2.2 TEN-YEAR COMPARISON OF DAILY PRECIPITATION FROM THE 4 INCH DIAMETER CLEAR PLASTIC RAIN GAUGE VERSUS THE 8 INCH DIAMETER METAL STANDARD RAIN GAUGE

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1. INTRODUCTION

I purchased my first four-inch diameter clear plastic high-capacity rain gauge back in 1968. I found it for sale in a hardware store in central Illinois and thought it would be a great gift for my weather-watching father. Together, we enjoyed recording rainfall to the nearest 0.01 inch. It was such an improvement over the little glass tube gauges we used to have that we got from the bank and grain elevator. We also learned to measure the water content of snow and saw how that varied from storm to storm.

After I left for college in 1970, my dad kept the records. It was in college where I saw my fist National Weather Service 8-inch diameter standard rain gauge (SRG) as well as tipping bucket and weighing bucket gauges (Figure 1). I had no idea then that the gauges might actually report different amounts of precipitation from a storm. I assumed they would all read the same.

Since that time, I have learned that all gauges do not perform equally. Depending on shape, height, diameter and mechanism, as well as precipitation type, intensity and associated wind speed, the gauge catch and capture can vary.

As far back as the 1970s, I recall hearing that the 4" plastic gauge, when used properly, provided precipitation data of comparable quality to the larger Standard Rain Gauge. I am sure there was some formal or informal study that reached that conclusion, but I have never found it. Based on its reputation and its affordable cost, we selected the 4 inch-diameter gauge as our standard for the Community Collaborative Rain, Hail and Snow Network (Reges et al., 2005).

We began an informal gauge comparison at the Colorado State University Historical Climate Network weather station in the early 1990s when testing a recreation of the old "Marvin Shield." This wind shield had been used at some NWS stations in the Rocky Mountains early in the 20th century to help reduce the undercatch of wind driven snow that some observers had noted. However, it seemed to increase the catch of summer rain and hail and may have produced some anomalously high readings (Jarrett and Crow, 1988). Although unrelated to the 4" gauge questions, this early study helped establish a test bed for gauge intercomparisons that has been maintained ever since.

Figure 1. Example rain gauges at the Fort Collins, Colorado, National Weather Service Historical Climate Network weather station 05-3005-4.

2. DATA

A continuous time series of 12-hour and daily precipitation measurements have been maintained at the CSU Campus weather station since 1995 for five types of gauges.

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- NWS Standard Rain Gauge (SRG),
- 8" diameter Dual-traverse Universal Weighing-Bucket Gauge,
- 8" diameter Fischer-Porter weighing gauge with 15-minute paper tape punch block,
- 8" diameter tipping bucket rain gauge,
- 4" diameter clear plastic gauge.

This paper examines only two of these gauges and summarizes the results of ten years of intercomparisons. The two gauges were located less than five feet apart. The top of the SRG was nearly 3 feet above ground level while the 4" gauge opening was less than 2 feet above the ground. Only the 24-hour precipitation totals, measured at 1900 MST each day, are compared. During the ten year period, there were nearly 900 days with measurable precipitation observed in either or both gauges. A total of 167 inches of rain and melted snow fell during this period, as measured by the NWS SRG. A total of 32 days were identified where the 4" gauge was either not measured, or the measurement was in obvious error. Most of these occurred in the earlier years. The only recent missing data point was during a snowstorm in March 2003 when the 4" gauge was totally buried in the snow. These 32 days contributed a total of 6.99" (4.4% of the total) and these data were removed from the comparison.

All remaining days were tallied and summed into monthly and annual totals. Individual daily differences were also computed and examined.

3. RESULTS

Figure 2 and Table 1 shows the 10-year average monthly precipitation in inches for the 8" and 4" gauges, respectively. Precipitation for the 4" gauge equaled or exceeded the 8" gauge in all months. Very small differences were noted during winter months when precipitation totals are low. The largest differences were noted in March (0.08") and May (0.11"). For the entire year, the average precipitation from the 8" gauge was 15.95" compared to 16.42" with the 4" gauge. This difference of 0.47" per year is 3%, with the 4" gauge consistently measuring more precipitation than the 8" gauge.

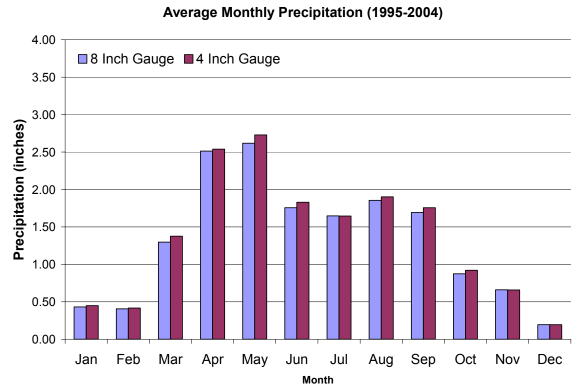

Figure 1. Ten year, 1995-2004, monthly average precipitation comparison at Fort Collins, Colorado, CSU Campus Weather Station

Monthly Averages	8 inch RG	4 inch RG	Average Difference
Jan	0.43	0.45	-0.02
Feb	0.41	0.42	-0.01
Mar	1.30	1.38	-0.08
Apr	2.51	2.54	-0.03
May	2.62	2.73	-0.11
Jun	1.76	1.83	-0.07
Jul	1.65	1.65	0.00
Aug	1.86	1.90	-0.05
Sep	1.69	1.76	-0.06
Oct	0.87	0.92	-0.05
Nov	0.66	0.66	0.00
Dec	0.20	0.20	0.00
Annual	15.95	16.42	0.47

Table 1. Average monthly precipitation in inches for the 10-year period 1995-2004. Fort Collins, Colorado (32 days removed due to incomplete or suspect data).

Annual precipitation during this 10-year period, measured with the SRG, ranged from a low of 9.07 inches 2002 to a high of 24.25 inches 1997 (Figure 2). Precipitation as measured by the 4" gauge exceeded the 8" gauge in every year with differences ranging from a minimum of 0.09" (0.8%) in 2000 to a maximum of 0.96" (5.8%) in 1999.

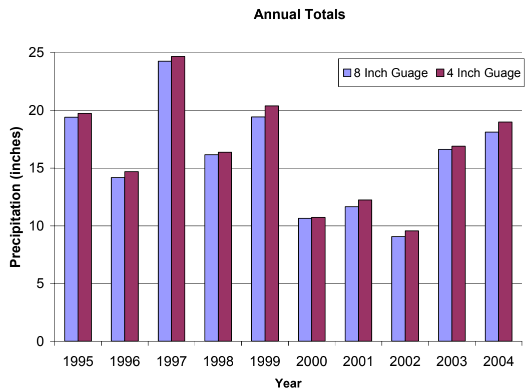

Figure 2. Annual precipitation comparison, 1995-2004 between the 8" diameter SRG and the 4" diameter clear plastic gauge.

Differences of 0.05" or greater were observed just 39 days in ten years. In 27 cases, the 4" gauge showed more precipitation than the 8" gauge and in 12 cases the opposite occurred. Only 13 times did the 4" measurement differ from the 8" gauge by 0.10" or greater with the largest difference being 0.26 inches. Most (73%) of the large differences were associated with precipitation that fell in the form of snow.

4. CONCLUSIONS

Based on ten years of side by side measurements of the NWS 8" diameter Standard Rain Gauge and the similar design but small 4" diameter clear plastic gauge, the 4" gauge consistently showed more precipitation than the 8" gauge. Most daily difference were 0.00” or 0.01” but when summed over all precipitation events each year, the differences amounted to 0.48" or 3% of the annual average of 15.96 inches. Annual differences ranged from 0.8% to 5.8%. The majority of the differences accrued during spring and summer months. Large daily differences of 0.05" or greater were uncommon but typically occurred during snow, heavy rain, hail, or high wind. In rare instances of high winds and snow, or heavy rains with hail, the 4" gauge would show less precipitation than the 8" gauge.

The most likely explanation for consistent small differences is that the metallic surface of the 8" diameter SRG absorbed or evaporated more water than the equivalent surface of the plastic gauge. Based on visual observation, the 4" gauge measurements appeared to reach the 0.01" mark more quickly. There were many instances during this period where light rain would totally wet the adjacent streets and sidewalks and the 4" gauge would indicate 0.01" of accumulation, while the 8" gauge only measured a trace.

Overall, the 4" gauge has shown itself consistent and reliable. While there are a few obvious limitations (capacity, poor gauge catch for windblown snow, breakability, limited life time due to UV-breakdown, etc.) the gauge performs very well over a wide range of conditions and is an excellent choice for a lower cost alternative to the traditional SRG.

5. ACKNOWLEDGEMENTS

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6. REFERENCES

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