AN EXPERIMENT TO MEASURE FRESH SNOWFALL WATER EQUIVALENT AT CANADIAN CLIMATE STATIONS

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Currently, at more than 85% of the Atmospheric Environment Service's observing stations, precipitation in the form of snow is estimated from snow depth measurements assuming the density of fresh snow is 100 kg/m^{-3}. This is a convenient, but not necessarily, an accurate estimate of the fresh snowfall water equivalent.

There is an ever increasing demand, particularly from the water resource sector, for accurate winter precipitation data for use in engineering design or environmental assessment investigation. Studies in many regions of Canada depend on the climatological station data and are consequently limited to analyses of snowfall and the estimated water equivalent. The density of fresh snowfall even at one station will be characterized by large inter- and intra-storm variations in actual density (Potter, 1965; Goodison, 1977; O'Neill and MacNeil, 1977). Depending on the region of the country and the associated snowfall characteristics, density may vary considerably from the 10:1 depth to water equivalent ratio used throughout Canada. To get away from universal application of this ratio, however, a rational assessment of density variations throughout the country was necessary. It was proposed, therefore, to measure fresh snowfall water equivalent at selected stations. From these measurements, regional densities of snowfall might be determined and the need for an alternative method of determining snowfall precipitation at climatological stations could be assessed.

In 1979 an experiment was initiated at over 20 observing stations of the Atmospheric Environment Service to test the use of the Type B rain gauge as a "cookie-cutter" snow sampler. This was both a convenient and inexpensive method to measure the fresh snowfall water equivalent. The rain gauge orifice was used as the sampler for depths up to 4 cm and the base of the gauge for greater depths. Samples were taken on a snowboard and a shovel or spatula was used to slide under the sample to hold the snow in place while the gauge was inverted. The snow sample was then melted and the water equivalent read directly as for rainfall.

Table 1 summarizes the 1979-80 results. The density, determined from snowboard depth and water equivalent measurements, varied widely from region to region and even station to station across the country. It was also apparent that for the period of observation the average measured density was generally less than the 100 kg/m^3 value currently being used. Observers' comments indicated that drifting or blowing snow and mixed precipitation (rain and snow mixed) were the main problems in accurately measuring snow on the snowboard. The ratio of snowboard to ruler in column (6), Table 1, gives an indication of this problem at each station. Low ratios indicate stations where this was a problem.

An attempt was made to reduce the effect of drifting and melting on the snowboards during the 1980-81 winter season by covering them with felt. Initial results (Table 2) are inconclusive on the usefulness of the felt, particularly since observers' comments on the past season's experience have not yet been received. The 1980-81 results which are available do indicate surprisingly consistent average densities for individual stations for the two years. Variations within AES Regions is not surprising because of the different snow regimes which may exist.

The method of observation, that is, use of the Type B rain gauge as a "cookie-cutter", seems to provide a reasonable method of measuring fresh snowfall water equivalent at selected stations. The method was not conceived as an observational procedure to be used at every climate station in Canada and use of the method at selected stations to determine regional densities is perhaps a more feasible approach. The technique itself

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Table 1: Snowfall Water Equivalent Measurements at Selected Atmospheric Environment Service Stations, 1979-80

	Depth Measurement		Water Equivalent			Ratios		
	MSC Ruler (cm) (1)	Snowboard (S.B.) (cm) (2)	Ruler (10:1) (mm) (3)	Nipher Gauge (mm) (4)	Type "B" Rain Gauge (mm) (5)	S.B. / MSC Ruler (6)	Nipher / MSC Ruler (7)	Type "B" / S.B. (8)
ATLANTIC REGION								
Shelburne, N.S.	106.0	66.2	106.0	101.0	61.6	.62	.095	.093
Royal Road, N.B.	58.2	55.4	58.2	101.4	91.2	.94	.174	.165
Churchill Falls, Nfld and Lab.	361.0	84.0	361.0	336.2	75.6	.23	.093	.090
Burgeo, Nfld	219.6	90.7	219.6	208.1	96.9	.41	.095	.107
QUEBEC REGION								
La Pocatiere	70.2	15.1	70.2	68.6	16.3	.22	.098	.108
Ste Agathe Des Monts	75.5	31.9	75.5	68.2	30.2	.42	.090	.095
Maniwaki	31.8	31.8	31.8	29.3	29.1	1.00	.092	.092
ONTARIO REGION								
Kemptville	No Data							
Pinery	88.0	87.0	88.0	n/a	67.4	.99		.077
Monticello	91.7	91.7	91.7	62.9	77.9	1.00	.069	.085
Powassan	128.3	128.3	128.3	n/a	136.7	1.00		.107
CENTRAL REGION								
Rawson Lake	26.5	32.6	26.5	27.0	30.3	1.23	.102	.093
Lloydminster	78.6	80.4	78.6	n/a	57.4	1.02		.071
Wynyard	45.9	17.7	45.9	44.3	18.1	.39	.097	.102
WESTERN REGION								
Jasper	No Data							
Fort Reliance	33.5	30.1	33.5	19.8	21.3	.90	.059	.071
PACIFIC REGION								
Blue River	287.6	287.6	287.6	231.7	232.4	1.00	.081	.081
Dease Lake	78.4	78.4	78.4	53.6	55.3	1.00	.068	.071
Hope	56.5	26.6	56.5	44.4	27.6	.47	.079	.104

Table 2: Snowfall Water Equivalent Measurements at Selected Atmospheric Environment Service Stations, 1980-81

	Depth Measurement		Water Equivalent			Ratios		
	MSC Ruler (cm) (1)	Snowboard (S.B.) (cm) (2)	Ruler (10:1) (mm) (3)	Nipher Gauge (mm) (4)	Type "B" Rain Gauge (mm) (5)	S.B. / MSC Ruler (6)	Nipher / MSC Ruler (7)	Type "B" / S.B. (8)
ATLANTIC REGION								
Shelburne, N.S.	152.6	59.3	152.6	127.2	52.0	.39	.083	.088
Royal Road, N.B.	207.3	197.6	207.3	182.9	183.6	.95	.088	.093
Churchill Falls, Nfld and Lab.	177.4	75.6	177.4	167.8	67.8	.43	.095	.090
Burgeo, Nfld	123.3	57.8	123.3	103.5	47.3	.47	.084	.082
QUEBEC REGION								
La Pocatiere	*NOT ENOUGH DATA*							
Ste Agathe Des Monts	34.4	24.4	34.4	33.2	25.0	.71	.097	.102
Maniwaki	145.5	145.5	145.5	154.0	137.3	1.00	1.06	.094
ONTARIO REGION								
Pinery	81.4	81.4	81.4	n/a	63.2	1.00		.078
Monticello	160.6	155.2	160.6	122.5	134.5	.97	.076	.087
Powassan	114.6	114.6	114.6	n/a	108.9	1.00		.095
CENTRAL REGION								
Rawson Lake	74.1	73.9	74.1	64.6	63.7	1.00	.087	.086
Lloydminster	81.0	81.0	81.0	n/a	78.3	1.00		.097
Wynyard	47.2	30.4	47.2	47.2	26.3	.64	1.00	.087
Rock Point	39.1	38.9	39.1	n/a	35.5	.99		.091
WESTERN REGION								
Jasper	40.5	40.5	40.5	30.5	30.6	1.00	.075	.076
Fort Reliance	50.1	50.4	50.1	34.4	35.3	1.00	.069	.070
PACIFIC REGION								
Dease Lake	115.7	115.7	115.7	94.7	96.8	1.00	.082	.084
Hope	*NOT ENOUGH DATA*							

may not be useful at certain stations because of drifting snow or large numbers of rain-on-snow events. Drifting snow is a concern in the determination of snowfall precipitation using this method, but that problem currently exists with our ruler measurements. In the method tested, perhaps more than one sample should be taken to help reduce sampling errors. This, however, increases the observer's workload. Some observers expressed concern about the length of time required to carry out this type of program as compared to making a ruler measurement. This has to be considered as the vast majority of climatological station observations are taken by volunteer observers. The time to take the observation and melt the sample is a factor when considering the applicability of the method.

Detailed analyses of data collected to this time will be carried out to assess inter-storm variability at stations, compare measurements with Nipher gauge data, finalize annual statistics and compare the results with data from synoptic stations collected earlier using different techniques (e.g. Potter, 1965). The study will be terminated at some stations and perhaps extended to some other climate stations. Operational use of the method has not been considered at this time.

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