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SNOWFALL WATER EQUIVALENT COMPARISON OF EIGHT INCH STANDARD GAUGE VERSUS HEATED TIPPING BUCKET

David E. DeRung
National Weather Service Forecast Office
Bismarck, North Dakota

1. Introduction

On the morning of March 16, 1990, Station A reported a 24-hour precipitation amount of .01. For the same time frame, Station B logged .73 with nine inches of new snow. Station A and Station B are only one mile apart, and neither has a shielded precipitation gauge. The primary difference between the stations is, Station A is an AMOS (Automatic Meteorological Observation System) site equipped with a heated tipping bucket precipitation gauge, and Station B is a National Weather Service (NWS) co-op station equipped with a standard eight inch gauge.

The scenario mentioned above was extreme. In comparing the gauges, there were days when precipitation amounts from the eight inch gauges and the heated tipping bucket (HTB) type gauges were the same, or even a little higher at the HTB site. Nonetheless, over the winter and summer periods studied, the inability of the HTB to accurately melt and record water equivalent of snowfall was evident.

In this study, two different locations were used to compare the HTB and Standard gauges. The example used above was data from Devils Lake, which is located in northeastern North Dakota. The other site used was Lidgerwood, located in southeastern North Dakota. At Lidgerwood, the HTB gauge is part of a RAMOS (Remote Automatic Meteorological Observation System). None of the gauges had wind shielding.

This study includes precipitation recorded from June 1984 to March 1990. Two periods were taken into consideration; November through March and June through August. This was done to separate the data into a summer grouping and a winter grouping. That way it could be determined if the differences between amounts received were due to gauge types alone or if the type of precipitation normally encountered during the separate periods caused the difference. This amounts to six warm and six cold seasons worth of data.

Also, it should be noted that during any known outage of the AMOS/RAMOS equipment, precipitation amounts for the co-op sites during the same time frame were deleted.

2. Data for Devils Lake, North Dakota

The co-op station for Devils Lake is KDLR Radio Station, located in Devils Lake. The gauge site is obstructed by a satellite dish to the southeast (120 to 160 degrees). This dish is just over 40 degrees in elevation from the top of the precipitation gauge. Studies of gauge locations have indicated that in no case should obstructions be closer to the gauge than their own height (45 degrees) (USDA, 1979). Since the prevailing wind direction at Devils Lake is northwest during the winter months, this obstruction has little affect on the precipitation recorded.

The AMOS site in the Devils Lake area is station P11, located on the edge of town just over a mile to the southwest of KDLR Radio Station. The top of the gauge is slightly over 4 1/2 feet, this is a half foot lower than the eight inch gauge at the co-op site. Studies have shown that the closer the gauge was to the ground, the less the wind reduced gauge catch (USDA, 1979). This is true provided the gauge is not so low that blowing and drifting snow are caught instead of falling snow. The height of 4 1/2 feet is good because more than 90% of the blowing snow has been shown to be contained within the first meter above the ground (Mellor, 1965).

What follows are the precipitation amounts:

Devils Lake, North Dakota
Total Summer Precipitation (June-August)
1984-1989

KDLR (Standard gauge)	P11 (Heated Tipping Bucket)	Percent of Standard
50.27	41.49	83%

Total Winter Precipitation (November-March)
1984/1985-1989/1990

KDLR (Standard gauge)	P11 (Heated Tipping Bucket)	Percent of Standard
22.34	3.69	16%

Here is the precipitation data month by month (six years each):

	KDLR (Standard 8-inch)	P11 (HTB)	Percent of Standard
JUNE	19.66	14.51	74%
JULY	17.53	14.84	85%
AUGUST	13.08	12.14	93%
NOVEMBER	7.77	.82	11%
DECEMBER	2.68	.23	9%
JANUARY	2.73	.24	9%
FEBRUARY	2.96	.55	19%
MARCH	6.20	1.80	29%

It is evident that as the winter deepens, the HTB loses accuracy. Also note how the data improves in February and March as the temperature climbs. As shown in the data, the P11 HTB is severely deficient in accurately measuring December and January snowfall water equivalent.

3. Data for Lidgerwood

In Lidgerwood, the co-op observer is located just to the southwest of town. The site is unobstructed and the gauge opening is about 4 1/2 feet above the ground. The only help in reducing the wind comes from the grove of trees around the observers house located about 100-150 feet to the north-northwest.

The RAMOS station in Lidgerwood (P67), is located 1 3/4 miles north of the co-op site along a highway. There is a building about 50 feet to the south of the site. Since the gauge is located on top of a 20 foot instrumentation tower, it is doubtful that the building significantly affects the gauge catch. The height of the gauge is the main problem here due to the wind affect on solid precipitation (USDA, 1979). Here is the data for the Lidgerwood sites:

Lidgerwood, North Dakota
Total Summer Precipitation (June-August)
1984-1989

Lidgerwood (Standard Gauge)	P67 (Heated Tipping Bucket)	Percent of Standard
48.31	43.13	89%

Total Winter Precipitation (November-March)
1984/1985-1989/1990

Lidgerwood (Standard Gauge)	P67 (Heated Tipping Bucket)	Percent of Standard
18.13	4.28	24%

Here is the data month by month (six years each):

	Lidgerwood (Standard 8-inch)	P67 (HTB)	Percent of Standard
JUNE	14.15	12.13	85%
JULY	17.91	15.27	85%
AUGUST	16.25	15.83	97%
NOVEMBER	4.88	1.22	25%
DECEMBER	1.64	.45	27%
JANUARY	1.80	.33	18%
FEBRUARY	2.29	.10	4%
MARCH	7.52	2.18	29%

Again, it is clear that the HTB has problems when the temperature drops. In the case of the P67 gauge, the weakest month is February when only 4% of the eight inch gauge amount is measured. Note the error improves in March as warmer weather arrives.

4. Conclusions

The heated tipping bucket gauges at the sites compared failed to accurately record water equivalent amounts from snowfall, especially in December through February. This is no big news to those who have monitored the performance of the HTB during winter. Winter time accuracy rates of 16% to 24% fall far short of the required accuracy for climatic and hydrologic use.

Heating the gauge in order to melt snow causes unacceptable amounts of evaporation (Middleton and Spilhaus, 1953). After melting the snow, the water droplet is surrounded by air with a much lower dew point than that of the droplet, enhancing evaporation.

Another possible problem during a snowfall event with little or no wind is a "heat island" affect which deflects the snow around the top of the gauge, thus reducing the snow catch.

With the Modernization and Associated Restructuring, care must be taken to ensure gauges more accurate than the AMOS and RAMOS HTB's are put in use with ASOS (Automated Surface Observation System). This is especially critical where significant amounts of snow occur. A study should be done at a northern-tier site to compare the new ASOS precipitation gauge with a weighing gauge. Both gauges would be configured the same, eliminating the discrepancies cited in this study. Doing such a study before wide-scale implementation would offer conclusive evidence of the new gauges accuracy.

5. Acknowledgements

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6. References

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