NORTH AMERICAN PARTICIPATION IN THE WMO SOLID PRECIPITATION MEASUREMENT INTERCOMPARISON

by

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INTRODUCTION

In North America, hydrologists have long been aware of the problems of integrating precipitation data, particularly snowfall data, into conceptual and operational models. More recently, the need for improved precipitation measurement to assess the total deposition of acid rain over the continent and to provide long term homogeneous time series of precipitation data for climate analyses has been recognized by other scientific disciplines. In response to these needs, an international comparison of current national methods of measuring solid precipitation, including those suitable for use at automatic weather stations was started in 1986 under the auspices of the World Meteorological Organization (WMO). This experiment provides a reference standard in the form of a double fence shield surrounding a Tretyakov (USSR) precipitation gauge (DFIR), against which all methods of solid precipitation measurement can be compared (Goodison et al., 1989).

Canada has established Evaluation stations for the Intercomparison at six sites. All of these are operated by the Atmospheric Environment Service (AES), with the most intensively instrumented site being located at Kortright Centre, Ontario. In the United States, four sites have been installed. Each of these sites is operated by a different agency. The USDA-Agricultural Research Service established a site on the Reynolds Creek Watershed, Idaho; the U.S. Army Corps of Engineers Cold Regions Research and Engineering Laboratory (CRREL) operates a site within the Sleepers River Research Watershed (SRRW) in Danville, Vermont. The other two locations are in Colorado and North Dakota. All sites operate the DFIR with Tretyakov gauge.

TEST SITES

Reynolds Creek Site

This site is located about 65 km southwest of Boise, Idaho at an elevation of 1193 m in the Reynolds Creek valley which lies in the northern end of the Owyhee mountains in southwestern Idaho. The site is gently sloping sagebrush-covered rangeland. Mean annual precipitation is 281 mm, with December having the mean maximum monthly amount of 32 mm, and July the minimum monthly amount of 8 mm. Gauges at the site include a Wyoming shielded Universal recording gauge (Hanson, 1989; Rechard and Wei, 1980), the dual-gauge system (Hamon, 1973; Hanson et al., 1979) which is used in the gauge-network on the watershed and other gauges used at numerous locations in the United States.

Sleepers River Research Watershed

Started by the USDA-Agricultural Research Service (ARS) in 1957 and later jointly operated by the National Weather Service, NOAA, and ARS during the 60's and 70's. In recent years CRREL has been the sole federal government operator of the SRRW until the USGS joined CRREL in 1990. The Town Line R-3 test site, within the SRRW, is located near the eastern edge of a 6 ha clearing (see Anderson et al., 1977 for a detailed site description). The site is located at an elevation of 552 m and has a mean annual precipitation of 1092 mm. Supporting meteorological instrumentation located nearby includes wind speed and direction, air temperature, dew point, solar radiation and accumulated snow depth. Snow property measurements along with routine snow course measurements assist in verification of water equivalents measured by the independent gauges.

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During the first winter of testing, three conventional snow gauges, i.e. Tretyakov gauge (USSR), unshielded and Alter shielded Universal gauges were installed at the R-3 site along with the DFIR. Also, two gauges under development by CRREL (Koh and Lacombe, 1986), i.e. Rapid Response Precipitation Gauge (RRPG) and Optical Snow Gauge (OPG) were tested.

Kortright Centre

The site at the Kortright Centre for Conservation is a 162 ha area of slightly rolling agricultural land north of Toronto, Ontario at an elevation of 208 m above mean sea level. The mean annual precipitation for this area is 762 mm. The average annual snowfall is 131 cm. Prevailing wind direction during winter storms is N and NW, with average speeds of 5 m/s. Observations in support of the WMO Intercomparison began during the 1986/87 winter season.

All Canadian WMO sites operate the DFIR (with Tretyakov gauge), the Canadian Nipher shielded snow gauge system, an AES Type-B raingauge, a snow ruler and measure wind speed and direction (three levels), air temperature and humidity. Data loggers are used to record the data at various sampling intervals. As well at the Kortright site, a DFIR with Universal gauge, unshielded and Alter shielded pairs of Universal and Fischer & Porter type gauges, a USSR Tretyakov gauge, an acoustic snow depth sensor and a large Nipher shielded Universal gauge are operated.

DISCUSSION

Reynolds Creek Site

The gauge information presented in Table 1 is based on the total catch for the 1988/89 and 1989/90 winter seasons. The unshielded National Weather Service gauge caught the least precipitation which was 6% less than the DFIR and the Wyoming shielded gauge the most. Dual-gauge catch, which was computed using the equation presented by Hamon (1973), was the second greatest catch. The Wyoming shielded gauge catch was greater than the DFIR gauge by 6 percent for snow and 8 percent for rain.

Statistical analyses were done for both snow and rain events >0.2 mm. These analyses showed that none of the mean amounts per event was significantly different between the three gauging systems for snow or rain. There were not enough snow events to establish a relationship between wind speed and the ratio of the catch between the DFIR and either of the other two gauging systems.

Table 1.

Gauge catch for two winter seasons (1988-1990) from the WMO site at Reynolds Creek, Idaho, USA.

		Gauge System			
Precipitation Type	DFIR[1] (mm)	Wyoming[2] / DFIR (%)	Dual-gauge[3] / DFIR (%)	NWS[4] / DFIR (%)	Universal[5] / DFIR (%)
Snow	151.3	106	103	90	101
Rain	90.1	108	104	102	103
Total	241.4	107	103	94	102

[1]Double Fence Intercomparison Reference shield with Tretyakov gauge (DFIR)
[2]Wyoming shield with Universal recording gauge
[3]Dual-gauge system
[4]unshielded National Weather Service gauge
[5]Alter shielded Universal recording gauge

Sleepers River Research Watershed

Total daily precipitation amounts have been recorded for all intercomparison gauges since the winter of 1986/87. Bates and Pangburn (1987) reported that initial linear regressions and correlation coefficients from the first season of data collection (all data) showed that when each gauge was compared to the DFIR, $R^2 = 0.991$ for the Tretyakov, 0.978 for the 20.3 cm (8 inch) NWS standard, 0.960 for the Alter shielded Universal and 0.958 for the unshielded Universal. Preliminary analysis show that shielded gauges show slightly higher relative precipitation catch than unshielded gauges.

Hourly data were recorded for the two Universal gauges as well as for the two CRREL gauges (RRPG and optical). The time series from all the recording gauges compared quite favourably except during freezing rain events.

<u>Kortright Centre</u>

The Canadian Nipher Shielded Snow Gauge System, a manual observation requiring an observer, has been designated as the standard AES instrument for measuring snowfall amount in terms of water equivalent. Preliminary results from the WMO Intercomparison show results similar to those found previously (Goodison, 1978) and indicate the catch of the national standard Nipher shielded snow gauge to be almost the same as the WMO reference standard (DFIR).

Figure 1 shows that at the Kortright Centre site the total amount measured by the Nipher shielded gauge (NAT) was within 1% of that of the DFIR for all snow only storms >3.0 mm . The average wind speed during these events was 2.5 m/s and the mean temperature was -7.5°C. The DFIR and Nipher gauge totals have been corrected for average retention or wetting loss (Goodison and Metcalfe, 1989), but neither gauge has been adjusted for any undercatch due to wind (Golubev, 1986; Goodison, 1978). Unshielded (UnB) and Alter shielded (AlB) Belfort Universal weighing recording precipitation gauges which are commonly used on automatic stations showed catches of 66% and 81% of the DFIR, respectively. In an attempt to improve the catch efficiency of recording gauges, AES designed and tested a large Nipher-type shield for use on gauges with a 20.3 cm (8 inch) orifice (Goodison and Metcalfe, 1982). Figure 1, once again confirms these earlier tests, with the large Nipher shielded Belfort Universal gauge (LNB) totals being within 6% of the DFIR.

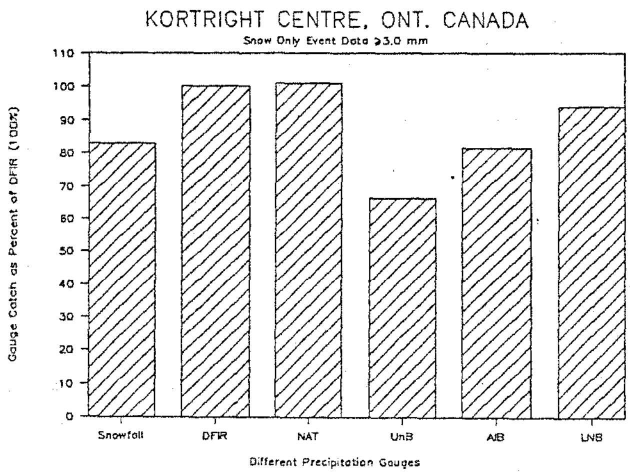

Fig. 1 Accumulated totals of snow only event data (equal to or greater than 3.0 mm) at Kortright Centre, Ont. from 1987-1989 for different precipitation gauges: fresh snowfall ruler measurement (Snowfall), Double Fence Intercomparison Reference with Tretyakov gauge (DFIR), Canadian Nipher shielded snow gauge system (NAT), unshielded Universal gauge (UnB), Alter shielded Universal gauge (AlB), large Nipher shielded Universal gauge (LNB).

<u>CONCLUSIONS</u>

The USSR Tretyakov gauge (the collector used in the DFIR), like the Canadian Nipher shielded snow gauge is a non-recording system which employs a volumetric method of measuring the melted contents. Both gauges retain a certain amount of water which cannot be poured out; this is known as the wetting loss. Recent experiments as part of the WMO Intercomparison indicate that the Tretyakov gauge wetting loss averages 0.20 mm per observation (Goodison and Metcalfe, 1989b; Huovila et al., 1988). The Canadian data in Fig.1 takes this systematic loss into account each time the contents are melted and poured out. In order to eliminate this error at Renolds Creek, the contents of the cans are weighed rather than poured out. No attempt to account for this systematic loss was made in the SRRW analyses. The magnitude of the correction for wetting loss could be quite large atsome sites. At Reynolds Creek, for the 1987/88 and 1988/89 seasons there were only six snow events >3.0 mm. Hopefully, over the duration of the Intercomparison, a sufficient number of significant events will occur at this site to allow for a complete analyses of the data including the effects of gauge type, temperature and wind speed.

The range of wind speeds experienced at each WMO site will no doubt influence the results from that location. The fairly light wind regime at Danville, Vermont may be the cause for initial results showing limited differences between the various gauge systems for daily or storm totals at the SRRW site. A major concern with automatic gauges, observed at both the SRRW and Canadian sites, is that wet snow or freezing rain can stick to the inside of the orifice of the gauge and not be recorded until sometime later.

Golubev (1986) has demonstrated that the correction factor to estimate true precipitation for winter precipitation measurements can be 3 times greater than that for summer rainfall measurements. If the results from the WMO Intercomparison are to be applied then the events of rain, snow and mixed precipitation should be analyzed separately to derive the systematic wind related errors.

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