

## RECENT RESULTS

By

B.E. Goodison 1/ and J.R. Metcalfe 1/INTRODUCTION

The Atmospheric Environment Service has been involved for several years in assessing the accuracy and performance of snow gauges used in Canada. Goodison (1978a; 1978b) and Goodison and McKay (1978) reported on field tests which showed that the Canadian MSC Nipher shielded snow gauge had a generally superior catch efficiency, with respect to wind speed, compared to unshielded or Alter-shielded Universal Belfort and Fischer and Porter gauges. However, the Nipher gauge is non-recording and it is only used at manned stations. Measurements from this gauge may require correction for trace amounts of snowfall which are not accumulated between observations, and in Arctic and Prairie regions, over 80% of all winter observations of precipitation may be trace amounts (Goodison, 1978b). Given these limitations, and realizing that most new precipitation stations in these regions would likely be recording gauges located at remote sites, an assessment of alternative methods of artificial shielding of gauges to improve catch efficiency was warranted. This paper reviews the performance of two types of shielding for recording gauges - the Wyoming shield and a large prototype Nipher-type shield.

INSTALLATIONS AND OBSERVATIONS

Based on results reported by Recharad et al. (1974), Wyoming shielded recording gauges were installed at selected sites in Canada in order to assess their performance. Installations at Regina (Cork, 1978; Dublin, 1979) and the Toronto Meteorological Research Station used the basic design proposed by the Wyoming Water Resource Institute researchers. At the Toronto site, an "Arctic version" Wyoming shield was constructed which used lightweight nylon snowfencing instead of wood and had no Alter shield around the gauge. There was no difference in gauge catch between the two shields, so the "Arctic version" was used for subsequent installations at Resolute Bay, N.W.T. and at Monticello and Peterborough, Ontario. Data are available since 1977-78, except for periods of gauge malfunction.

As a possible alternative to the Wyoming shield and in an effort to obtain recording gauge measurements which would be compatible with the standard Nipher snow gauge, a Nipher-type fiberglass shield was designed by the Data Acquisition Services Division of AES to fit 20.7 cm (8 inch) diameter recording gauges. Goodison and Metcalfe (1980) provide additional details on the gauge and initial results. Prototype shields were fitted to Fischer and Porter and Universal recording gauges and installed at eight sites in various climatic regimes. A variety of local siting conditions were chosen to assess the gauge's performance, and where possible, the gauges were co-located with Wyoming shielded gauges. Initial testing began during the 1978-79 winter season.

Modifications to the original design of the Nipher-type shield were found to be necessary and changes are now in progress. The physical size of the shield made servicing of the gauge awkward and difficult. Wind tunnel tests showed that the shield could be shortened by 30 cm without changing the air flow pattern over the orifice, so this change has been initiated. The support structure for the shield has been refined to permit easy and accurate positioning of the shield around the orifice extension and the need for support bars has been eliminated.

RESULTS

In this initial comparison, none of the gauge measurements was corrected for undercatch due to wind or trace amounts. The MSC Nipher shielded snow gauge is used as

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1/ Hydrometeorology Division, Atmospheric Environment Service, 4905 Dufferin Street, Downsview, Ontario, Canada M3H 5T4

the standard against which all other measurements are compared since it is the "official" Canadian snow gauge.

Table 1 summarizes the seasonal totals for gauges located at the Toronto Meteorological Research Station. The unshielded and Alter shielded gauges recorded the lowest totals, (generally, 50-65% of the Nipher), but this is in line with previous results (Goodison, 1978a). The Wyoming shielded Belfort gauge measured from 70-80% of the MSC Nipher, but it is not known why the catch has progressively increased each year. Finally, the gauges shielded with the large Nipher-type shield recorded approximately 90% of the MSC Nipher total. This site is flat and very exposed, but blowing snow is not a common problem. For conditions encountered at this station both the Wyoming and large Nipher-type shields are more effective than no shield or the Alter shield.

TABLE 1  
SEASONAL SNOW GAUGE MEASUREMENTS, TORONTO MET RESEARCH STATION\*

| SNOW SEASON                    | MSC NIPHER | UNSHIELDED BELFORT GAUGE | ALTER SHIELDED BELFORT GAUGE | NIPHER SHIELDED BELFORT GAUGE | WYOMING SHIELDED BELFORT GAUGE | ALTER SHIELDED F&P GAUGE | NIPHER SHIELDED F&P GAUGE |
|--------------------------------|------------|--------------------------|------------------------------|-------------------------------|--------------------------------|--------------------------|---------------------------|
| 1977-78                        | 82.0 mm    |                          |                              |                               | 56.1 mm                        |                          |                           |
| CATCH TOTAL AS % OF MSC NIPHER | 100%       |                          |                              |                               | 68%                            |                          |                           |
| 1978-79                        | 102.6 mm   | 54.5 mm                  | 65.4 mm                      | 94.7 mm                       | 72.8 mm                        | 60.8 mm                  | 86.2 mm                   |
| CATCH TOTAL AS % OF MSC NIPHER | 100%       | 53%                      | 64%                          | 92%                           | 71%                            | 59%                      | 84%                       |
| 1980-81                        | 120.8 mm   | 63.7 mm                  | 81.2 mm                      | 112.0 mm                      | 96.0 mm                        | 73.7 mm                  | 116.8 mm                  |
| CATCH TOTAL AS % OF MSC NIPHER | 100%       | 53%                      | 67%                          | 93%                           | 79%                            | 61%                      | 97%                       |
| 1981-82                        | 76.4 mm    | 36.8 mm                  | 46.5 mm                      | U/S                           | 62.5 mm                        | U/S                      | 68.6 mm                   |
| CATCH TOTAL AS % OF MSC NIPHER | 100%       | 48%                      | 61%                          |                               | 82%                            |                          | 89%                       |

\* NONE OF THE DATA HAS BEEN CORRECTED FOR UNDERCATCH DUE TO WIND, TRACE AMOUNTS OR RETENTION (WHERE APPLICABLE); ALL TOTALS INCLUDE RAINFALL WHERE APPLICABLE.

Table 2 provides a summary of the measurements made at Regina Airport during the last three winters. The test site is very exposed and well away from the airport buildings. The seasonal total for the Wyoming shielded gauge is more variable and less than that of the Nipher shielded Fischer and Porter gauge, with the latter measuring within 5% of the standard Nipher shielded gauge located at the test site. Although seasonal totals for the two Nipher shielded gauges compare well, the Fischer-Porter gauge was equipped to record in only increments of 2.54 mm. Thus, the timing of precipitation events, particularly small ones, could not always be determined. As the average catch efficiency of a gauge decreases, this becomes an even greater problem in these low snowfall regions.

Results from Resolute Bay, N.W.T. are summarized in Table 3. The two shielded gauges caught more than the standard Nipher gauge. Malfunction of the Wyoming shielded gauge has precluded complete analysis during the past two years. The two factors causing recording gauges to measure higher amounts are their accumulation of trace amounts and of blowing snow. Why the Nipher shielded recording gauge should measure an amount so much greater than the standard Nipher has not been determined. In both years, a sudden increase caused by something falling into the gauge (presumably snow stuck to the orifice extension) has occurred in the Nipher shielded Fischer and Porter. An assessment of whether this accumulation is real or not must be made.

The problems caused by blowing snow and snow collecting around the orifice and then falling into the gauge is also evident from data collected at different sites at Monticello, Ontario during January 1982 (Table 4). These data are given as they were recorded by each gauge, with no "quality control" applied. There are differences in timing between the gauges because they record only increments of 2.54 mm and because each has a different catch efficiency. There are other days when totals are difficult to rationalize. For example, the measurement of 50.8 mm by the Wyoming shielded gauge on January 10-11 is significantly greater than the other gauges. Was this a result of

TABLE 2  
SNOW GAUGE COMPARISONS, REGINA, SASKATCHEWAN \*

| SNOWFALL SEASON                    | MSC NIPHER SHIELDED GAUGE** | NIPHER SHIELDED FISCHER & PORTER GAUGE | WYOMING SHIELDED BELFORT GAUGE |
|------------------------------------|-----------------------------|--|--------------------------------|
| JANUARY 18 TO MARCH 17, 1980       | 35.1 mm                     | 33.0 mm                                | 23.6 mm                        |
| CATCH TOTAL AS % OF MSC NIPHER     | 100%                        | 94%                                    | 67%                            |
| OCTOBER 24, 1980 TO MARCH 23, 1981 | 38.2 mm                     | 40.6 mm                                | 33.3 mm                        |
| CATCH TOTAL AS % OF MSC NIPHER     | 100%                        | 106%                                   | 87%                            |
| NOVEMBER 16, 1981 TO APRIL 6, 1982 | 109.2 mm                    | 104.1 mm                               | 81.5 mm                        |
| CATCH TOTAL AS % OF MSC NIPHER     | 100%                        | 95%                                    | 75%                            |

\* OPERATED BY PERSONNEL FROM AES CENTRAL REGION, SCIENTIFIC SERVICES DIVISION  
\*\* READ EVERY 24 HOURS

TABLE 3  
SNOW GAUGE COMPARISONS, RESOLUTE BAY, NWT

| SNOW SEASON | MSC NIPHER (mm) | WYOMING BELFORT GAUGE (mm) | NIPHER SHIELDED F&P GAUGE (mm) |
|-------------|-----------------|----------------------------|--------------------------------|
| 1977-78     | 116.3           | 135.5                      | N/A                            |
| 1978-79     | 69.6            | 93.9                       | N/A                            |
| 1979-80     | 67.7            | 82.2                       | N/A                            |
| 1980-81     | 62.6            | U/S                        | 114.3                          |
| 1981-82     | 34.2            | U/S                        | 121.9                          |

blowing snow? A similar problem occurred with the Nipher shielded Fischer and Porter gauge on January 23. The reasons for such inconsistencies in the recorded gauge data must be understood before the gauges can be operated successfully at automatic stations in Canada. A Nipher shielded recording gauge was also located in a small opening in the bush, but it capped over early in the winter and no accumulation was recorded. This type of shield is susceptible to capping at a sheltered site.

#### SUMMARY

Results from the Canadian test sites indicate that a Nipher shielded recording gauge will undercatch the standard MSC Nipher snow gauge by less than 10%, while a Wyoming shielded gauge will undercatch it by about 25%. A summary of the advantages and disadvantages of each shield is possible. The Wyoming shield provides improved gauge catch compared to unshielded or alter shielded gauges. However, its physical size can be a constraint at some locations and its installation is more time consuming and difficult. Annual inspection and maintenance of the shield is required, the extent of which depends largely on the local environment. The shield in Resolute is in excellent condition compared to installations at southern Ontario stations. It can be difficult to service the gauge.

The Nipher-type shield improves gauge catch compared to unshielded, Alter-shielded and Wyoming shielded installations. There is little maintenance required and the new design will allow easy servicing of the gauge. However, snow can build up on the shield even at open sites and the gauge can cap over at sheltered sites. A gauge with this type of shield appears to be more susceptible to catching blowing snow. Finally, manufacture of the shield does require a mould.

TABLE 4  
COMPARISON OF SNOW GAUGE MEASUREMENTS (mm), MONTICELLO, ONTARIO  
JANUARY 1982

|        | RAIN GAUGE<br>MAIN SITE | MSC NIPHER GAUGE<br>MAIN SITE | SNOWBOARD<br>MAIN SITE | ALTER SHIELDED<br>F&P GAUGE<br>MAIN SITE | NIPHER SHIELDED<br>F&P GAUGE<br>MAIN SITE | ALTER SHIELDED<br>F&P GAUGE<br>BUSH SITE | WYOMING SHIELDED<br>F&P GAUGE |
|--------|-------------------------|-------------------------------|------------------------|--|---|--|-------------------------------|
| 1      | 1.8                     | 5.4                           | Blowing Snow           | 6.0                                      | 7.6                                       | 7.6                                      |                               |
| 2      |                         |                               |                        | 0.4                                      |   |  |                               |
| 3      | Trace                   |                               |                        |  |   |  |                               |
| 4      | 13.8                    |                               |                        |  | 22.9                                      | 25.4                                     | 12.7                          |
| 5      |                         | 7.0                           | Blowing Snow           | 7.0                                      |   | 5.1                                      | 2.5                           |
| 6      |                         | 1.4                           |                        | 1.4                                      |   | 7.6                                      |                               |
| 7      |                         | 1.0                           |                        | 0.6                                      |   |  |                               |
| 8      |                         | 1.8                           | Blowing Snow           | 1.4                                      |   |  | 2.5                           |
| 9      |                         | 2.4                           |                        | 1.8                                      |   |  |                               |
| 10     |                         | 1.2                           |                        | 1.0                                      | 5.1                                       | 7.6                                      | 2.5                           |
| 11     |                         | 8.0                           | Blowing Snow           | 6.2                                      | 7.6                                       | 12.7                                     | 5.1                           |
| 12     |                         | 0.2                           |                        | 0.2                                      |   | 7.6                                      |                               |
| 13     |                         | 5.2                           |                        | 4.4                                      |   | 7.6                                      | 5.1                           |
| 14     |                         | 1.0                           |                        | 0.6                                      |   | 2.5                                      |                               |
| 15     |                         | Trace                         |                        |  |   |  | 2.5                           |
| 16     |                         | 2.6                           | Blowing Snow           | 2.6                                      |   | 5.1                                      | 5.1                           |
| 17     |                         | 0.8                           |                        | 1.0                                      |   | 2.5                                      | 5.1                           |
| 18     |                         | 0.2                           |                        | 0.2                                      |   |  |                               |
| 19     |                         |                               |                        |  |   | 5.1                                      |                               |
| 20     |                         | 0.8                           |                        | 0.6                                      |   |  | 2.5                           |
| 21     |                         | 1.8                           |                        | 1.8                                      |   |  |                               |
| 22     |                         | Trace                         |                        |  |   |  | 2.5                           |
| 23     | 0.5                     | 7.0                           | Blowing Snow           | 6.3                                      | 30.5                                      | 27.9                                     | 17.8                          |
| 24     |                         | 0.8                           |                        | 0.8                                      |   | 7.6                                      | 2.5                           |
| 25     |                         | 2.0                           |                        | 2.8                                      |   | 2.5                                      |                               |
| 26     |                         | 0.2                           |                        | 0.2                                      |   |  |                               |
| 27     |                         |                               |                        |  |   |  |                               |
| 28     |                         | 1.0                           |                        | 0.8                                      |   |  | 2.5                           |
| 29     |                         |                               |                        |  |   |  |                               |
| 30     |                         | 7.2                           |                        | 7.6                                      |   |  | 5.1                           |
| 31     |                         | 8.0                           |                        | 9.0                                      | 10.2                                      | 15.2                                     | 10.2                          |
| TOTALS | 15.1                    | 67.0                          | = 82.1 mm              | 64.7 mm                                  | 83.9 mm                                   | 149.6 mm                                 | 73.6 mm                       |
|        |                         |                               |                        |  |   |  | 124.3 mm                      |

One more year of testing of the shields is planned, with particular emphasis being placed on the performance of the modified large Nipher-type shield.

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