value for each region can also be expected from month to month and year to year. The standard deviations from the average values (Table I) show the extent of these monthly and yearly variations.

Skewness (departure from symmetry) coefficients, based on the quartile method (Mode, 1948), were computed for each station and are shown in Table I. The quartile values were obtained by plotting the observed snow densities proportionally between 0 and 100% frequency distribution and precisely interpolating between the densities for the 25, 50 and 75% locations. All but two stations in Categories 1 and 2 show positive skewness, i.e., the peak of the frequency curve is toward lower densities, and all but three of the stations in Categories 3 and 4 show negative skewness, i.e., the peak of the frequency curve is toward higher densities. This difference supports the separation of Category 2 from 3, but since the significance of the computed values has not been determined the results are used only as an indicator.

Table I. Summary of snow-cover densities and climate for 27 stations in North America and Greenland (1952-63).

Station	*Years of record*	*Average seasonal snow density (g/cm^3)*	*Std dev*	*Skewness*	*Average seasonal temp † (°C)*	*Average seasonal wind speed † (m/sec)*
Category 1						
Eielson AFB (Fairbanks), Alaska	6	0.199	0.053	+.178	−20.3	1.3
Tatalina, Alaska	9	0.203	0.047	+.010	−15.5	2.1
Hill (Ogden), Utah	8	0.219	0.083	+.282	− 1.7	3.6
Galena, Alaska	10	0.233	0.060	−.088	−20.7	2.2
Category 2						
Utopia Creek, Alaska	9	0.241	0.069	+.154	−19.1	2.8
Naknek, Alaska	2	0.244	0.035	+.361	− 9.2	4.3
Sagiek, Labrador	6	0.249	0.091	+.588	−10.6	3.8
Griffiss (Rome), N.Y.	9	0.252	0.052	+.121	− 4.3	3.1
Malmstrom (Great Falls), Montana	8	0.252	0.046	+.178	− 2.2	5.4
Elmendorf (Anchorage), Alaska	7	0.253	0.081	+.035	− 8.6	2.5
Ernest Harmon (Stephenville), Newf.	9	0.255	0.102	+.100	− 4.9	5.1
Sondrestrom, Greenland	5	0.262	0.032	+.522	−17.6	3.1
Goose Bay, Labrador	2	0.268	0.068	−.451	−10.9	4.1
Category 3						
Sparrevohn, Alaska	9	0.279	0.045	−.047	−11.5	2.7
Sault Ste Marie, Mich. *	10	0.290	0.057	+.101	− 8.4	4.4
Frobisher, NWT	4	0.292	0.066	−.555	−22.8	4.8
Fargo, North Dakota *	2	0.294	0.050	+.204	− 9.4	6.6
Loring (Caribou), Me.	11	0.294	0.080	−.005	− 9.2	5.3
Northeast Cape, Alaska	2	0.296	0.033	−.237	−10.2	5.9
Wurtsmith (Oscoda), Michigan	8	0.297	0.073	−.018	− 5.1	4.5
Category 4						
Cape Lisburne, Alaska	2	0.320	0.051	+.141	−18.2	5.5
Barter Island, Alaska	3	0.325	0.059	−.654	−25.3	5.9
Eureka, NWT *	11	0.328	0.057	−.325	−35.3	2.6
Resolute, NWT *	10	0.342	0.044	−.016	−30.2	5.4
Alert, NWT *	10	0.345	0.061	−.044	−30.5	2.7
Mould Bay, NWT *	7	0.354	0.050	−.038	−32.2	4.3
Isachsen, NWT *	11	0.363	0.051	−.054	−33.2	4.4

* U.S. Weather Bureau and Canadian Department of Transport stations. All others are U.S. Air Force, Air Weather Service stations.

† From U.S. Air Force, 1952-63; U.S. Weather Bureau, 1952-63.

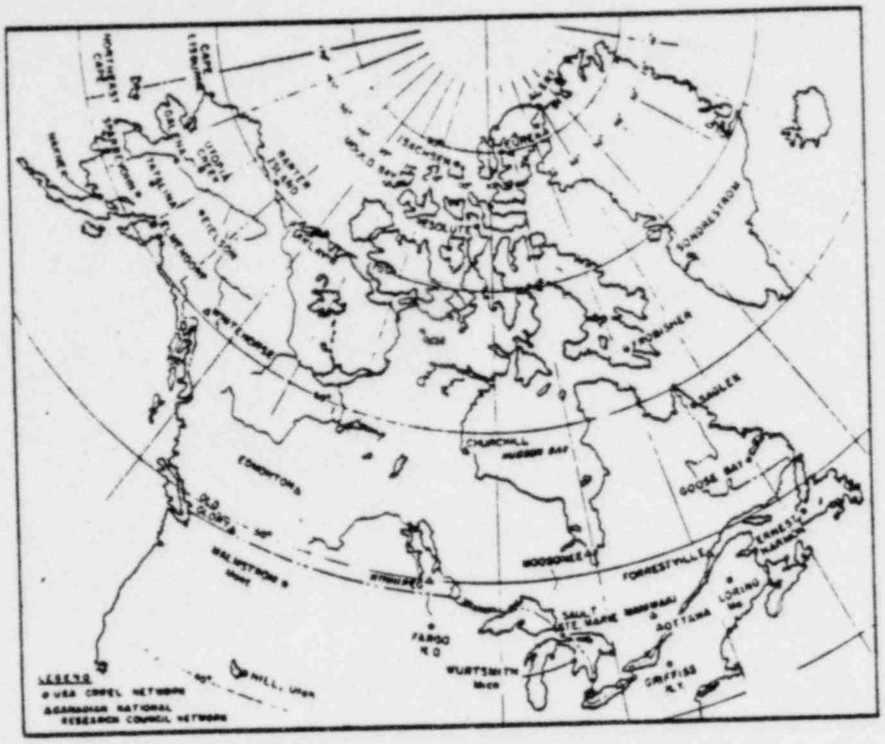

Figure 1. Locations of stations.

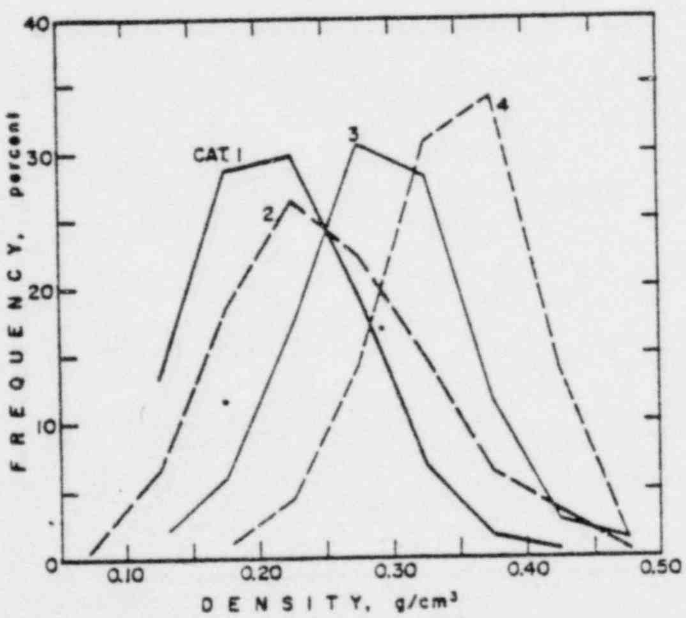

Figure 2. Frequency curves for density Categories 1-4. Curves comprise line segments connecting mid-points of class intervals 0.10 - 0.15 g/cm³, 0.15 - 0.20 g/cm³, etc.

MONTHLY INCREASE IN DENSITY

The metamorphic processes which take place within a snow cover with time have been described by a number of investigators (e.g., Bader et al., 1939; de Quervain, 1945; Kingery, 1960). It has been shown (e.g., Shepelevsky, 1938; Work, 1948; Thornthwaite, 1950; and Gold, 1958) that this aging process results in a gradual increase in the snow-cover density as the winter progresses.

This time-densification process was substantiated in this study on average monthly density values. The computed monthly values for the stations within each category were combined and the results are shown in Figure 3. The density for the stations in Categories 1, 2 and 3 (except for 2 between November and January) increases by approximately 0.01 g/cm^3 each month. The decrease in density during December for Category 2 is believed due to the fact that the stations in this group are principally located in a region of heavy snowfall and that the new snow of lighter density that accumulates between November and January dominates the snowpack. The stations in Category 4 show little change throughout the winter because their densities are initially near maximum and because they are located at latitudes where the heat derived from solar radiation between December and March is very small and has negligible effect on snow density.

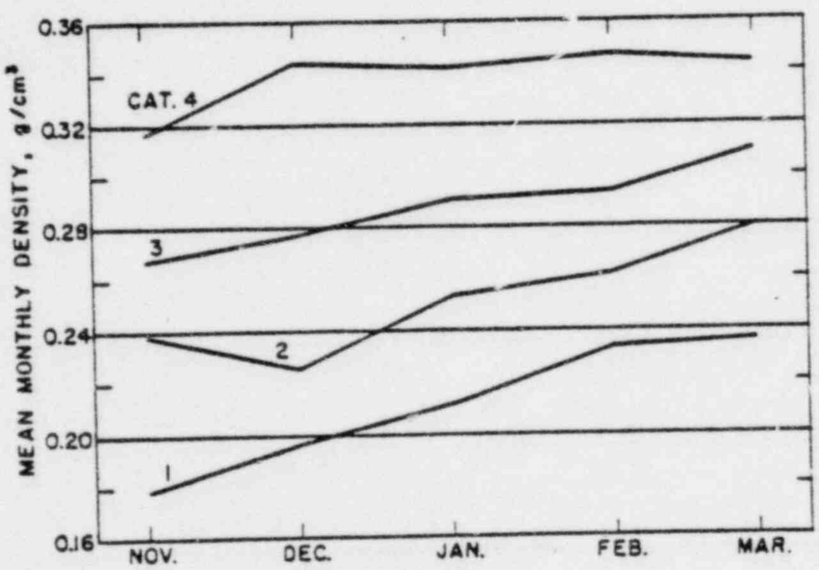

Figure 3. Increase in density from November through March for Categories 1-4.

NOMOGRAPH TO ESTIMATE AVERAGE SNOW-COVER DENSITY

One of the main objectives of this study was to develop a nomograph from which the relationship between climatic parameters and the density of winter snow cover could be determined.

There are a number of fundamental conditions which determine the structure, and physical and mechanical properties, of a snow cover (Yosida, 1955). In addition to the meteorological environment, other processes directly or indirectly attributable to weather could affect the snow cover. For example, Kondrat'eva (1945) reports that the sublimation process in the snow cover can bring about a significant redistribution of snow mass and that a temperature difference of 11 C in a snowpack caused the density in the lower layer to decrease by 0.08 g/cm^3 in 5 days. The heat flow from the soil and the soil conditions with respect to water content and depth of freezing also may influence the metamorphic processes within the snowpack. However, these subtle effects and the resultant changes in snow density are not within the scope of this report. These processes and such factors as humidity, radiation and cloud cover must be considered if one wishes to undertake a micro-scale study of changes in snow-cover density.

Dmitrieva (1950) presents a method of calculating the mean density of the snow cover from the following data: the time of snow cover appearance; the number of days with wind speeds over 6 m/sec between the time of appearance of the snow cover and the date of calculation; the sums of positive mean diurnal air temperatures for this period; and snow cover depth or amount of precipitation for cases of heavy snowfall. Dmitrieva states that an accuracy of ± 0.03 g/cm^3 was found in 91% of the calculations for regions where winter temperatures fluctuate little, and least accuracy where frequent thawing occurred. Weinberg and Gorlenko (1940) also note that the effect of wind on densification of the snow cover is important. Wind fragments the snow crystals, causes the finer grains to re-sort, and by packing increases the density.

As Williams and Gold (1958) point out, many difficulties complicate the problem of relating snow cover characteristics to climate. For example, in any one area meteorological factors vary from year to year, and the elements measured at a site may not be representative. However, they also found that wind speed and air temperature appear to be the dominant factors in the formation of the cover. Consequently, they developed a weather index using these elements to estimate average monthly densities. Although there was considerable spread in density for any particular index a correlation did exist between the variables. However, when monthly averages were calculated for sheltered stations and plotted against the weather index for the month, little correlation was found.

In Research Report 39 (Bilello, 1957) nomographs were developed for estimating average monthly densities. Since that study included only stations north of 62°N latitude reasonable results were obtained in the month-to-month analysis. A similar approach was tried for the 27 stations in this study, but the results were less favorable. Apparently, the climatic regime under consideration is too extensive for predicting densities from month to month. Therefore, multiple regression analysis was made in which *seasonal* snow-cover density was related to the average air temperature and wind speed (Table I) observed during the same period. The resultant equation derived through the use of a computer is:

$$\rho = 0.152 - 0.0031\,T + 0.019\,W$$

where

ρ = average seasonal snow-cover density (g/cm^3)

T = average seasonal air temperature (°C), and

W = average seasonal wind speed (m/sec).

The correlation coefficient and the standard error of estimate are 0.84 and 0.025 g/cm^3, respectively.

By coincidence, the numerical constant (0.152) appearing in the equation is almost identical to that given by Dmitrieva (1950) for the average density of fresh snow (0.15 g/cm^3). This value, obtained from two independent studies, implies that when the Arctic, Subarctic and Temperate Zones are considered the average density of freshly fallen snow is higher than the generally accepted water equivalent value of 10%. Figure 4 is the nomograph developed from the above equation.

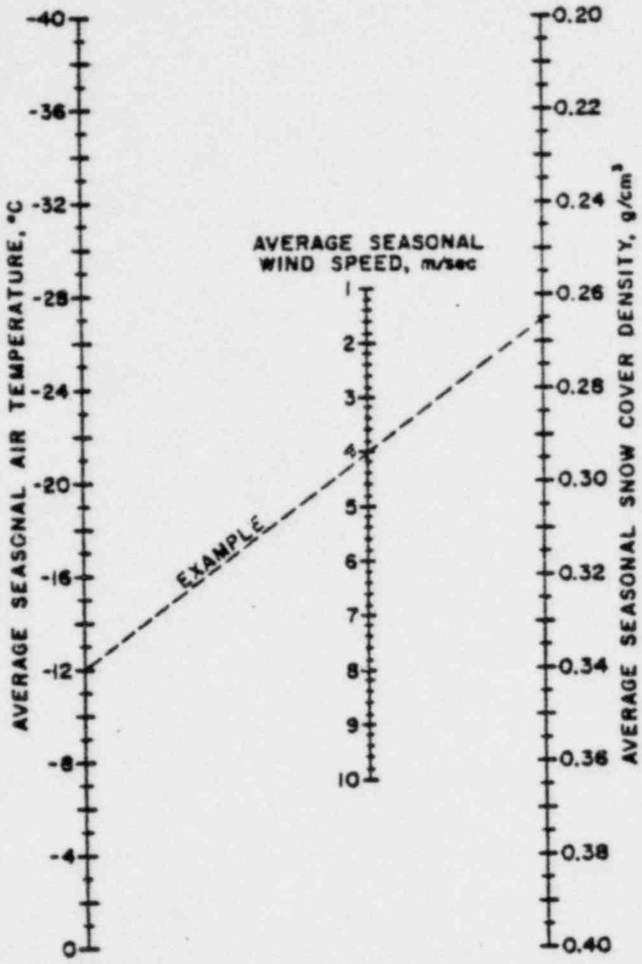

Figure 4. Nomograph for estimating average seasonal snow-cover density. The term seasonal *refers to November through March inclusive, unless the average air temperature for the month is above freezing. Example: Assume the average seasonal air temperature and wind speed for a location are -12C and 4.0 m/sec. Extend a straight line through these two points and read 0.265 g/cm³ on the snow density scale.*

TEST AND APPLICATION OF THE NOMOGRAPH

To test the nomograph, the densities for ten locations not included in the study were stimated. These stations (Table II; Canadian network, Fig. 1) were used because they cover a wide climatic range and their average observed densities were reported by Gold and Williams (1957). Their report, dated 1957, stated that the snow survey was initiated in 1946. Consequently, average air temperatures and wind speeds for the winter seasons between 1946 and 1957 (Table II) were used as the independent variables (Department of Transport, 1946-57).

Figure 5 shows the observed and estimated densities for these stations. There is good agreement between the values (correlation coefficient =0.91) and the standard error of estimate obtained from a least squares computation was 0.016 g/cm³.

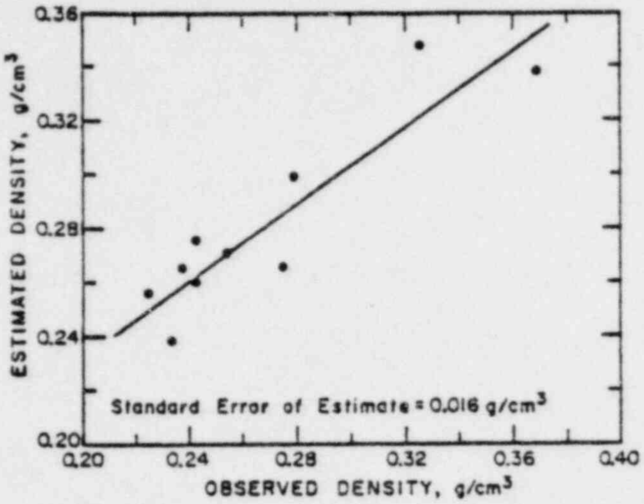

Figure 5. Estimated versus observed densities for ten test stations (from Gold and Williams, 1957).

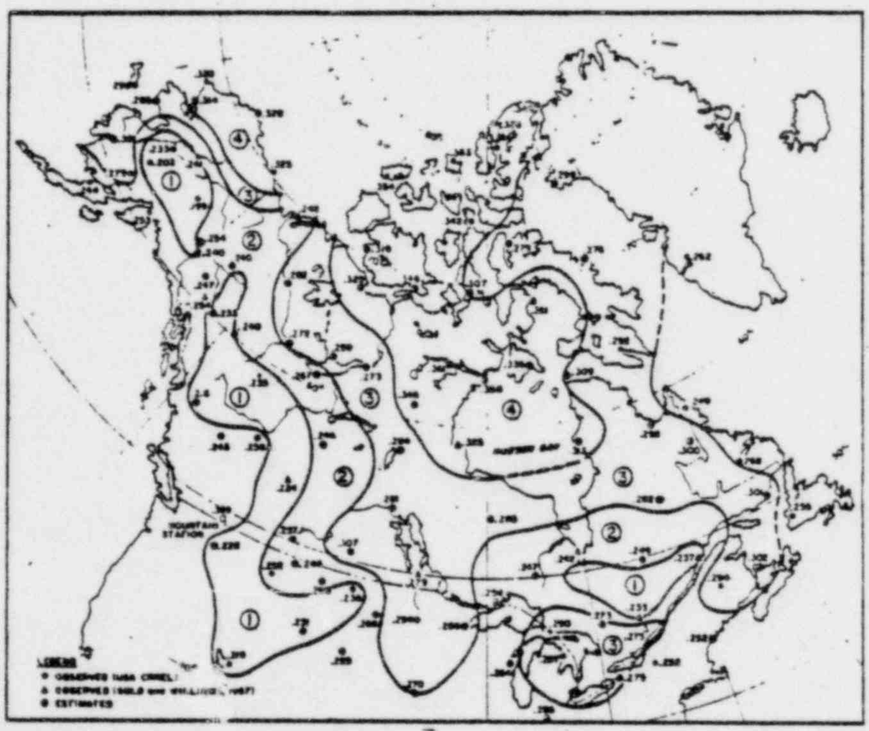

Figure 6. Average seasonal snow-cover densities. Categories 1-4 are separated at densities of 0.24; 0.27 and 0.31 g/cm³.

The results of density computation from this nomograph gave sufficient confidence to warrant its application to a number of stations throughout North America. The necessary climatological data for 10 years of record (between 1952 and 1965) for 61 stations (Table III) were compiled and average seasonal density values were estimated from the nomograph. These values, plus those observed in this and the Gold and Williams (1957) study, were used to draw an average seasonal snow-cover density map for North America (Fig. 6). Using the density ranges of the four categories described previously the continent was divided into zones. The zones were separated at density values of 0.24, 0.27 and 0.31 g/cm³.

Table II. Observed average snow density, seasonal air temperature and wind speed for stations in Gold and Williams's (1957) report used to test nomograph.

Station	*Density* (g/cm^3)	*Temp* (°C)	*Wind speed* (m/sec)
Edmonton, Alberta	0.224	-10.8	3.7
Maniwaki, Quebec	0.233	- 8.2	3.2*
Forestville, Quebec	0.237	- 9.4*	4.4*
Aklavik, NWT	0.242	-24.7	2.5
Moosonee, Ontario	0.242	-13.4	3.5
Whitehorse, Yukon	0.254	-13.9	4.0
Ottawa, Ontario	0.275	- 7.7	4.7
Winnipeg, Manitoba	0.279	-12.6	5.7
Churchill, Manitoba	0.325	-21.6	6.8
Old Glory, British Columbia	0.369	- 9.6	8.2

* Values obtained from nearby stations.

Table III. Stations for which average snow-cover densities were estimated from nomograph.

Aishihik, Yukon
Arctic Bay, NWT
Baker Lake, NWT
Barrow, Alaska
Bethel, Alaska
Bismarck, North Dakota
Brochet, Manitoba
Buffalo, New York
Cache Lake, Quebec
Cambridge Bay, NWT
Chesterfield, NWT
Clyde, NWT
Coppermine, NWT
Coral Harbour, NWT
Duluth, Minnesota
Ennadai Lake, NWT
Fort Chimo, Quebec
Fort Nelson, British Columbia
Fort Reliance, NWT
Fort Simpson, NWT
Fort Wayne, Indiana
Fort William, Ontario
Glasgow, Montana
Grand Prairie, Alberta
Green Bay, Wisconsin
Hall Beach, NWT
Harrington Harbour, Quebec
Havre, Montana
Hay River, NWT
Holman Island, NWT
Indian House Lake, Quebec
Kotzebue, Alaska
Mayo Landing, Yukon
McMurray, Alberta
Medicine Hat, Alberta
Nitchequon, Quebec
Nome, Alaska
Norman Wells, NWT
North Bay, Ontario
Northway Junction, Alaska
Nottingham Island, NWT
Pagwa, Ontario
Port Harrison, Quebec
Portland, Maine
Prince George, British Columbia
Rapid City, South Dakota
Regina, Saskatchewan
Sheridan, Wyoming
Sioux City, Iowa
Smithers, British Columbia
Snag, Yukon
Spence Bay, NWT
Spokane, Washington
Summerside, Prince Edward Island
Teslin, Yukon
The Pas, Manitoba
Thule, Greenland
Trout Lake, Ontario
Watson Lake, Yukon
Williston, North Dakota
Yellowknife, NWT

Gold and Williams (1957) divided Canada into five main snowfall regions. In addition to the physical characteristics of the snow cover these regions were determined by the amount of snowfall, temperature, time of first snowfall, and the length of time the snow stays on the ground.

Except for eastern Canada, their arctic region coincides closely with Category 4 where the highest densities are recorded. Except for some eastern portions and the area around the Great Lakes, Category 3 corresponds roughly with their Northern Forest region. The region they classify as the freeze-thaw area, which includes mostly the Atlantic Provinces, southern Ontario and southern Quebec, approximately coincides with the Category 1, 2 and 3 areas used in this study. As they point out, rain, heavy snowfalls, ice lenses within the snow cover, sleet and above-freezing temperatures are common in this area during the winter. Similarly, the other two regions (1: Prairie zone, and 2: Western Mountain and Coastal zone) covered portions of Canada where areas assigned to Categories 1, 2 and 3 are used in this study.

DISCUSSION

The system developed in this study provides an estimate of the average snow density for a general area over a number of years. It does not attempt to predict the density of a snow cover from point to point nor from week to week, nor year to year. Estimated values for 61 locations and observed values for 37 other locations were used to divide North America into geographical areas which fall into one of four predefined ranges of density. Except for those areas with snow densities above 0.31 g/cm^3 it is shown that the density of the snowpack increases slightly from month to month during winter.

The snow cover and its characteristics are extremely variable in mountainous regions (Alciatore, 1916; TSomaia, 1956; and McKay, 1964). Snowpacks range from permanent snowfields at higher elevations to an occasional brief snow cover in the lower and warmer plains and valleys. Large changes in density that occur in a short distance are exemplified by the mountain station, Old Glory, British Columbia (Fig. 6). The value for this station places it in Category 4 whereas a station nearby is in Category 1, indicating that the area bridges four categories. The scale of the map and insufficient data preclude the delineation of the intermediate categories. Consequently, caution should be used when interpreting Figure 6 in mountainous areas. In some portions of such regions, where the winter air temperatures and wind speeds over a wide area are reasonably uniform, the results presented in this study are applicable. For example, the stations in Category 1 in western United States and Canada and the interior of Alaska are mostly sheltered stations in valleys or on the lee sides of mountains where light winds and low densities are consistently observed.

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APPENDIX A: OBSERVED, WEIGHTED SNOW-COVER DENSITIES (G/CM^3) FOR STATIONS IN TABLE I.

Extracted, computed and compiled by Roy E. Bates, USA CRREL.

Eielson AFB, Fairbanks, Alaska

Nov	Dec	Jan	Feb	Mar
1952-1953				
.204	.260	.240	.260	.255
.220	.270	.270	.260	.240
	.250	.260	.240	.350
	.240	.310	.260	
		.300		
1954-1955				
	.165	.176	.207	.219
	.150	.171	.163	.187
	.152	.187	.191	.208
	.164	.201	.181	.200
	.146	.186	.189	.216
1957-1958				
.160	.181			
.140	.184			
.180	.152			
.190	.189			
.160	.201			

Nov	Dec	Jan	Feb	Mar
1953-1954				
.190	.200	.136	.231	.181
.180	.139	.184	.213	.201
	.136	.151	.198	.206
	.134	.151	.196	.198
		.201		
		.209		
1955-1956				
.197	.221	.292	.234	
.308	.232	.347	.292	
.124	.210	.349	.260	
.188	.153	.248	.250	
	.297			
	.299			
1959-1960				
.142	.159	.131	.167	.159
.133	.148	.138	.212	.162
.160	.110	.136	.150	.163
.140	.172	.155	.167	.162
	.136	.167	.152	
			.147	

Tatalina AFS, Alaska

Nov	Dec	Jan	Feb	Mar
1953-1954				
.130	.215	.213	.173	.204
.140	.135	.146	.185	.179
.140	.248	.218	.187	.188
.200				.211
1955-1956				
.216	.150	.208	.245	.236
.125	.236	.213	.242	.245
.202	.196	.225	.243	.241
	.236	.249	.241	.240
	.209	.205	.241	.230
	.239			.272
				.305
1957-1958				
.102	.203	.219	.214	.249
.204	.193	.252	.269	.247
.165	.163	.250	.264	.255
.140	.167	.200	.279	.242
.137	.201			.260
.138	.200			
.202	.220			

Nov	Dec	Jan	Feb	Mar
1954-1955				
	.150	.179	.250	.228
	.177	.193	.258	.236
	.190	.161	.239	.241
	.218	.246	.238	.257
		.258		
1956-1957				
.211	.191	.250	.249	.171
.218	.221	.225	.251	.293
.232	.251	.221	.161	.229
.204	.180	.131	.237	.176
.201	.332	.148	.142	.289
.165		.179		
		.179		
1958-1959				
.105	.150	.120	.230	.232
.115	.121	.109	.200	.229
.105	.122	.111	.231	.234
.128	.125	.184	.235	.210
.131		.192	.235	
.137		.196		
.136				

Tatalina AFS, Alaska (cont'd)

Nov	Dec	Jan	Feb	Mar
1959-1960				
.120	.187	.166	.173	.255
.158	.167	.195	.172	.245
.179	.158	.219	.191	.200
.157	.162	.219	.185	.196
.179	.159	.169		
		.178		

Nov	Dec	Jan	Feb	Mar
1960-1961				
.120	.134	.195	.164	.262
.144	.190	.163	.251	.272
.225	.163		.271	
.152	.142			
	.182			

Nov	Dec	Jan	Feb	Mar
1961-1962				
.306	.186	.196	.255	.238
.303	.220	.219	.244	.304
.260	.182	.220	.260	.253
.199	.198	.229	.250	.276
.213	.195			.262
	.206			

Hill AFB, Ogden, Utah

Nov	Dec	Jan	Feb	Mar
1951-1952				
			.120	
			.120	
			.130	
			.140	
			.270	
1953-1954				
	.199	.200		
	.160	.180		
1955-1956				
	.350		.200	
	.300		.300	
1961-1962				
		.192		
		.270		

Nov	Dec	Jan	Feb	Mar
1952-1953				
	.127			
	.120			
1954-1955				
		.150	.401	
		.260	.422	
		.200	.393	
		.225	.388	
		.186		
		.225		
		.241		
		.280		
1957-1958				
	.170	.160	.200	
	.170	.190	.170	
	.180			
1962-1963				
		.140		
		.200		

Galena Airport, Alaska

1953-1954

Nov	Dec	Jan	Feb	Mar
	.266	.269	.203	.260
	.266	.292	.213	.274
		.208	.224	.214
		.202	.192	.303
		.194		.246

1954-1955

Nov	Dec	Jan	Feb	Mar
	.176	.175	.280	.303
	.154	.142	.299	.279
	.196	.180	.279	.287
	.198	.258	.282	

1955-1956

Nov	Dec	Jan	Feb	Mar
.196	.186	.251	.200	.330
.156	.205	.237	.281	.291
.162	.254	.231	.224	.244
.164	.258	.249	.275	.275
	.228			.282

1956-1957

Nov	Dec	Jan	Feb	Mar
	.230	.320	.365	.338
	.260	.317	.319	.333
	.250	.361	.337	.338
	.240	.373		.334
	.260			.339

1957-1958

Nov	Dec	Jan	Feb	Mar
.121	.137		.164	.120
.128	.199		.155	.234
.145			.163	.216
.150			.170	.164
.153				.157

1958-1959

Nov	Dec	Jan	Feb	Mar
.165	.135	.156	.203	.220
.121	.121	.121	.206	.221
.114	.119	.167	.220	.212
.103	.124	.166	.217	.177

1959-1960

Nov	Dec	Jan	Feb	Mar
.165	.252	.309	.241	.351
.341	.270	.268	.287	.324
.265	.246	.264	.300	.266
.274	.211	.259	.279	.287
.280	.211	.218		
		.231		
		.253		

1960-1961

Nov	Dec	Jan	Feb	Mar
.160	.219	.219	.257	.344
.155	.204	.223	.251	.268
.188	.235	.251	.244	.262
.208	.245	.202	.261	.274
	.233	.279		

1961-1962

Nov	Dec	Jan	Feb	Mar
.240	.254	.198	.298	.290
.250	.155	.201	.210	.301
.190	.269	.261	.282	.272
.138	.189	.180	.328	.305
.239	.206			.290
.254				.302
.318				

1962-1963

Nov	Dec	Jan	Feb	Mar
.238	.124	.210	.308	.215
.215	.165	.160	.240	.161
.173	.268	.165	.217	.172
.127	.261	.168	.209	.200
	.262	.212		.204
		.299		.309
				.295

Utopia Creek AFS, Alaska

1953-1954

Nov	Dec	Jan	Feb	Mar
			.300	.325
			.300	.275
			.300	.300
			.300	.250
				.320

1954-1955

Nov	Dec	Jan	Feb	Mar
	.196	.300	.240	.217
	.190	.283	.150	.210
	.320	.280	.135	.252
		.310	.195	.238
				.156

Utopia Creek AFS, Alaska (cont'd)

1955-1956

Nov	Dec	Jan	Feb	Mar
.290	.160	.166	.182	
.100	.280	.183	.301	
	.240	.300	.320	
	.300	.310	.220	
			.249	

1956-1957

Nov	Dec	Jan	Feb	Mar
.240	.202	.180	.217	.264
.210	.211	.151	.200	.253
.200	.202	.214	.209	.317
.207	.178		.235	
	.220			
	.175			

1958-1959

Nov	Dec	Jan	Feb	Mar
.292	.280	.224	.204	.259
.306	.287	.311	.219	.248
.238	.236	.295	.215	.231
.252	.243	.313	.237	.214
.300		.320	.252	
.299				

1959-1960

Nov	Dec	Jan	Feb	Mar
	.170	.180	.220	.240
	.210	.196	.210	.330
		.340	.330	.330

1960-1961

Nov	Dec	Jan	Feb	Mar
.300		.400	.320	.400
.320		.420	.350	.300
.290				.280

1961-1962

Nov	Dec	Jan	Feb	Mar
.360		.121	.137	.122
.320		.116	.151	.118
.200		.127	.146	.126
.240		.132	.134	.153
.250		.109		.156

Naknek AFS, Alaska

1953-1954

Nov	Dec	Jan	Feb	Mar
.271	.280	.280	.256	.230
.260	.254	.275	.219	.220
.229	.230	.260	.216	.266
.253	.160		.265	.340
			.256	

1954-1955

Nov	Dec	Jan	Feb	Mar
	.240	.210		
	.222	.260		
	.212	.230		
	.212	.220		

Saglek, Labrador, Canada

1953-1954

Nov	Dec	Jan	Feb	Mar
			.332	.352
			.324	.377
			.334	

1954-1955

Nov	Dec	Jan	Feb	Mar
.210	.217	.210	.236	.330
.202	.200	.230	.255	.259
.190	.240	.325	.312	.298
.255		.377	.385	.321
.231		.303		

1955-1956

Nov	Dec	Jan	Feb	Mar
	.186	.449	.351	.364
		.468	.345	.395
		.357	.375	.384
			.371	.374

1956-1957

Nov	Dec	Jan	Feb	Mar
.198	.143	.145		
.125	.137	.153		
.137	.150	.164		
.133	.165	.170		
	.180			

Saglek, Labrador, Canada (cont'd)

1957-1958

Nov	Dec	Jan	Feb	Mar
.410	.155	.176	.189	.200
.377	.152	.169	.186	.199
.178	.158	.172	.197	.202
.164	.171	.172	.202	.202
	.162			.204

1958-1959

Nov	Dec	Jan	Feb	Mar
.150	.307	.193	.160	
.154	.250	.191	.158	
.219	.344	.190	.159	
.237	.342	.197	.164	
		.197		

Griffiss AFB, Rome, N. Y.

1954

Dec
.199
.200
.280

1956

Feb
.267
.190
.235

1957

Jan	Feb
.211	.260
.224	.169

1957-1958

Dec	Jan	Feb
.160	.240	.315
.120	.235	.211
	.333	.224
	.225	.241
	.247	.228
	.325	.319
	.290	

1959-1960

Nov	Dec	Jan	Feb	Mar
		.220	.335	.268
		.236	.215	.300
		.241	.270	
		.251	.231	
		.217		

1960-1961

Nov	Dec	Jan	Feb	Mar
	.208	.170	.197	.280
	.250	.235	.360	.353
	.190	.290		
	.280	.286		
		.290		

1961-1962

Nov	Dec	Jan	Feb	Mar
	.231	.353	.260	.260
	.140	.180	.240	.285
			.226	
			.211	
			.332	

1962-1963

Nov	Dec	Jan	Feb	Mar
	.294	.260	.248	.265
	.320	.289	.267	.302
	.264	.298	.260	.170
	.344			

Malmstrom AFB, Great Falls, Montana

1954

Jan
.185
.243
.248
.298

1955

Feb	Mar
.227	.248
.239	.182
	.250
	.270
	.290

1955-1956

Dec	Jan
.275	.201
.341	.355
.258	.283
	.290

1957

Jan	Feb
.270	.187
.287	.245
.254	.282
.260	

Malmstrom AFB, Great Falls, Montana (cont'd)

1958

Feb	Mar
.244	
.265	.266
.230	
.240	.240

1958-1959

Dec	Jan	Feb
.151	.265	.350
.181	.225	.364
.155	.280	.249
	.280	.236

1960

Feb	Mar
.212	.226
	.249

1962

Jan
.230
.246

Elmendorf AFB, Anchorage, Alaska

1952-1953

Nov	Dec	Jan	Feb	Mar
	.112	.186	.195	
	.142	.221	.302	
	.147	.271	.244	
		.259	.317	

1953-1954

Nov	Dec	Jan	Feb	Mar
	.209	.175	.285	.297
	.154	.148	.273	.247
	.145	.192		
	.172	.241		
	.174	.154		
	.198			

1957-1958

Nov	Dec	Jan	Feb	Mar
.200	.259	.343		
.280	.320	.457		
	.320	.317		
		.392		

1958-1959

Nov	Dec	Jan	Feb	Mar
.208	.277	.228	.389	.357
.184	.281	.360	.404	.335
.206	.196	.360	.380	.321
	.186	.348	.284	.324
	.191	.405	.366	.348
		.405	.360	

1959-1960

Nov	Dec	Jan	Feb	Mar
.128	.156	.323	.267	.252
.267	.217	.302	.276	.283
.194	.343	.276	.278	.205
.256	.173	.292	.270	.400
	.236	.241	.272	
			.292	

1960-1961

Nov	Dec	Jan	Feb	Mar
	.240	.150		.360
	.200	.250		.120
	.252			

1961-1962

Nov	Dec	Jan	Feb	Mar
.220	.194	.175	.154	.135
.120	.097	.230	.188	.311
.200	.145		.246	.400
.224	.159		.180	

Ernest Harmon AFB, Newfoundland, Canada

1953-1954

Nov	Dec	Jan	Feb	Mar
	.180	.232	.385	.125
	.355	.222	.440	.158
	.388	.212		.159
	.215	.158		.210
		.157		.226
				.313
				.282
				.268

1954-1955

Nov	Dec	Jan	Feb	Mar
		.320	.227	.220
		.140	.323	.180
		.231		.330

1955-1956

Nov	Dec	Jan	Feb	Mar
	.080		.130	
	.200		.208	
	.130			
	.090			
	.164			

1956-1957

Nov	Dec	Jan	Feb	Mar
	.180	.180	.170	
	.150	.302	.180	
	.220	.200		
	.289	.420		

1957-1958

Nov	Dec	Jan	Feb	Mar
	.160		.150	
	.180		.225	

1959-1960

Nov	Dec	Jan	Feb	Mar
	.200	.250		
	.230	.410		
	.159	.450		
	.200			

1960-1961

Nov	Dec	Jan	Feb	Mar
	.160	.144	.376	.417
	.097	.159	.344	.402
		.151	.335	.371
		.353	.453	.419
				.426

1961-1962

Nov	Dec	Jan	Feb	Mar
	.119	.199	.388	
	.120	.312	.267	
		.188	.255	
		.239	.257	

1962-1963

Nov	Dec	Jan	Feb	Mar
	.235	.240	.270	.414
	.417	.200	.320	.405
			.400	.420
				.388

Sondrestrom AFB, Greenland

1954-1955

Nov	Dec	Jan	Feb	Mar
.300	.350			.250
.350	.360			

1956-1957

Nov	Dec	Jan	Feb	Mar
.260				.278
.230				.335

Sondrestrom AFB, Greenland (cont'd)

1957-1958

Nov	Dec	Jan	Feb	Mar
			.342	
			.309	

1959-1960

Nov	Dec	Jan	Feb	Mar
.250	.290	.251	.250	.218
.270	.240	.222	.246	.261
.217	.250	.235		.252
	.251			.286

1960-1961

Nov	Dec	Jan	Feb	Mar
.233	.240	.251	.250	.258
.300	.250	.240	.266	.258
	.213	.300	.250	
		.300	.240	

1961-1962

Nov	Dec	Jan	Feb	Mar
.252	.202	.203	.263	
.286	.206	.239	.265	
.306		.223		

Goose Bay AFB, Labrador, Canada

1953-1954

Nov	Dec	Jan	Feb	Mar
.225	.190	.190	.279	.342
.200	.246	.202	.248	.466
.192	.268	.303	.298	.380
.300	.315	.299	.310	.400
.232	.243	.349	.298	.292
	.281		.294	.317
			.384	.293
				.333
				.322
				.203
				.242

1954-1955

Nov	Dec	Jan	Feb	Mar
.121	.169	.284	.243	.197
.110	.181	.296	.236	.298
	.210	.221	.340	.279
	.280		.238	.309
	.177		.190	
			.282	

Sparrevohn AFB, Alaska

1953-1954

Nov	Dec	Jan	Feb	Mar
.310	.273	.392	.281	.319
.276	[illegible]	.362	.299	.316
.219		.365	.347	

1954-1955

Nov	Dec	Jan	Feb	Mar
	.278	.279	.290	.297
	.254	.261	.257	.300
	.272	.286	.248	

1955-1956

Nov	Dec	Jan	Feb	Mar
	.210		.220	
	.300		.167	

1956-1957

Nov	Dec	Jan	Feb	Mar
.274	.268	.244	.256	.286
.290	.347	.297	.286	.269
.320	.305			.270

1957-1958

Nov	Dec	Jan	Feb	Mar
.230	.299		.316	.278
.280	.334		.305	.240
			.236	

1958-1959

Nov	Dec	Jan	Feb	Mar
.210		.281	.280	.303
.380		.300	.312	.325

Sparrevohn AFS, Alaska (cont'd)

Nov	Dec	Jan
1960-1961		
.160	.305	.243
.235	.280	.271
.219	.275	
.242	.300	
.245	.249	

Nov	Dec
1961	
.260	.260
.320	.273

Dec	Jan	Feb
1962-1963		
.264		.194
.242		.202
.326		.340

Sault Ste Marie, Michigan

Jan	Feb	Mar
1953-1954		
.300	.300	.276
.200	.335	.359
.255	.350	.280
.277	.280	
.250		

Jan	Feb	Mar
1954-1955		
.230	.350	.259
.230	.220	.320
.210	.260	.277
	.298	.310
		.370

Dec	Jan	Feb	Mar
1955-1956			
.340	.285	.254	.250
.246	.312	.242	.170
.302	.330	.284	.269
	.203	.323	.311
			.340
			.297

Jan	Feb
1956-1957	
.232	.258
.260	.253
.263	.263
.254	.293

Dec	Jan	Feb	Mar
1957-1958			
.254	.223	.270	.360
.350	.224	.281	.396
.230	.250	.240	
	.232	.370	
	.301		

Dec	Jan	Feb	Mar
1958-1959			
.188	.320	.291	.274
.227	.340	.323	.315
.230	.277	.318	.276
.295	.281	.308	.335

Nov	Dec	Jan	Feb	Mar
1959-1960				
		.160	.335	.400
		.260	.350	.400
		.310	.390	.440
		.329	.390	.318
1961-1962				
	.210	.279	.269	.281
	.222	.296	.280	.330
	.157	.308	.288	.390
	.232	.270	.269	.440

Nov	Dec	Jan	Feb	Mar
1960-1961				
	.240	.310	.277	.390
	.210	.310	.340	.290
		.300	.313	.295
		.270	.320	.384
1962-1963				
	.100	.285	.320	.335
	.180	.280	.284	.280
	.280	.330	.344	.360
		.230	.321	.310
				.400

Frobisher Bay, NWT, Canada

Site 2

Nov	Dec	Jan	Feb	Mar
1953-1954				
.330	.330	.340	.345	.279
.330	.320	.310	.345	.317
	.330	.360	.340	.377
			.220	.360

Nov	Dec	Jan	Feb	Mar
1954-1955				
.350	.218	.300	.230	.250
.230	.142	.380	.220	.330
.230	.360	.333		.286
.162		.250		.238
		.192		

Frobisher Bay, NWT, Canada (cont'd)

Site 1

Nov	Dec	Jan	Feb	Mar
1953-1954				
.394	.298	.364	.373	.242
.328	.327	.354	.339	.328
	.339	.349	.360	.385
	.332	.309	.349	.329
		.328		

Nov	Dec	Jan	Feb	Mar
1954-1955				
.200	.290	.338	.236	.290
.224	.219	.266	.248	.360
.240	.171	.176		.289
.170	.290	.172		
		.171		

Fargo, North Dakota

Nov	Dec	Jan	Feb	Mar
1953-1954				
	.297	.310	.337	
	.300	.292	.349	
		.320		
		.352		

Nov	Dec	Jan	Feb	Mar
1954-1955				
	.259	.300	.185	.275
	.285	.336	.360	.310
		.240	.180	
			.290	

Loring AFB, Caribou, Maine

Nov	Dec	Jan	Feb	Mar
1952-1953				
	.126	.309	.130	.166
	.272	.320	.172	.250
	.336	.226	.231	
	.224	.157	.234	
	.249		.261	
1954-1955				
	.220	.247	.391	.370
	.150	.341	.361	.380
	.340	.371		.405
	.232			.379
1956-1957				
		.327		
		.244		
		.297		
1958-1959				
	.268			
	.406			
	.390			
	.474			
	.474			

Nov	Dec	Jan	Feb	Mar
1953-1954				
	.350	.240	.394	.294
	.275	.250	.250	.300
		.289	.245	.330
		.300	.282	.370
			.380	
			.280	
1955-1956				
	.350	.237		.405
	.290	.340		.295
	.120	.260		
	.230			
	.160			
1957-1958				
	.450			
	.300			
	.400			
1959-1960				
	.248	.160	.322	
	.135	.190	.280	
		.182		

Loring AFB, Caribou, Maine (cont'd)

1960-1961

Jan	Feb	Mar
.263		.282
.243		.314
		.317
		.340

1961-1962

Dec	Jan	Feb
.300	.330	.370
.350	.330	.450
		.483

1962-1963

Jan	Feb	Mar
.230	.291	.294
.207	.304	.329
.314	.319	.355
.276		

Northeast Cape AFS, Alaska

1961-1962

Nov	Dec	Jan	Feb	Mar
.258	.292	.293	.281	.298
.254	.266	.303	.318	.307

1962-1963

Nov	Dec	Jan	Feb	Mar
.300	.308	.318	.264	.260
.270	.283	.334	.294	.314
				.290
				.411

Wurtsmith AFB, Oscoda, Michigan

1954

Feb	Mar
.256	.250
.217	.216
.240	.333

1954-1955

Dec	Jan
.440	.216
.312	.288
	.260
	.252

1958

Jan
.300
.260

1959

Feb	Mar
.275	.320
.252	.415
.357	.340
.313	
.262	
.261	

1959-1960

Nov	Dec	Jan	Feb	Mar
	.233	.340	.398	.341
	.280	.422	.410	.383
	.410	.372	.381	.316
	.200	.334	.333	.316
	.300			
	.212			

1960-1961

Nov	Dec	Jan	Feb	Mar
	.270		.253	.210
	.275		.140	.240
			.174	.351
			.355	

1961-1962

Nov	Dec	Jan	Feb	Mar
		.174	.290	.304
		.228	.380	.351
		.263	.253	.390
		.212	.209	.400
		.300	.293	

1962-1963

Nov	Dec	Jan	Feb	Mar
	.200	.280	.300	
	.150	.300	.350	
	.320	.300	.450	
		.240	.450	

Cape Lisburne AFS, Alaska

1961-1962

Nov	Dec	Jan	Feb	Mar
.271	.366	.422	.354	.400
.310	.358	.353	.311	.364
		.342		.400

1962-1963

Nov	Dec	Jan	Feb	Mar
.254	.290	.290	.347	.220
.320	.280	.240	.344	.267
	.290			.298

Barter Island, Alaska

1952-1953

Nov	Dec	Jan	Feb	Mar
.177	.242	.244	.255	.244
.236	.192	.311	.286	.304
.232	.232	.254	.241	.240
.238	.296		.300	.312
				.294

1953-1954

Nov	Dec	Jan	Feb	Mar
.384	.385	.421	.335	.332
.373	.398	.400	.334	.325
.378	.399	.361	355	.297
.382	.408	.261		.254
		.288		
		.344		

1954-1955

Nov	Dec	Jan	Feb	Mar
.348	.360	.354	.355	.368
.361	.361	.353	.346	.382
.361	.361	.356	.364	.382
.359	.354	.356	.369	.416
		.355		

Eureka, NWT, Canada

1951-1952

Nov	Dec	Jan	Feb	Mar
		.378	.431	.345
		.399	.422	.373
			.394	
			.345	

1953-1954

Nov	Dec	Jan	Feb	Mar
	.372	.342	.345	.381
	.369	.363	.362	.396
	.361	.347	.356	.388
	.350	.366	.350	
	.345			

1954-1955

Nov	Dec	Jan	Feb	Mar
.351	.371	.356	.336	.383
.369	.383	.355	.321	.364
	.322	.364	.361	.372
	.367	.336		.367
	.361			.357

1955-1956

Nov	Dec	Jan	Feb	Mar
.259	.360	.330	.336	.346
.355	.363	.350	.351	.352
.339	.333	.311	.367	.352
.349	.360	.323	.362	
.370			.361	

1956-1957

Nov	Dec	Jan	Feb	Mar
.334	.321	.311	.315	.334
.273	.304	.327	.319	.331
.300	.308	.315	.291	.322
	.336	.274	.261	.362
		.270		

1957-1958

Nov	Dec	Jan	Feb	Mar
.302	.239	.273	.360	.424
.292	.248	.339	.361	.438
.254	.258	.382	.371	.430
.262	.261	.342	.416	.389
	.254			.382

1958-1959

Nov	Dec	Jan	Feb	Mar
.255	.254	.257	.255	.277
.243	.257	.247	.272	.277
.252				.270
.258				.264
				.259

1959-1960

Nov	Dec	Jan	Feb	Mar
.186	.260	.301		.314
.204	.268	.238		.320

Eureka, NWT, Canada (cont'd)

1960-1961

Nov	Dec	Jan	Feb	Mar
.286	.338	.332	.336	.293
.282	.298	.295	.293	.353
			.332	

1961-1962

Nov	Dec	Jan	Feb	Mar
.275	.322	.322	.330	.363
.222		.365	.370	.360
		.337		

1962-1963

Nov	Dec	Jan	Feb	Mar
.242	.224	.344	.297	.303
.232	.369	.350	.284	.362

Resolute, NWT, Canada

1952-1953

Nov	Dec	Jan	Feb	Mar
.275		.336	.349	.365
.283		.374	.358	.330

1953-1954

Nov	Dec	Jan	Feb	Mar
.308	.292	.284	.321	[illegible]
.251	.310	.297	.352	.360
.327	.276	.306	.350	.371
	.272	.306	.352	.374

1954-1955

Nov	Dec	Jan	Feb	Mar
.301	.321	.332	.304	.329
.305	.315	.326	.314	.325
.322	.346	.322	.308	.334
.318	.335	.324	.325	.334
.306			.335	

1955-1956

Nov	Dec	Jan	Feb	Mar
.308	.371	.370	.336	.346
.343	.355	.335	.301	.333
.317	.356	.360	.350	[illegible]
.335	.397	.355	.368	.366
		.353		

1956-1957

Nov	Dec	Jan	Feb	Mar
.380	.382	.393	.362	.394
.397	.419	.371	.397	.347
.387	.396	.324	.394	.376
.268	.420	.426	.397	.415
	.421			.389

1957-1958

Nov	Dec	Jan	Feb	Mar
.260	.350	.290	.330	.270
.310	.310	.240	.341	.250
.300	.340	.320	.310	.290
.320	.310	.350	.341	.300
.250	.330	.310		.295

1959-1960

Nov	Dec	Jan	Feb	Mar
.300	.448	.365	.395	.366
.418	.368	.408	.363	.368
.437	.405			
.337				

1960-1961

Nov	Dec	Jan	Feb	Mar
	.340		.309	.323
	.311		.252	.359
	.396			

1961-1962

Nov	Dec	Jan	Feb	Mar
.254	.364	.361		.381
.247	.460	.357		.433
		.356		.361

1962-1963

Nov	Dec	Jan	Feb	Mar
	.372	.374	.380	
	.374	.387	.374	
	.361			

Alert, NWT, Canada

1953-1954

Nov	Dec	Jan	Feb	Mar
.203		.146	.209	
.166		.172	.184	

1954-1955

Nov	Dec	Jan	Feb	Mar
.289	.371	.294	.372	.359
.338	.296	.273	.352	.295
.323	.343	.331	.368	.359
.321	.335	.380	.372	.327
	.283			.406

1955-1956

Nov	Dec	Jan	Feb	Mar
.388	.370	.374	.383	.386
.407	.412	.359	.394	.324
.408	.381	.414	.386	.351
.384	.376	.407	.372	.339
	.380			.334

1956-1957

Nov	Dec	Jan	Feb	Mar
.360	.402	.404	.440	.415
.418	.430	.387	.430	.419
.278	.385	.436	.463	.402
.405	.330		.461	.327
	.382		.440	

1957-1958

Nov	Dec	Jan	Feb	Mar
.300	.384	.387	.322	.329
.288	.266	.260	.322	.337
.283	.332	.360	.331	.332
.361	.406	.368		.328
	.316			

1958-1959

Nov	Dec	Jan	Feb	Mar
.357	.329	.323	.341	.384
.399	.367	.292	.347	.331
.256		.424		.338
.423				.362
				.281

1959-1960

Nov	Dec	Jan	Feb	Mar
.248	.272	.360	.286	.242
.203	.327	.360	.288	.316
.310			.367	.331
.370				.328

1960-1961

Nov	Dec	Jan	Feb	Mar
.300	.329	.313	.344	.323
.400	.312	.312	.327	.367

1961-1962

Nov	Dec	Jan	Feb	Mar
	.371		.383	.405
	.489		.439	.357
	.452		.275	

1962-1963

Nov	Dec	Jan	Feb	Mar
.264	.329	.363	.383	.367
.271		.340	.346	.317
.359				

Mould Bay, NWT, Canada

1953-1954

Nov	Dec	Jan	Feb	Mar
.297	.297	[illegible]	.305	.290
.316	.323	.304	.314	.349
	.292	.287	.291	.309
			.291	
			.336	

1954-1955

Nov	Dec	Jan	Feb	Mar
.428	.407	.414	.391	.415
.420	.415	.403	.402	.401
.429	.409	.364	.364	.410
.433	.421	.392	.404	.354
		.399		

1955-1956

Nov	Dec	Jan	Feb	Mar
.341	.404	.382	.317	.313
.380	.359	.318	.378	.338
.413	.369	.375	.369	.345
.459	.431	.353	.329	.358
	.353	.314		

1957-1958

Nov	Dec	Jan	Feb	Mar
.385	.375	.415	.320	.373
.407	.387	.401	.358	.318
.390	.395	.447	.383	.267
	.388	.362	.366	.327
	.399			

Mould Bay, NWT, Canada (cont'd)

1958-1959

Nov	Dec	Jan	Feb	Mar
.247	.301	.260	.327	.349
.271	.304	.317	.261	.350
.285				.309
.294				.255

1960-1961

Nov	Dec	Jan	Feb	Mar
.390	.290	.422	.349	.359
.256	.382	.306	.352	.331

1961-1962

Nov	Dec	Jan	Feb	Mar
.303		.403	.403	.360
.313		.328	.375	.348
			.401	.378

Isachsen, NWT, Canada

1952-1953

Nov	Dec	Jan	Feb	Mar
.309	.339	.314	.355	
.305	.311	.333	.358	
	.308	.359	.350	
		.358	.328	

1953-1954

Nov	Dec	Jan	Feb	Mar
.392	.401	.420	.401	.401
.387	.409	.435	.431	.424
.422	.439	.4[illegible]6	.420	.424
.409	.443	.418	.438	.430
.375		.377		

1954-1955

Nov	Dec	Jan	Feb	Mar
.310	.375	.351	.335	.420
.400	.361	.333	.427	.333
.340	.336	.400	.327	.438
.340	.318	.420		.330
.352				.323

1955-1956

Nov	Dec	Jan	Feb	Mar
.389	.428	.408	.372	
.297	.403	.413	.393	
.406	.450	.458	.425	
.406		.403		

1956-1957

Nov	Dec	Jan	Feb	Mar
			.322	.324
			.324	.308

1957-1958

Nov	Dec	Jan	Feb	Mar
.348	.329	.383	.378	.310
.313	.336	.309	.394	.366
.357	.311	.371	.347	.377
.346	.400	.399	.401	.382
.374				.368

1958-1959

Nov	Dec	Jan	Feb	Mar
.247		.292		
.212		.276		
.264				

1959-1960

Nov	Dec	Jan	Feb	Mar
.248		.287		.384
.252		.332		.342
.334				.418
.373				

1960-1961

Nov	Dec	Jan	Feb	Mar
.280	.306	.283		.344
.256	.303	.319		.346

1961-1962

Nov	Dec	Jan	Feb	Mar
.320	.315	.325	.413	.393
.319	.350	.399		.473

1962-1963

Nov	Dec	Jan	Feb	Mar
.342	.371	.355	.412	.403
	.378	.366	.412	.378
				.376

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13. ABSTRACT

Analysis of snow-cover observations made during November - March at 27 stations in Alaska, Canada and the northern United States for a 2 to 11 year period showed that the average snow density can be classified in four general categories: Category 1 (density 0.20 to 0.23 g/cm^3), inland stations reporting light winds; Category 2 (0.24 to 0.27 g/cm^3), stations reporting moderate winds; Category 3 (0.28 to 0.30 g/cm^3), inland and coastal locations with stronger winds; Category 4 (0.32 to 0.36 g/cm^3), cold and windy stations of the Arctic. Skewness coefficients computed for each station showed bias toward lower densities for cat. 1 and 2, and bias toward higher densities for cat. 3 and 4. A nomograph in which the average winter air temperature and wind speed are the independent variables makes it possible to estimate the average snow-cover density for any location in the Arctic, subarctic and North Temperate Zones. A comparison between observed and estimated densities for ten other test stations yielded a correlation coefficient of 0.91 with a standard error of estimate of 0.016 g/cm^3. An average snow density map of North America was drawn and the continent was divided into areas based on the four categories.

14. KEY WORDS

Climatology
Snow cover
Snow density

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